BIRMINGHAM CITY
University

The influence of the dietary and lifestyle practices of Seventh-day Adventists on COVID-19 health outcomes.

Robert Krisztian Janko

A thesis submitted in partial fulfilment of the requirements of Birmingham City University for the degree of Doctor of Philosophy

The Faculty of Health, Education, and Life Sciences

Acknowledgements

I must express my gratitude to everyone who has supported me in my PhD journey. Firstly, I have to thank my wife Elizabeth for her love and encouragement throughout my studies as well as my parents for their support and the numerous sacrifices they have made for my education.

I am also grateful to my supervisors, Dr. Ashok Patel and Dr. Irmgard Haussmann, for their advice and guidance. Thank you for believing in the potential of my project and providing me the opportunity 4 years ago to embark on this wonderful journey.

I feel compelled to thank all the participants who took part in my project since their contributions have been vital for this research. I would also like to express my gratitude to the Seventh-day Adventist Church and the 'Adventist News' newsletter for their help with participant recruitment and raising awareness of my research. Your assistance was invaluable.

Lastly, I must give thanks to Jesus Christ for instilling in me an interest and passion for science and nutrition from my teenage years and for giving me a life purpose to help others improve their health and wellbeing through nutrition.

This PhD project could not have been accomplished without the assistance and advice of each person mentioned above, and I will be forever grateful for all your support.

Abstract

This thesis assessed the influence of the dietary practices of Seventh-day Adventists within the context of their lifestyle on COVID-19-related health outcomes such as the incidence of COVID-19 infection, symptom severity and risk of long-COVID.

Therefore, a two-year prospective cohort study involving 170 participants (86 Adventists and 84 non-Adventists) was conducted to compare COVID-19 outcomes among Adventists and non-Adventists. The study showed that Adventists had a significantly lower incidence of COVID-19 infection (OR 0.45, 95% CI 0.2,1.0, $p=0.05$) and had a significantly reduced risk of experiencing severe symptoms as well as long COVID symptoms. These outcomes were observed despite Adventists being older and having a lower vaccination rate. Logistic regression analysis further revealed that adherence to a plant-based diet was significantly associated with reduced COVID-19 risk. Furthermore, being a vegetarian Adventists was associated with significantly less weight gain during the pandemic compared to non-vegetarians and Adventists overall reported frequent lower levels of pandemic-related stress and less weight gain during the lockdowns, which may have positively influenced their COVID-19 risk significantly.

Plant-based Adventists were shown to consume fewer dietary supplements than omnivores, specifically vitamin B12 and vitamin D; however, this did not correspond to increased COVID-19 risk. A systematic review and meta-analysis supported that vegan and vegetarian Adventists typically met recommended intakes for most nutrients that can influence immunity and thus COVID-19 susceptibility, though potential deficiencies in calcium, zinc and iron were noted. These findings led to the design and implementation of a targeted educational intervention among plant-based Adventists who were living in the UK. The

educational intervention identified significant gaps in general and COVID-19 specific nutrition knowledge among the recruited plant-based Adventists at baseline, which was effectively improved by the educational intervention, which showed a large effect size (Hedges' $g = -2.681$, $p < 0.001$). The 4-week follow-up questionnaire showed that 49% of participants had begun to use supplements after the intervention and 59% reported using more fortified foods, indicating that the intervention successfully led to behaviour change.

These findings suggest that the Adventist lifestyle, characterized by the widespread consumption of a plant-based diet, regular fasting, abstention from harmful substances such as alcohol and tobacco, maintenance of a healthy bodyweight, and the use of stress management practices such as Bible reading, prayer and singing and the strong social support structure may offer protection against COVID-19 infection. In conclusion, the studies described within this thesis have provided important answers for the association between COVID-19 incidence and Adventist dietary practices and may have implications for health promotion for Adventists living in the UK and worldwide.

Publications

Janko, R.K., Haussmann, I. and Patel, A. (2024). A Longitudinal Investigation of the Prevalence and Incidence of Self-Reported COVID-19 Disease and the Pandemic's Impact Among Seventh-day Adventist and Non-Adventists Living in the UK. Journal of Religion and Health. doi:https://doi.org/10.1007/s10943-024-02129-x.

Janko, R.K., Haussmann, I. and Patel, A. (2024). Vitamin B12 Status in Vegan and Vegetarian Seventh-Day Adventists: A Systematic Review and Meta-Analysis of Serum Levels and Dietary Intake. American Journal of Health Promotion. doi:https://doi.org/10.1177/08901171241273330.

Janko, R.K., Haussmann, I. and Patel, A. (2025) 'The effect of a lecture-based educational intervention to improve the nutrition knowledge and behavior of plant-based Seventh-Day Adventists living in the United Kingdom', Health Science Reports, (Article ID: HSR270440). doi:https://doi.org/10.1002/hsr2.70440

Janko, R.K., Haussmann, I. and Patel, A. (2025). The prevalence of infectious diseases among Seventh-day Adventists: A systematic review. American Journal of Lifestyle Medicine. doi:https://doi.org/10.1177/15598276251370238.

Table of Contents

List of Tables

List of Figures

List of Appendices

1 Chapter 1. Introduction

1.1 THE INFLUENCE OF RELIGION ON HEALTH: A HISTORIC OVERVIEW

The Handbook of Religion and Health defines religion as a set of beliefs and practices which aim to help one get closer to the transcendent and to get a better understanding of the responsibilities required to live together in a community (Koenig, 2012). Historically, religion has been very closely related to human health. Religious beliefs frequently serve as influences that shape nearly every area of a believer's life such as their ultimate life purpose, dietary choices, the clothing they wear, daily routines, career paths, marital choices and practices, and the way children are raised (Barmania and Reiss, 2018). It is therefore not a surprise that religion has been closely interconnected with health.

Religious leaders throughout history have often been the source of health advice, and the first hospitals in the western world were established by religiously motivated Christian organisations (Koenig, 2012). Most religions have specific teachings and instructions about how followers should live, which includes dietary guidelines and hygiene practices. In ancient Egypt, health was often believed to be influenced by supernatural forces, requiring prayers, incantations, as well as practical treatments. The earliest known religious document that addresses health and survives to this day is the Ebers Papyrus, which is an ancient Egyptian medical text dating to around 1550 BC (Tikkanen, 2018). The text contains various remedies for ailments, such as crocodile bites, many of which invoke deities or incorporate spiritual rituals showing how interconnected religion and health was for the ancient Egyptians.

In the ancient Mesopotamian culture, religious leaders had a central role in the diagnosis and treatment of diseases, which were often believed to be manifestations of divine displeasure or demonic possession. This civilization's ancient text, which is still extant today, is called The Diagnostic Handbook (Stol, 1993) dating to 1060 BC, which contains an extensive list of disease symptoms, advanced systems for diagnosis and potential treatment recommendations including rituals, prayers, and practical remedies.

Hinduism's system of medicine is called Ayurveda, which has its roots in the Vedic scriptures, and has an emphasis on the balance between the body, mind, and spirit (Wujastyk, 2003). Hindu healers, also referred to as vaidya, were not only physicians but also spiritual guides, showing the deep interconnection between religion and health in Hinduism.

Traditional Chinese Medicine (TCM), influenced by Confucianism, Taoism, and Buddhism, incorporates acupuncture, qi flow, herbal medicine, dietary therapy, and herbal medicine with the aim of balancing the body's vital force, known as "qi" (Matos et al., 2021).

Islam is another one of the world's major religions that has certain teachings centred around health. Although the Islamic holy book, called the Koran, does not have a great deal of health-related information, it has some dietary restrictions, which will be discussed in more detail in the next section, however the Islamic and the Arab world played a key role in the shaping of modern medicine and pharmacy (Pan et al., 2014). According to Pan et al. (2014) Arab herbal medicine built upon Hippocratic-Greek medical knowledge and expanded on it such that European pharmacopoeia relied heavily on Muslim writings until the late 19th century. Islam's last prophet is recorded to have spoken on topics relating to hygiene, moderation, diet, and even human anatomy. Based on the example of the prophet of Islam, Muslims are encouraged to practise qailulah, which is the Islamic term for midday napping as a religious practice which is believed to have positive health effects (Tumiran et al., 2018).

The New Testament, which forms the basis of the Christian religion contains the following admonition in the third letter of John:

“Beloved, I pray that you may prosper in all things and be in health, just as your soul prospers.”. This shows that being in good health for the apostle was as much desirable as spiritual wellbeing since the verse creates a parallel between physical health and spiritual well-being and suggests that true prosperity is not just spiritual, but it includes being healthy. Ferngren (2009) suggests that illness was allowed to be viewed in early Christianity as both resulting from natural as well as from supernatural causes such as demonic possessions. The greatest testament to the importance of health within Christianity is the healing ministry of Christ as discussed in the Gospels (Reno, 2019). The Biblical stories from the New Testament about the life of Jesus highlight the Christian perspective that health cannot be separated from spiritual wellbeing (Reno, 2019). Related to this is the sacred calling to caregiving (Matthew 25:36) which is based upon Christ’s compassion and love. This emphasis on the importance of community care has served as a foundational principle in the early church for the congregation-centred systematic approach to caring for the sick (Ferngren, 2009). The legalisation of Christianity within the Roman Empire after A.D. 313 led to the establishment of hospitals, which made them a uniquely Christian organisation (Ferngren, 2009). In the ancient world, no such institutions existed before Christianity that fulfilled the role of caring for the sick in the same way as the Christian hospitals did by the end of the fourth century A.D. The first hospital was founded in A.D. 372 by Basil the Great, a bishop in Turkey, offering both medical care and spiritual support which reflects the holistic approach to health within Christianity. His institution was made up of a number of separate buildings and became known as the New Town due to its size (Esolen, 2022). Soon after, in A.D. 390, Fabiola, who was a wealthy convert to Christianity, established a hospital in Rome and dedicated her life to charitable work among the city’s poor and sick as documented by St. Jerome (Porter, 1999). It is estimated that by the 13th century, there were more than 20 Byzantine hospitals, which had physicians on-site working in them (Horden, 2006). Furthermore, during the Middle Ages, religious orders were established such as the Knights Hospitallers of Saint John who had the special mission of caring for the sick (Esolen, 2022). Later, these hospitals established during the Middle Ages in Europe served as models, which were exported by Christian missionaries to other parts of the world from the sixteenth century (Riva and Cesana, 2013).

Given the profound influence religion has historically had on health, dietary practices stand out as a particularly impactful area of lifestyle, which can influence health, therefore the following section explores how dietary rules and guidance across major world religions reflects this tight connection.

1.2 DIET AND WORLD RELIGIONS

The evidence is clear that religion and health have been closely related throughout human history. Many of these religions have a strong emphasis on diet and have various prescriptions for their followers to adhere to. All five of the world's major religions, which are Buddhism, Hinduism, Islam, Judaism, and Christianity, have teachings related to diet and health. For instance, vegetarianism is one of the most prominent features of Hindu dietary practices, especially within its sister community Jainism (Melton, 2011). According to the principle of ahimsa, killing animals for food is discouraged as it involves harm to living beings (Lodrick, 1981). Furthermore, vegetarianism is also closely linked to the concept of sattva, which is one of the qualities or modes of nature that influence all human behaviour, including health as described in Hindu philosophy. A sattvic diet includes the consumption of fresh fruits, vegetables, nuts, grains, and dairy, and is thought to promote mental clarity and physical well-being among other things (Chapple, 1993). On the other hand, foods categorized as rajas are believed to be stimulating, and this includes spicy or excessively salty foods, whilst tamasic foods are thought to be "heavy" and are often avoided. Another aspect of the Hindu religion, which is related to diet, is fasting. Fasting is often observed as an act of devotion and a means of purification. Fasts are associated with deities and festivals and are seen as opportunities for self-discipline and spiritual reflection (Melton, 2011). Fasting is also a fundamental tenant in the religion of Islam as it constitutes one of the so-called Five Pillars of the faith (Melton, 2011). Ramadan is a month based on the Islamic calendar, during which healthy Muslims are required to fast between sunrise and sunset and are only permitted to eat food and drink fluids between sunset and sunrise (Jahrami et al., 2020). Halal is a religious term in Islam, and it refers to what is permissible according to Islamic law (Samori et al., 2014). Although the concept of halal extends beyond food and beverages, it is most commonly associated with dietary regulations. In the context of foods and beverages, substances deemed harmful or impure (haram), such as alcohol or pork are prohibited to be consumed. This prohibition on pork consumption is also present in pre-Islamic religions such as Judaism and even in ancient Egypt, where pig was believed to be an abomination to the gods (Pritchard, 1969). Furthermore, vegetarianism and fasting are also commonly practiced in Buddhism (Waibel, 2019). While dietary practices are integral to many religions globally as shown so far, Biblical religions like Judaism and Christianity are the closest in connection to Seventh-day Adventism, therefore understanding the dietary practices and principles of Judaism and various Christian denominations is essential for contextualizing the dietary practices of Adventists.

1.3 DIETARY PRACTICES IN BIBLICAL RELIGIONS

Judaism has a comparable concept to halal in Islam, known as kosher, which refers to foods fit for consumption according to Biblical dietary laws, which are outlined in the Biblical books of Leviticus and Deuteronomy (Waibel, 2019). On the other hand, there are significant differences between the dietary laws in Judaism and Islam. In Islam, the dietary laws focus primarily on the prohibition of pork and the requirement of halal slaughter for other animals, whilst Judaism provides a more detailed categorization of animals, dividing them into "clean" and "unclean" categories. For land animals to be considered kosher, they must have cloven hooves and chew their cud according to the book of Leviticus; therefore, pigs are prohibited because, although they have cloven hooves, they do not chew their cud. Similarly, animals that live in water must have fins and scales to be deemed kosher, making shellfish and other seafood like shrimp and lobster unclean and, therefore, unfit for consumption. Some modern-day religious leaders within Judaism believe that the prohibition of animals in the book of Leviticus stem from a realisation that the consumption of the flesh of these animals has the potential to transmit diseases, however, others argue that the concept of Kosher foods was solely based on religious principles concerning pollution and purification (Porter, 1999). It is also worth noting that the dietary laws concerning clean and unclean animals contained in the book of Leviticus are unique in ancient literature (Moskala, 2011). Whether intentional or not, some of the cleanliness rituals of Judaism indirectly promoted public health. These include the mandate that wells were not to be dug near burial or waste sites, or that water should be boiled before consumption, and waste must be burned or buried outside of the camp (Porter, 1999).

Another key distinction is that alcohol is allowed to be consumed in Judaism, whilst it’s forbidden in Islam (Waibel, 2019).

Christianity does not have as many dietary restrictions, in general, as Judaism, however, this may vary between denominations (Chouraqui et al., 2021). The Catholic and Orthodox Churches share some common traditions of dietary practices including fasting, but these are mainly driven by religious custom rather than health reasons. Both traditions observe fast days and restrict certain meats on holy days. In Catholicism, Fridays are traditionally meat-free days, especially during Lent, which is a 40-day period of penitential preparation leading up to Easter. Additionally, Catholics observe Ash Wednesday and Good Friday as days of fasting and abstinence. Similarly, the Orthodox Church emphasizes fasting periods, such as Great Lent, the Nativity Fast, and the Dormition Fast, where restrictions extend beyond meat to include dairy, eggs, and even oil and wine. These practices are deeply rooted in the religious beliefs about self-denial, reflection, and preparation, rather than being motivated by potential health benefits (Waibel et al., 2019). On the other hand, Protestant Christianity in general, does not have a similar emphasis on fasting or abstinence from foods as do Catholicism and Orthodoxy (Waibel et al., 2019). Mormons discourage the consumption of alcohol and routinely practise fasting, while Jehovah's Witnesses forbid the consumption of blood, however none of the denominations have a more comprehensive approach to diet and lifestyle than the Seventh-day Adventists, also referred to as Adventists (Chouraqui et al., 2021). While Judaism has a comprehensive set of dietary practices rooted in the Bible, this is mostly absent in Christianity, however Adventism has uniquely adapted and expanded these Biblical health principles. Therefore, the following section explores the distinctive dietary practices of Adventists and highlights the specific differences that make them unique, especially among the Biblical religions.

1.4 THE ADVENTIST LIFESTYLE AND DIETARY PRACTICES

Seventh-day Adventists are Protestant Christians who are known for their observance of a weekly Sabbath day of rest and emphasis on the Second Coming of Jesus Christ. The church was established in the 1800s in the United States and has now a total worldwide membership of around 20 million individuals. Church membership in the United Kingdom (UK) has been reported to be just over 34,000 (Adventist.uk, 2024). The health effects of the Adventist lifestyle will be introduced in greater detail in chapters 2 and 3 of this thesis, but briefly, Adventists are encouraged to eat a diet which is low in animal products, and is rich in fruits, vegetables, wholegrains, pulses, nuts and seeds, which is in strong agreement with international dietary guidelines such as those published by the World Health Organization (2020). The Adventist diet is guided by biblical principles and the writings of Ellen White, who was one of the founders of the church. The church advocates for a plant-based diet, which reflects a belief in the Biblical teaching that the body is a temple of the Holy Spirit and should be cared for accordingly. Biblical texts which suggest that our "…bodies are temples of the Holy Spirit. Therefore, honour God with your bodies." are central to the Adventist understanding of a healthy lifestyle. Ellen G. White claimed to have received divine revelations and wrote extensively on topics relating to theology, history, health and nutrition. Her writings further elaborate on the Bible and her book "The Ministry of Healing" published in 1905 appeals to Adventists to "return" to a plant-based diet. The reason given in the book for this dietary approach is that the diet, which was the original diet given to humanity by God after creation, was a plant-exclusive diet in the biblical story. Therefore, it is generally believed by Adventists that a diet which excludes animal products is the healthiest way to eat because humans were designed to eat such a diet.

However, the writings of Ellen G. White provide a second reason for the avoidance of meat consumption, which is that "disease in animals is so rapidly increasing" (White, 1905). This assertion directly connects with the central theme of this thesis, because it suggests that diet in Adventism is not only believed to impact chronic disease risk, but it may also influence infectious disease risk, which is not a commonly held perspective in science.

It is, therefore, not a surprise that studies have shown that the diet of Adventists usually contains high amounts of vegetables, and fruits as well as nuts, and whole grains, and low amounts of fats and processed foods (Segovia-Siapco and Sabaté, 2018). The denomination's health principles also encourage that foods are consumed in their most natural and minimally processed form, which may be one of the reasons the Adventist lifestyle has been shown in scientific studies to have several health benefits, which will be discussed in more detail in the next chapter.

In addition to their vegetarian diet, Adventists are encouraged to avoid stimulants, including caffeine, and to completely abstain from alcohol and tobacco. The church's health message promotes moderation and self-control in all areas of life, which includes avoiding foods that are overly processed, high in fat and added sugars.

Fasting is another practice that is encouraged by the church, similar to other religions, however Adventist fasting practices are closely linked to improving health, whereas fasts in other religions are more often motivated by religious or spiritual reasons.

The Adventist focus on a mostly plant-based diet, nutrient-dense foods, and lifestyle habits underscores their holistic approach to health. Similar to Jewish kosher laws, Adventists avoid consuming the so-called “unclean” meats such as pork and shellfish, based on the scriptural instructions. While most Christian denominations do not adhere to specific dietary restrictions, since they hold the view that the Old Testament dietary laws were intended only for ancient Israel, Seventh-day Adventists believe that the distinction between clean and unclean meats predates the time of Moses, dating back to the time of Noah. This is the position held by the Adventist Theological Seminary, who suggest that the dietary laws contained in the book of Leviticus should be interpreted in the earlier context of the book of Genesis, where God is recorded to have informed Noah of what animals were clean and unclean, although an actual list of animals, similar to that contained in the book of Leviticus is not mentioned (Moskala, 2011). Moskala (2011) further clarifies that Adventists do not believe that keeping the dietary laws found in Leviticus earns one’s salvation, rather, they reflect what is suitable and beneficial for human consumption and health since they were directly given by God. Therefore, Adventists interpret these dietary guidelines as timeless principles intended to promote health and well-being, rather than arbitrary law or mandates. Ellen G. White's book, called The Ministry of Healing (1905), further reinforces and develops this concept and argues that abstaining from animal products promotes better health and reduces the risk of diseases.

It is important to mention that the Adventist lifestyle extends beyond diet. Adventists adhere to 8 health "laws", which they believe are vital for good health. These health principles include a healthy diet, the observance of the Sabbath as a day of rest, the importance of clean air, physical exercise, the healing properties of sunlight and the consumption of water as one's main fluid source, and the importance of faith in God and temperance in all things (Kaiser, 2019).

This unique combination of dietary and non-dietary lifestyle components practised widely by Adventists, sets them apart from other Christian and non-Christian religious practices, which provides a valuable framework to explore the broader relationship between religious practices and health outcomes, especially in the context of infectious diseases.

The Adventist dietary and lifestyle practices are not just about personal health but serve as a means of helping the broader community and are considered as a tool for evangelism. The church has always been involved in health promotion efforts, which is evident by the fact that it has established numerous hospitals, clinics, and educational institutions worldwide for the purpose of disease prevention and treatment. All these places, as well as the actual church buildings, are utilised for health promotion, which is defined as the act of enabling individuals to improve their health, with one of its four core tenets being lifestyle (Phillips, 2019).

Adventists researchers and participants have contributed in a significant way to research on plant-based diets, with the Adventist Health Studies serving as the best examples. These studies will be described in more detail in the next chapter, but they are comprehensive investigations into the health effects of vegetarian and vegan diets and have reported lower rates of chronic diseases present among the Adventist cohorts which can be attributed to Adventists' dietary habits and overall lifestyle (Orlich and Fraser, 2014). In addition, a major advantage to studying the influence of diet on the risk of diseases is that the lifestyle of Adventists is fairly similar regardless of whether they consume some animal products or not, which greatly reduces confounding factors that can directly influence health such as smoking, consuming alcohol or having a higher BMI (Fraser, 1999). Furthermore, the Adventist church is a global community of believers, which means that there is great variance between members in socioeconomic status as well as in other social and environmental factors such as access to healthcare, place of birth, the type of job they do and how they live their lives, which are known as the social determinants of health (WHO, 2019). These social determinants of health do not directly have an impact on our biology and health but can have indirect effects. Despite these differences in social and environmental factors that can influence health, Adventists share a common lifestyle, which is centred around health-promoting behaviours, including dietary practices, which makes them an ideal population to study in the context of health research.

In summary, Adventist dietary practices are somewhat similar to the dietary practices of Muslims in that they do not consume alcohol and pork, however Adventists are encouraged to be vegetarians, and are discouraged to consume coffee. Additionally, Adventists keep a regular day of rest on Saturdays, which are not a lifestyle practice within Islam. Furthermore, Adventists share the concept of the Sabbath day of rest and clean and unclean meats with Judaism, however Adventism has a strong emphasis on vegetarian diets and discourages the consumption of alcohol, unlike Judaism. Since most of the other Christian denominations do not have these extensive dietary and lifestyle restrictions, the lifestyle of Adventists is not only unique among the Abrahamic religions, but also within Christianity, which provides a key foundation for investigating the dietary and lifestyle practices of Adventists in relation to COVID-19 disease.

Before focusing on the connection between COVID-19 disease and the Adventist lifestyle, the next section provides essential background information on how religion in a broader context has been shown to impact health outcomes and public health activities in the context of both chronic and infectious diseases.

1.5 THE IMPACT OF RELIGION ON HEALTH

Ichiro Kawachi (2019) suggests that the way religion influences health is multifaceted, yet it is a significant social determinant of health. There is evidence to suggest that being religious, regularly praying, and attending regular church services, is associated with various health benefits, such as improved mental well-being, reduced stress, and other more favourable health outcomes. For instance, Ironson et al. (2006) showed that being religious after a HIV diagnosis was associated with a significantly slower disease progression rate over 4 years of follow up, which persisted even after statistical adjustment for important covariates. A meta-analysis of 29 intervention studies showed that interventions which incorporated religious practices were generally effective in the treatment of depression and anxiety in young people (Aggarwal et al., 2023). In fact, a meta-analysis of 42 study samples, involving almost 130,000 participants showed that people who were involved with religious activities were 29% more likely to survive to follow-up, and this result was statistically significant (OR=1.29; 95%, CI 1.20–1.39), suggesting a significant mortality benefit to being religiously involved (McCullough et al., 2000). These findings agree with the results published by Ahrenfeldt et al. (2023) who showed among almost 3000 Danish adults that religious attendance was associated with a significantly lower mortality over a 3-year period (HR 0.70;

95% CI 0.50–0.99). However, the mechanisms that explain the mortality benefit of religious practice are less clear, therefore this relationship was investigated by Kim and VanderWeele (2018), who showed that attending religious services has positive effects on psychological well-being, social connections, and health behaviours, thereby improving life satisfaction, which has been shown as a significant mediator to the observed reduced mortality risk. Moreover, the authors showed that religious service attendance reduced hopelessness and anger, which were found to be major mediating factors as well. In addition, mediation effects were identified through contact with friends, which relates to the social support and community engagement that religious services provide, but exercise and reduced alcohol intake were also significant mediators to the lower mortality risk. Although, it's worth mentioning that the study relied on self-reported data on religious practices, which may have introduced bias relating to measurement error and overreporting. The association between the positive impact of religion on life satisfaction has been confirmed by other studies such as Chen and VanderWeele (2018) who showed that involvement in religious practices such as prayer and religious worship attendance from childhood were associated with greater life satisfaction. Religious upbringing also influenced other lifestyle factors and resulted in a lower likelihood of drug use, fewer sexual partners, and a higher age at first sexual encounter. On the other hand, questions remain regarding the generalizability and applicability of the positive effects of religion to non-religious people (Kawachi, 2019). This is an area, where researching the Adventist lifestyle could prove to be especially useful as it contains lifestyle practices that can be practised in a non-religious context.

Hemmati et al. (2018) investigated the relationship between religion and spirituality and coronary heart disease (CHD) risk. The study showed that higher religious service attendance was linked to progressively lower CHD risk, with odds ratios of 0.77 (CI 95% 0.65-0.91) and 0.27 (CI 95% 0.11-0.65) for once a month and five times a month attendance respectively compared to non-attendance. The study also showed that, overall, religion and spirituality were associated with a significantly lower CHD risk. Furthermore, being religious was significantly associated with improvements in physical health following a cancer diagnosis as reported by a meta-analysis published by Jim et al. in 2015. The mechanisms for these potential benefits often include better social connections and psychological resilience, however it may be that religion actually exerts a direct physiological effect. Shattuck and Muehlenbein (2018) explored this potential mechanism by conducting a systematic review which examined the relationship between religiosity/spirituality (R/S) and physiological health markers. The results showed a significant association between R/S and improved health markers such as blood pressure and c-reactive protein (CRP), which the authors attributed to religion's potential anti-stress effects. As mentioned previously, fasting is commonly practised across a number of religions, and it's worth noting that religious fasting has been shown to be associated with positive effects on BMI, blood pressure, and total cholesterol (Negin et al., 2024). For instance, Trepanowski and Bloomer (2010) showed that religious fasts practiced by Greek Orthodox Christians are associated with improved body weight and blood lipids. Similar results have been shown for Ramadan fasting. Jahrami et al. (2020) conducted a systematic review on the effects of Ramadan fasting on body weight and showed that based on the pooled results of 85 studies, Ramadan fasting was associated with a small but statistically significant body weight lowering effect. The three primary types of fasting that have been most frequently researched are caloric restriction (CR), alternate day fasting (ADF), and dietary restriction (DR) with religious fasts usually falling into one of these three categories (Trepanowski and Bloomer, 2010). It is believed that the beneficial effects of fasting are exerted by reducing caloric intake, which has been associated with a number of health benefits such as a lower risk of autoimmune disorders, arterial and heart diseases, malignancies, metabolic disorders, kidney disease, and many chronic conditions

(Trepanowski and Bloomer, 2010). In addition, fasting is one of the lifestyle factors that is generalizable to non-religious groups, and several studies have investigated the health effects of non-religious fasts (Venegas-Borsellino et al., 2018). Tinsley and La Bounty (2015) showed that alternate day fasting in a non-religious context produces the same benefits on body weight and cholesterol levels as in the religious context.

Jussawalla et al. (1985) examined the cancer incidence rate among Indian Christians living in Greater Bombay and compared it to non-Christian controls. The only significant difference in a site-specific cancer incidence rate among male Christians and non-Christians was a lower incidence of cancer of the hypopharynx among Christians. Regarding females, Christians had a significantly lower cervical and oesophageal cancer risk as compared with non-Christians. The rest of the cancer types did not show any significant results; however, a major limitation of this study was that it did not provide any information about the denominational affiliation of the recruited Christians as there can be great variations in lifestyle practices and religious practices among Christian denominations, which may influence cancer risk. More recently in 2008, Hoff et al. published a review on epidemiological studies investigating cancer risk in religious cohorts. The authors identified 17 observational studies on the topic, most of which were case-control or cross-sectional in design. Most included studies focused on Mormons and Seventh-day Adventists, but some of the studies recruited other types of Protestants and even Catholics. Most studies showed a protective effect of religion against cancer and the authors concluded that association is best explained by the lifestyle hypothesis, which states that being religious influences people’s lifestyles, which may lower the risk of cancer, but being religious on its own is not sufficient. This becomes especially relevant as it pertains to the Seventh-day Adventist Church as it has a comprehensive set of lifestyle behaviours, which are unique to this group. However, since the central theme of this thesis is the influence of the Adventist dietary practices on COVID-19 outcomes, it is first essential to establish what COVID-19 disease is.

1.6 THE EPIDEMIOLOGY OF COVID-19 DISEASE

COVID-19 infection is caused by the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), with the first case being identified in December 2019 in Wuhan, China (Umakanthan, 2020). A wide array of symptoms were associated with the infection ranging from asymptomatic cases to severe pneumonia and death. Patients often developed acute respiratory distress syndrome (ARDS) within 48 hours following hospital admission, which in many cases resulted in the need for ventilatory support.

The virus primarily spread through respiratory droplets, aerosols, and via contact with contaminated surfaces and was believed to have originated from a zoonotic source, although its origin has been extensively debated in the scientific literature with a second hypothesis suggesting that the naturally occurring virus was spread to humans from a laboratory source (Alwine et al., 2023). Nevertheless, the zoonotic nature of this species of virus allows it to pass between species and spread from animals to humans. The virus can gain cellular entry by binding to the the angiotensin-converting enzyme 2 (ACE2) receptor on the host cells, which then allows for viral replication within the host cells (Keni et al., 2020).

The WHO declared the COVID-19 outbreak a global pandemic in March of 2020 with the first clinical symptoms described as fever, cough, and shortness of breath (WHO, 2020). By May of 2020, over 3.5 million cases had been identified globally (Umakanthan, 2020). The estimated mortality rate of COVID-19 was estimated to be around 2% in 2020 (Keni et al. 2020). One of gold standard methods of COVID-19 detection has been the Reverse-Transcriptase polymerase chain reaction (RT-qPCR) test, which is able to detect viral DNA from human blood, saliva, urine, faecal and sputum samples (Dutta et al., 2022). However, RT-PCR testing has some limitations such as the 4-to-6-hour requirement for completion as well as its cost, other diagnostic tests for COVID-19 were developed. These methods are enzyme-linked immunosorbent assays (ELISA), and rapid antigen and antibody tests using lateral flow chromatographic immunoassay, which are cheaper and faster diagnostic techniques than RT-PCR, albeit less sensitive and specific.

Several important risk factors have been identified that can increase the risk and severity of COVID-19 infection such as a history of diabetes, cardiovascular disease and cancer (Farshbafnadi et al., 2021). Connected to these chronic diseases is obesity, which has been shown to increase the risk of all three conditions as well as the risk of COVID-19 disease (Albashir, 2020). It is suggested that the mechanism of obesity increases the risk of COVID-19 disease and severity by leading to chronic, low-grade inflammation, which leads to the elevation of pro-inflammatory cytokines (Albashir, 2020). This is exacerbated by the further overproduction of pro-inflammatory cytokines in a process known as the cytokine storm. This results in lung damage and pneumonia, thereby intensifying disease severity (Montazersaheb et al., 2022). Despite its potential complications, around 80% of infected patients have been shown to be asymptomatic carriers (Keni et al., 2020), which made it difficult to identify all patients with a potential to transmit the virus, especially in countries where testing was not readily available. Additionally, age has also been a significant determinant of COVID-19 disease as infection rates were highest among adults over the age of 60 years (Keni et al., 2020).

The infection has also been associated with longer term symptoms called long-COVID, which is believed to affect up to 63% of individuals with a history of SARS-CoV-2 infection, usually arising three months after the onset of initial symptoms, with a duration of at least 2 months (Lippi et al., 2023).

The public health interventions in the early phase of the pandemic focused on limiting international travel and introduced social distancing guidelines in an attempt to reduce the transmission rate of the virus (Tabari et al., 2020). Additionally, social gatherings were limited or entirely banned in many countries and patients with COVID-19 symptoms and those returning from international travel were required to self-isolate. Institutions such as churches and schools were closed in most countries, and access to hospitals and elderly homes were restricted.

Over time, the virus spread to various geographic areas and as it mutated, several variants arose with varying levels of infectivity and resistance to medical treatment, among which the Delta and Omicron variants became the most widely recognized (Bostanghadiri et al., 2023). By early 2021, several vaccines had been developed and received emergency authorisation against COVID-19, with the vaccines developed by Pfizer-BioNTech, Moderna and AstraZeneca gaining the most public and media attention (Sibanda and Haryanto, 2024).

Since the risk and severity of COVID-19 infection is associated with lifestyle preventable diseases such as obesity and type 2 diabetes, investigating the impact of the Adventist diet and lifestyle on COVID-19 outcomes may provide insights into COVID-19 prevention and treatment strategies.

1.7 THESIS OUTLINE

This chapter has presented an overview of the research context regarding health and religion. Chapter 2 contains two literature reviews. The first is a systematic literature search of COVID-19 outcomes among religious groups in Europe and the UK, while the second discusses the health impacts of the Adventist lifestyle. Important gaps in the literature were identified during these literature reviews such as the overwhelming emphasis of Adventist studies focusing on chronic diseases and an absence of studies published about Adventists living in the UK. Furthermore, Chapter 2 highlights the importance of investigating the nutrient intake of plant-based Adventists, given the potential nutrient deficiencies associated with vegan and vegetarian diets. The gaps identified during this literature review justify the overarching aim of this thesis, which was to investigate the Adventist diet's influence on COVID-19 outcomes, particularly in the UK context.

Chapter 3 presents the results of a systematic literature review, which specifically focused on the risk of COVID-19 and other infectious diseases in Adventist cohorts as compared with non-Adventists. It directly relates to the first objective of this thesis as it synthesised the results of studies that investigated infectious disease risk among Adventist and non-Adventist groups, and it also addresses the third thesis objective since it identified trends in lifestyle factors such as dietary practices that may influence the risk of infectious diseases. Additionally, this chapter further justifies the overarching aim of the thesis as no published studies were identified from the UK following the comprehensive systematic literature review, which provides a foundation for subsequent chapters, which assessed the diet and lifestyle of UK Adventists and compared their risk of COVID-19, the most prevalent infectious disease at the time, to non-Adventists in.

Chapter 4 is a longitudinal study with a 2-year follow-up, and it assessed the diet and lifestyle of Adventists living in the UK and compared the self-reported COVID-19 infection incidence rate to non-Adventists. This quantitative study has been published in the Journal of Religion and Health (Janko et al. 2024) and it directly relates to the thesis' main aim of investigating the impact of the dietary practices of Adventists on their COVID-19 risk as well as to the second and third objectives. Furthermore, the study raised important questions concerning the knowledge of Adventists regarding nutrient intake and dietary supplement use in the context of plant-based diets and beliefs and motivations behind COVID-19 vaccination rates since both of these factors can influence the risk of infectious diseases including COVID-19.

Based on these findings, Chapter 5 includes a systematic literature review of the essential nutrient intake of plant-based Adventists with the purpose of identifying whether they are at an increased risk of any type of nutritional deficiency. The results of this study concerning vitamin B12 intake and status were meta-analysed and were subsequently published in the Journal of American Health Promotion. By comparing the nutrient status and intake of plant-based Adventists to omnivorous controls, the study evaluates potential nutritional vulnerabilities that may influence infectious disease risk, connecting back to the thesis's broader aim.

Moreover, Chapter 6 describes an educational intervention study, which was undertaken to assess the nutritional and supplement knowledge of vegan and vegetarian Adventists living in the UK both in relation to general and COVID-19 specific knowledge. The study also evaluated the effectiveness of an online educational intervention designed for improving dietary knowledge and behaviours, with insightful implications for church-based health promotion strategies concerning infectious disease prevention.

Chapter 7 integrates findings from all studies to provide a comprehensive answer to the overarching aim, which was to understand the relationship between the dietary practices of Adventists in the context of their lifestyle and the risk of COVID-19 infection. The chapter concludes with a discussion of the broader implications for church-based health promotion, and future research, with a particular focus on improving the nutritional status and health outcomes of UK Adventists.

1.8 THEORETICAL FRAMEWORK

This thesis utilised the Health Belief Model of behaviour change (HBM) as its theoretical framework as it was deemed to be particularly relevant for the Adventist population. The model was developed by the Public Health Service of the United States over 70 years ago and it relies on following six theoretical constructs to explain behaviour change: perceptions of susceptibility, severity, and advantages of an intervention as well as the perceived barriers, motivational signals and self-efficacy (Alyafei and Easton-Carr, 2024). The model's effectiveness to predict behaviours has been shown by a meta-analysis of 18 studies (Carpenter, 2010). In fact, an earlier meta-analysis by Harrison et al. (1992) showed that 22 out of the 24 effect sizes derived from 16 different studies were statistically significantly positive, which shows that the model could be used to facilitate informed decision-making, although the authors also highlighted the limitations of the model's power to predict behaviour change since analysing its constructs individually showed that each construct only explained less than 10% of the variance in behaviour.

Nevertheless, the HBM's focus on individual perceptions of health risks and benefits aligns closely with the Adventist emphasis on health and dietary practices as a religious duty. The dietary and lifestyle practices of Adventists such as abstinence from smoking and alcohol as well as from certain meat products and the promotion of plant-based diets may be explained by HBM's concept of perceived severity, which would posit that Adventists avoid certain foods and lifestyle practices because they are believed to harmful and cause disease. In addition, the keeping of the Sabbath, consuming a vegan diet and other lifestyle aspects of Adventism require self-efficacy, which is another key dimension of the HBM.

Also, the perception of the protective effects of plant-based dietary practices might also serve as a potential barrier in adopting additional preventive behaviours, such as the use of dietary supplements or vaccinations, which makes the HBM a particularly useful tool for understanding Adventists' attitudes towards these practices.

On the other hand, the HBM has been criticised mostly for its lack of consideration of social and emotional factors that may influence behaviour change (Janz and Becker, 1984), which are particularly relevant when investigating Adventists since they are known for their strong social support structure (Kent et al., 2015), which can certainly impact behaviour change. Furthermore, the HBM assumes that everyone makes rational decisions about their health by carefully weighing the benefits and risks of certain behaviours, however decisions in the real-world setting can be more complex since rational decisions are often superseded by psychological or social factors (Alyafei and Easton-Carr, 2024).

In addition, Michie et al. (2011) highlighted that despite the widespread use of the HBM, it does not address some important variables that can influence behaviour change such as impulsivity, self-discipline, associate learning and emotional management. The authors emphasized that interventions should be tailored to the specific behaviour targeted for change, which in the case of the intervention study described in Chapter 6 of this thesis, was dietary supplement use. The HBM was thought to be an appropriate model in this context, since it was hypothesised that the reason some plant-based Adventists avoided supplement use was due to a low perception of risk for nutrient deficiencies and an overestimated perception of the adequacy of exclusively plant-based diets.

Furthermore, the HBM was used in a study published by Abood et al. (2003), which utilised a nutritional educational intervention among university staff to encourage healthy behaviours that are associated with reduced cardiovascular and cancer risk. The results showed that the intervention improved participants’ perceptions and knowledge about what contributes a healthy diet, however the study has received criticism about the fact that the intervention only focused on perceived benefits and barriers because of the HBM as the theoretical framework and neglected important factors such as susceptibility to the investigated diseases as well as their severity (Timlin et al., 2020). However, this systematic review by Timlin et al. (2020), which investigated dietary interventions that used a theoretical model of behaviour change, mentioned that two of the included studies utilized the HBM, both of which reported positive findings, although the health action process approach (HAPA) model was more often used (n=3). The HAPA and HBM frameworks are similar, in that they both emphasise risk perception and self-efficacy, but the HAPA model places a greater emphasis on the maintenance of behaviour change, whereas the HBM mostly focuses on providing an explanation on why people tend to make behavioural changes. The HAPA model incorporates action planning, self-monitoring and coping planning, which are especially useful to support more extensive behaviour changes such as starting a new diet (Schwarzer, 1992).

However, this thesis did not include any intervention study, which required extensive behaviour change impacting a person's entire lifestyle or diet. The educational intervention study described in Chapter 6 only aimed to influence participants' perceptions and behaviour towards dietary supplements and fortified foods, but it did not involve participants changing their entire diet. In this context, the HBM has been shown to be effective. A study published by Parwati et al. (2021) tested the efficacy of an intervention designed for improving medication adherence among patients diagnosed with tuberculosis and showed that the intervention, which was based upon the Health Belief Model, greatly improved medication adherence. The authors of the study attributed the success of the intervention to the HBM's focus on overcoming potential barriers to medication adherence.

Therefore, the use of the HBM as the theoretical framework was deemed appropriate for this thesis since it can help explain why individuals, in this case Adventists living in the UK, decide to adopt a healthier diet and lifestyle, and how the COVID-19 pandemic and its perception impacted Adventists' risk of COVID-19 and willingness to be vaccinated. Given that the thesis included only a single interventional study, while the rest of the chapters contained two systematic reviews and an observational study, the HBM was selected not because of its accuracy to predict behaviour change, but due to its explanatory power, which may help understand health related decision making by Adventists. It is hypothesized that Adventists' dietary and lifestyle choices are shaped by their beliefs and perceptions about health risks, making the HBM a suitable framework for understanding how these perceptions influence their decisions in the context of the COVID-19 pandemic.

1.9 RESEARCHER POSITIONALITY

An important aspect to be considered with regard to the validity of this research is the positionality of the researcher as it could be a source of bias, therefore I feel that it is important to clearly define my positionality to help with defining the motivations and boundaries of the research (Jafar, 2018). I think that my position as both an insider and an outsider in this work presents a unique perspective since I have been a Seventh-day Adventist for almost 15 years, however I am also a scientist and a nutrition professional. I have an in-depth knowledge of the beliefs, lifestyle practices and communal aspects of Adventism, which has allowed me to approach this research project with intimate knowledge. Following my conversion to Adventism at the age of 17, I had first-hand experience of the emphasis the Adventist church places on healthy lifestyle through the regular workshops and presentations

I was immediately exposed to, which focused on health-related topics, as well as through observing the lives and lifestyle practices of church members. This is where my interest in science, and more specifically human nutrition, was sparked and it motivated me to pursue an undergraduate degree in biomedical sciences, and subsequently a master's degree in clinical nutrition.

On the other hand, my academic background instilled in me a strong commitment towards scientific methodology and evidence-based medicine. This is evident by the methodological approaches I have applied and utilised in my research to mitigate any known sources of bias, including researcher bias.

In my professional life working as a Medical Information Lead within the pharmaceutical industry I have been involved with scientific communication, which has allowed me to further develop my critical thinking skills. I have utilised these skills on social media platforms to tackle nutrition related misinformation with over 30,000 followers. Therefore, I do not feel conflicted investigating Seventh-day Adventists as an insider since I am also a scientist and science communicator who always strives to remain objective.

In conclusion, the findings of my research have been anchored in robust scientific methodologies and contribute valuable insights into the dietary and lifestyle practices of Adventists living in the United Kingdom in the context of the COVID-19 pandemic.

1.10 CHAPTER SUMMARY

This chapter has established the close relationship between religion and health with a historical overview of the connection between health and religion. Additionally, it has also provided an introduction of the dietary and lifestyle practices of major world religions with the purpose of highlighting the distinctiveness of the Adventist lifestyle, particularly its comprehensive approach to diet. Furthermore, the chapter has outlined the theoretical framework which underpins this thesis.

Having established the historical relationship between religion and health in this chapter, the next chapter narrows the focus to examine the influence of religious affiliation on COVID-19 outcomes. Subsequently, the second part of Chapter 2 shifts the focus to the Adventist lifestyle and provides a comprehensive review of the existing literature on the Adventist lifestyle and its documented broader health effects, which will be an extension of Chapter 1, where the context was about the broader relationship between religion and health. All of this provides essential context for assessing the Adventist dietary and lifestyle practices and their potential relevance to COVID-19 in the latter chapters of this thesis.

2 Chapter 2. Literature review

2.1 Part 1. The influence of religion on COVID-19 outcomes

2.1.1 The risk of COVID-19 infection among religious groups: A systematic literature search

Having established the interrelationship between health and religion in Chapter 1, the first part of this chapter focuses on the broader influence of religious affiliation on COVID-19 related outcomes. Given that certain religious practices, as presented in Chapter 1, may influence the risk of infectious diseases in both positive and negative ways, this systematic literature search aimed to investigate the evidence concerning the association between religion and COVID-19 infection. This broader analysis of the literature provides context and helps to establish whether religious affiliation in a more general sense may influence COVID-19 susceptibility. Following the systematic literature review, the second part of this chapter narrows the focus to the evidence concerning the health effects of the Adventist diet and lifestyle, which lays the foundation for subsequent chapters, which explored the direct association between the Adventist diet and COVID-19 outcomes.

2.1.1.1 Methods of the systematic literature search

A systematic search of the published literature was conducted in PubMed, Google Scholar and Scopus in order to identify studies that have investigated the risk of COVID-19 infection among religious communities in the UK or Europe. This was done in order to analyse the association between religion and COVID-19 disease and to establish how religion may influence COVID-19 outcomes. Therefore, the aim of this review was to investigate the influence of religion on COVID-19 risk and other outcomes such as symptom severity and mortality, and to identify gaps in the literature with regard to COVID-19 outcomes among Adventists in the UK context.

Initially, the scope of the review was limited to the UK, however due to the low number of expected studies following a scope of the literature, the search was extended to studies conducted in European countries due to the UK's geographic proximity and similar religious demographic and economic status as many European countries. In fact, up until the end of January of 2020, the UK was a member of the European Union (EU) and had similar approaches to COVID-19 testing and pandemic measures. For instance, European countries like Austria and Germany cancelled elective and non-emergency medical services during the first wave of the pandemic, which is similar to the UK's initial response (Carroll et al., 2020). Additionally, the UK utilised real-time PCR tests to identify infected people, which was later supplemented with antigens tests, which is similar to what happened in several European countries (Rajan et al., 2022).

The literature databases were searched using the following key words:

("COVID-19" OR "SARS-CoV-2" OR "coronavirus") AND ("Christian*" OR "Muslim*" OR "Jew*" OR "Sikh*" OR "Hindu*" OR "religious affiliation" OR "faith group" OR "religious minority") AND ("prevalence" OR "risk" OR "infection rate" OR "mortality") AND ("United Kingdom" OR "UK" OR "England" OR "Scotland" OR "Wales" OR "Northern Ireland" OR "Europe" OR "European Union" OR "EU" OR "France" OR "Germany" OR "Italy" OR "Spain" OR "Netherlands" OR "Sweden" OR "Norway" OR "Ireland")

Quantitative studies published in the English language were included if they reported COVID-19 related outcome data among one or more religious groups. Eligible studies had to be published between 2020 and 2024. Qualitative studies or studies that did not report results relating to COVID-19 disease related outcomes among a religious cohort or community were excluded. Furthermore, since the purpose of this review was to investigate the potential association between religion and COVID-19 outcomes, studies that only reported on vaccination uptake or vaccine perceptions were generally excluded unless they also reported data pertaining to COVID-19 risk or symptom severity.

2.1.1.2 Results of systematic literature search

The database searches yielded a total of 2310 results, which reduced to 299 after disregarding animal research, in-vitro experiments, and studies conducted outside of the UK or Europe. After removing duplicates, qualitative studies and studies which only reported on vaccinations or drug therapies, 7 studies were deemed relevant for inclusion.

One of the included studies reported on the seroprevalence of COVID-19 infection (Gaskell et al. (2021), whilst others focused on COVID-19 related mortality (Waqar et al. (2021), Staetsky (2021), Staetsky (2024), Gaughan et al. (2021), and Larsen et al. (2023)), with one of the included studies focusing on both of these outcomes (Laliotis and Minos (2021)).

2.1.1.2.1 COVID-19 outcomes in Jewish communities

Gaskell et al. (2021) conducted a cross-sectional study of the seroprevalence of the SARS-CoV-2 virus among Orthodox Jews living in the UK. The total sample included 1759 participants. Among the 1242 participants, who provided a serum sample, the seroprevalence of COVID-19 was over 64.3%, which the authors found concerningly high. For context, the authors stated that the seroprevalence among the general population in London was only 10%.

The higher COVID-19 incidence among the Jewish community in the UK was further confirmed by the Office for National Statistics (ONS) (Staetsky, 2021). The authors used mortality data from the ONS from the first three months of the COVID-19 pandemic and showed that the Jewish community had a 121% increased COVID-19 specific mortality compared to Christians. The authors argued that the higher mortality rate observed due to COVID-19 infection could not solely be explained by the slightly higher age of the Jewish community.

Staetsky (2024) investigated the global impact of the COVID-19 pandemic on Jewish mortality and presented data specific to European countries, which justified its inclusion into this systematic literature review. The results showed great variance in excess mortality during the first wave of the COVID-19 pandemic between the different European countries. Hungary and Scotland had the highest excess mortality rates with 52 and 51% respectively, but Belgium, and England were also around 30%. In all of these countries the Jewish excess mortality rates were higher than that observed among non-Jewish populations. On the other hand, France, Denmark, Germany and the Netherlands had the lowest mortality statistics among Jews, which were even lower than among the non-Jewish populations. The study argues that the higher mortality observed among Jews in many countries could partly be explained by their maintained social activities and larger families, where the elderly may have been more exposed to the infection.

2.1.1.2.2 COVID-19 outcomes in Muslim communities

Moreover, Waqar et al. (2021) investigated COVID-19 mortality in the context of Ramadan fasting among Muslims living in the UK. The authors hypothesized that daytime water restriction as practised during Ramadan could adversely impact COVID-19 risk, therefore they analysed UK specific mortality data from 15 areas of the country with significant Muslim populations and compared them to similar areas with lower proportion of Muslim populations. The total analytic sample included 5 million people with Muslims making up 1.5 million of the sample. The results showed similar trends of declining mortality statistics in both Muslim and non-Muslim areas, therefore the authors concluded that no significant associations were shown between Ramadan fasting and COVID-19 mortality.

2.1.1.2.3 COVID-19 outcomes in Christian communities

With regard to Christians, Gaughan et al. (2021) showed that among over 47 million residents living in England and Wales, Christians had the lowest COVID-19 specific mortality before and after the lockdowns as compared with other religious groups including Muslims, Jews, Buddhist, Sikhs and Hindus. According to the results of this study, the highest risk observed was among Jewish and Muslim males.

Only participants belonging to the non-religious group had a lower COVID-19 mortality rate than Christians, however, after adjusting for social, demographic, and geographic factors, the differences were no longer significant, which suggests that being Christian was not associated with a higher mortality rate.

The findings related to the lower mortality data observed for Christians are further confirmed by Larsen et al. (2023) who showed in a study involving data of 39 million UK residents, that compared to Christians, Muslims and Sikhs had 51% and 64% higher COVID infection rates respectively. However, none of these studies conducted in the UK included Adventists specifically. Although, Hansen and Pickering (2024) also investigated religious affiliation in the context of the COVID-19 pandemic, however their study focused on vaccine acceptance instead of infection prevalence, therefore it was excluded from this systematic review.

Data concerning COVID-19 infection risk among religious groups in Europe is scarce. A study conducted in Germany investigated the COVID-19 incidence and mortality rates as well as all-cause mortality rates of predominantly Catholic and non-Catholic counties (**regions within the country)** during the pandemic based on data derived from the Robert

Koch Institute (Laliotis and Minos, 2021). Although COVID-19 infection rates were higher during the first month of lockdowns among Catholic counties, possibly due to the stronger family relations of Catholics, the difference disappeared after 30 days and the authors did not report whether COVID-19 testing was similar among the Catholic and non-Catholic counties, which could further inflate the results.

Staetsky (2024) is the only other study, which presented COVID-19 specific results in the context of the Jewish communities living in Europe, which has already been discussed previously in detail. No other studies have been identified, which investigated COVID-19 related outcomes in European countries among religious groups. This conclusion concerning the lack of data from Europe on the influence of religion on COVID-19 outcomes is confirmed by Sisti et al. (2023), who conducted a systematic literature search and narrative review of the evidence on the role of religion in the context of the COVID-19 global pandemic. This shows that despite the complex impact religion and religious practices can have on health, the prevalence or incidence of COVID-19 infection among religious groups living in Europe and the UK have not been investigated extensively.

Moreover, religion doesn't only influence dietary practices, it can influence people's beliefs, views and perceptions, including those regarding infections and disease outbreaks. Therefore, religion can influence both personal and public health outcomes, particularly in the context of the COVID-19 pandemic.

2.1.2 The public health influence of religion during the COVID-19 pandemic

Religion doesn't only impact individual health, but also public health. During the COVID-19 pandemic, there were several examples of religious leaders or groups disregarding the public health guidelines, which amplified the spread of the virus and undermined public health efforts (Sisti et al., 2023). In Punjab, India, over 40,000 individuals were quarantined following a COVID-19 outbreak, which was linked to a single Sikh priest, who had ignored self-isolation guidance following international travel to Italy. The priest attended several religious gatherings following his return to India such as the Hola Mohalla festival. Followers of the religion were advised not to attend such gatherings, however, despite the public health guidance, the festival still had over 100,000 daily visitors, which led to significant public health concerns in the region. In addition, similar behaviours of disregard for COVID-19 related pandemic measures were observed among the Jewish religious community. Taragin-Zeller et al. (2023) investigated how religious views among the Haredi ultra-Orthodox Jewish communities influenced compliance with COVID-19 related public health guidance. The Haredi community includes Hasidic, Lithuanian, and Sephardi Jews. The study showed that Hasidic Jewish believers were the least compliant with public health guidelines. On the other hand, Sephardic Jewish leaders were more likely to encourage believers to adhere to public health guidelines, likely due to the government appointed Rabbinic positions they held. This highlights the need for tailored public health messaging since there can be diversity of views even within the same religious group. Since Adventists were shown to have lower vaccination rates than the non-Adventists and had low belief in the COVID-19 vaccines in the studies included in this thesis, Adventist religious and health leaders should aim to assist government efforts in public health campaigns, which highlights the importance of building partnerships between public health agencies and religious leaders.

Hajj and Umrah are two important religious pilgrimages in Islam, during which period millions of Muslim tourists travel to Saudi Arabia to visit holy sites in Mecca and Medina. Early on during the pandemic, these pilgrimages were identified as superspreader events (Memish et al., 2020). By June of 2020, the Saudi government placed restrictions on these pilgrimages, which were believed to have significantly contributed to the mitigation of

COVID-19 around the word (Ebrahim and Memish, 2020). The restrictions implemented by the government of Saudi Arabia included only allowing 1000 visitors around holy sites, all of whom were residents of Saudi Arabia and were followed up for 14 days with COVID-19 testing were important measures that advanced public health research at the time (Memish et al., 2020). Since the government of Saudi Arabia is both a religious and political establishment (The Embassy of The Kingdom of Saudi Arabia, 2023), their involvement during the COVID-19 pandemic shows the importance of the intersection between religion and health. It highlights how religious organisations can play an important role in shaping health policies that respect both religious values and public health during a global pandemic. Another potential positive effect of religion during the pandemic was on mental health. Chow et al. (2021) investigated the effects of religious coping, which is a coping mechanism which incorporates religious beliefs and practices to aid individuals deal with stress (Pargament et al., 2011), on the mental health of healthcare workers, who were the most exposed to the negative health effects of the virus as well as the public health measures that were established to contain the virus. Healthcare workers experienced social isolation, difficult workplace challenges, and the fear of transmitting the virus to colleagues or loved ones, which contributed to the high prevalence of depression and anxiety among them during the pandemic (Lai et al., 2020). However, the results of Chow et al. (2021) showed that positive religious coping among healthcare workers was associated with a reduction in depression and anxiety. These findings agree with previous research by Suresh et al. (2020) which showed that positive religious coping reduced suicidal thoughts and behaviours among elderly people living in the United States. Through a systematic literature review, Lee et al. (2021) identified 18 studies, in which religious gatherings and practices led to COVID-19 outbreaks and to the spread of the disease as they disregarded compliance to public health messaging such as social distancing guidelines. In addition, Lee et al. (2021) further argued that religious worship places were often sources of pandemic related misinformation which resulted in a lack of trust in health authorities among members of faith-based organisations and correlated higher religiosity with higher scepticism regarding public health messages and a higher likelihood of belief in COVID-19 conspiracies.

An important area of the COVID-19 related public health messaging, which was often debated among religious communities was vaccinations. Konstantine et al. (2024) investigated COVID-19 vaccine acceptance among countries categorised as either religious (defined as having over 50% of the population follow a specific religion) or not. The study showed that Catholic countries and non-religious countries showed higher vaccination rates, whereas countries where the majority of the population were either Muslim or Eastern Orthodox showed lower vaccination rates. This shows that some religious organisations such as the Catholic church placed a greater emphasis on promoting vaccinations, which resulted in higher vaccine acceptance rates among its adherents. On the other hand, the authors argued that in countries with an Eastern Orthodox majority, the anti-western ideologies and the anti-scientific misinformation disseminated by the Russian Federation are responsible for the lower vaccination rates.

The study by Oduwole et al. (2021) serves as further evidence that religion does not inherently lead to vaccine hesitancy as it showed among religious South African healthcare workers that willingness to receive a COVID-19 vaccine was over 90%. Interesting to note that the only religious group with a lower confidence in the COVID-19 vaccines was the Seventh-day Adventists, with a confidence level of 66.7%, while intention to receive a COVID-19 vaccine was even lower among the Adventists at 42.9%. Scepticisms regarding COVID-19 vaccinations stemmed from concerns regarding the rapid development and approval of the vaccines, the use of mRNA technology in the development of most of the vaccines and concerns about potential adverse reactions, which many felt were validated by the British Medical Journal who published a report about alleged data integrity issues during the Pfizer clinical trials (Thacker, 2021). The article highlighted concerns of poor practices in data handling and oversight during the clinical trial, which were raised by a whistleblower working for Ventavia, a clinical research company involved in the clinical trials of the Pfizer COVID-19 vaccine. Perhaps most concerning of these were the reports about the alleged improper handling of adverse event reports. While regulatory agencies maintained that the vaccines were safe and effective following the report, such revelations certainly amplified scepticism among religious groups, especially if they were already sceptical of the vaccines. In addition, the pause of the Johnson & Johnson (J&J) COVID-19 vaccine due to rare side effects, including thrombosis, raised even more concerns about COVID-19 vaccines, despite the fact that public health professionals argued that the pause of the use of the vaccine actually demonstrated the robustness of the vaccine safety monitoring system (Berg, 2021). However, this pause likely impacted public perception, particularly among communities that were already hesitant about vaccination. For religious groups, incidences like this may have fuelled scepticism about vaccine safety and transparency. In fact, Salmon et al. (2022) assessed awareness and perception of the J&J vaccine pause in an online survey involving 89,083 participants and showed that the individuals who were less willing to get vaccinated due to the pause tended to be hesitant about all vaccines, not just the J&J vaccine. The authors found that vaccine hesitancy among the unvaccinated respondents increased before and during the pause but stabilized after.

2.2 Part 2. The influence of the Adventist diet and lifestyle on health

2.2.1 The Adventist lifestyle and chronic disease risk

As shown in Chapter 1, Seventh-day Adventists are distinct from other Christian denominations not only in their theological beliefs, but also in their health-conscious lifestyle. Moreover, it was discussed in Chapter 1, that Adventists emphasize the integration of faith and health in their official teachings and beliefs and hold the view that healthy living is a moral responsibility. In fact, one of the twenty-eight fundamental beliefs of the church is that a member has to accept upon baptism that they abstain from unclean meats, which are specified in the books of Moses (General Conference of Seventh-day Adventists, 2020). This distinct focus on diet and health has made Seventh-day Adventists a subject of interest in scientific research in the past decades. This research has particularly focused on the relationship between lifestyle choices and health outcomes. The Adventist emphasis on health is reflected in several lifestyle practices that the church promotes such as regular physical exercise, abstinence from tobacco and alcohol, a regular weekly rest day, and a strong sense of community, as well as a mostly plant-based vegetarian diet.

One of the most prominent examples of the Adventist lifestyle and longevity is from the community of Loma Linda, California, who have been identified as one of the world's five "blue zones", which are regions around the world where residents live significantly longer and healthier lives compared to global averages (Buettner and Skemp, 2016). The Adventist residents of Loma Linda have a life expectancy that is estimated to be 10 years longer than that of the general U.S. population. Furthermore, research conducted in this community has revealed that residents are more likely to reach the age of 100 years and have lower rates of chronic diseases such as heart disease, cancer, and diabetes. These findings have sparked global interest in understanding the specific lifestyle practices and social factors that contribute to these outcomes.

However, there are several other research studies from different parts of the world that have investigated the lifestyle and health of Seventh-day Adventists, even before Dan Buettner's work. Therefore, the aim of the second half of this chapter is to provide a chronological and geographical review of key studies that have investigated the impact of the Seventh-day Adventist lifestyle on chronic diseases. This chapter also highlights important gaps in the research concerning Adventists and aims to establish the health promoting effect of the Adventist lifestyle, thereby laying the groundwork for investigating its effects on COVID-19 outcomes in the next chapters.

2.2.1.1 The Americas

The earliest studies focusing on Seventh-day Adventists were carried out in the 1950s and 1960s and were mostly focused on assessing blood lipid levels and cancer rates.
Wynder et al. conducted a preliminary study to the large-scale Adventist Mortality study in 1959 and assessed the potential association between alcohol consumption and smoking and cancer incidence. The results of the study showed that over 90% of Adventists who grew up in the faith had never consumed alcohol or smoked cigarettes. Adventists were also more likely to consume a vegetarian diet than non-Adventist controls, which confirm strong adherence to the Adventist health principles. In terms of the findings relating to cancer incidence, the study showed lower rates of lung related cancers, as well as cancer of the mouth, larynx, and oesophagus. Bladder cancer among Adventist men and cervical cancer among Adventist women were significantly lower than among non-Adventists. The researchers **inferred** that the abstinence from tobacco and alcohol as a well-known aspect of the Adventist doctrine is directly linked to the lower rates of cancers observed in the study.

The Adventist Mortality Study, which began in 1958 at Loma Linda University, is recognized as one of the more important prospective studies on Adventists. It included 22,940 Adventists residing in California who were followed for 5-years, although there was a less structured 25-year follow-up as well. The American Cancer Society (ACS) study began at the same time and comparisons between the two cohorts were made in subsequent publications. For example, Phillips et al. (1978) published a 6-year analysis of the Adventist Mortality Study cohort which showed that compared to the general Californian population, coronary heart disease (CHD) mortality rates among Adventists were 28% to 50% lower, depending on age. The authors attributed the lower risk observed among Adventists to their lifestyle, which excludes smoking, but they also found an association with diet such that fatal CHD risk was three times higher among non-vegetarian Adventists compared to vegetarian Adventists. Another study (Enstrom, 1979) revealed that the cancer rate among Adventists in this cohort was 39% lower than among the white population within the US.
Phillips et al. (1980) compared the cancer incidence rates of Adventists from the Adventist Mortality Study cohort with that observed in the ACS cohort and found that Adventists had significantly lower risk of death from cancer. The researchers further add that the ACS cohort was comparable to the Adventists in their educational and socioeconomic status. This was also confirmed by the same researchers in a separate publication, where they compared the two cohorts and confirmed that the educational status and socioeconomic status of participants in both samples was higher than that of the general white US population, although there were marked differences in smoking rates, meat consumption, and coffee consumption, but it is also worth adding that Adventists exercised more (Philips et al., 1980).

Data published from the 21-year follow-up of the Adventist Mortality Study still showed a lower mortality rate from bowel, breast and prostate cancer in favour of the Adventists

(Phillips and Snowdon, 1983). The researchers also analysed dietary factors that might have influenced bowel cancer risk and although meat consumption was not associated with mortality from bowel cancer, coffee consumption was associated with an increase in risk. Although a later analysis by Kahn et al. (1984) showed a negative association between all-cause mortality and green salad consumption, egg and meat consumption showed positive associations, meaning they increased risk. The study adjusted for important covariates including age, gender, and smoking history, thereby improving the validity of the findings. Furthermore, breast cancer survival rates were also examined in the Adventist Mortality Study by Zollinger et al. in 1984. All patients were treated at two Adventist hospitals in California and the analysis showed a higher 5-year survival than observed in non-Adventists, although the association became insignificant following statistical adjustment for cancer stage at diagnosis. The researchers concluded that the lower mortality rate following breast cancer among Adventists is partly due to their earlier diagnosis and treatment, which they believe is the result of the fact that Adventists in general are more exposed to health information and may thus be more interested in health and could be more likely to seek medical advice or treatment than non-Adventists. There is also the possibility, the authors argue, that the Adventist women who took part in this study had better survival rates because they had slower growing tumours, which made earlier detection possible. Epigenetic modifications resulting from diet and lifestyle as well as genetic factors separately and in combination can affect the growth rate of tumours (Barrero et al., 2022), therefore the lower mortality rate of the Adventist women in this study may have been partially the result of their Adventist diet and lifestyle.

Some of the other earlier publications involving Adventist cohorts also focused on blood lipids. For instance, Walden et al. (1964) compared the blood cholesterol and triglyceride

levels of Adventists to adults living in New York City and showed that Adventists had lower concentrations of serum cholesterol and higher levels of triglycerides than non-Adventists. The authors concluded that the increase in serum cholesterol among male Adventists occurs 10-15 years later than among the rest of the population.
West and Hayes (1968) also compared the serum cholesterol levels of Adventist vegetarians and omnivores and showed that vegetarian Adventists had a lower cholesterol concentration than omnivores, especially those who frequently consumed animal products.

The Adventist Health Study was initiated in 1976 (Beeson et al. 1989). The researchers targeted the entire adult Adventist population in the state of California, and 34198 individuals returned the baseline questionnaire. Fraser and Shavlik in 1997 published data about this cohort concerning the risk of CHD and dying from all causes after 12 years of follow-up. During this period 364 CHD cases and 1387 deaths occurred. CHD specific mortality was 16%, whilst all-cause mortality was 20% lower among subjects who exercised at least 3 times a week compared to those who did not exercise regularly. Furthermore, consuming nuts five times a week was associated with an almost 40% reduction in mortality, whilst the consumption of beef was associated with a two-fold increase in CHD risk.

Finally, the largest cohort study of Adventists was the Adventist Health Study 2 (AHS-2) which recruited over 96,000 Adventists (Herring et al., 2010). The researchers developed a 50-page questionnaire, which was self-administered by the participants. The study began data collection in 2002. The main findings of the study were published by Orlich et al. in 2013, in which the authors presented important results about the influence of diet on the risk of mortality. The analysis included data of over 73,000 Adventists who were followed for an average of 5.8 years. The main finding of the study was that vegetarian Adventists had a 12%

reduced risk of death compared to non-vegetarian Adventists after adjustment for important covariates. The authors presented subgroup analyses for all-cause mortality based on dietary patterns, which revealed that pesco-vegetarians and vegans had the lowest mortality compared to non-vegetarians, 15% and 19% respectively.
The vegetarians in the study didn't just have a lower all-cause mortality, but they also had lower cardiovascular, renal, and endocrine mortality rates. The overall mortality results were compared in a subsequent publication by Fraser et al. (2019) to non-smokers from the National Longitudinal Mortality Study (NLMS) and a sub-study of it, called the Surveillance, Epidemiology, and End Results study. All-cause mortality and cancer mortality were both 22 and 36% lower in the AHS-2 cohort than in the non-Adventist studies. Cancer incidence was also 30% lower among the Adventists. Notably, Black Adventists from the AHS-2 cohort were shown to have lower mortality rates than non-Adventist white males, which is noteworthy since ethnic disparities in mortality have been long known such that Black populations have been shown to have an up to 19% higher mortality than White populations (Dwyer-Lindgren et al., 2023).

In addition to mortality data, publications analysing the AHS-2 cohort have also focused on chronic disease prevalence rates such as the study published by Tonstad et al. (2013). This analysis included data from 31,387 participants and the results showed that compared to non-vegetarians, diabetes incidence was the lowest in vegan participants (OR 0.381; 95% CI 0.236-0.617) suggesting an over 60% reduced risk, but lacto-ovo-vegetarians and semi-vegetarians also had lower risks than regular meat eaters.

Studies conducted on Adventist populations in central or south America are limited in number, however the study with possibly the largest sample size outside of North America was conducted in Brazil by Oliveira et al. (2016). The study included over 14,000 Adventists who were followed between 2003 and 2009. The researchers wanted to examine if the mortality rate among Adventists was different from the mortality rate of the general population in the same state. During the observational period, 896 deaths occurred, and it was shown that all-cause mortality was 42.5% lower among Adventists than in the rest of the population. Similar risk reductions were found for ischaemic heart disease mortality and stroke mortality.

Brathwaite et al. in 2003 published the results of a study, which included data from 407 Adventists living in Barbados. The study showed that vegetarians were significantly leaner than non-vegetarian Adventists. Diabetes and hypertension prevalence were also lower among the vegetarian group, which were in agreement with the US Adventist studies.

Results from these previously cited studies have provided important insights into diet and health related questions and have informed public health particularly regarding the benefits of vegetarian diets, the importance of nuts in reducing heart disease risk, however the generalizability of these studies to Adventists outside of North America may be limited.
For this reason, the next section will present important studies that recruited Adventists outside of North America.

2.2.1.2 Europe

There are only a few cohort studies conducted in Europe that have included Seventh-day Adventists participants, but they all focused on the prevalence and incidence of chronic diseases as opposed to infectious diseases. A large register-based cohort study (Nanna et al., 2015) which recruited over ten thousand Danish Seventh-day Adventists and Baptists and contained over 30 years' worth of registry data showed that the incidence of cardiovascular disease was significantly lower among both Adventists and Baptists than amongst the general Danish population. Comparing disease incidence rates among the Adventists and Baptists, it was revealed that both groups, including Adventists, had a lower incidence of cardiovascular disease (CVD) than among the Danish population.

One of the earliest studies conducted in Europe was published by Berkel and de Waard in 1983 in the Netherlands. The researchers analysed the mortality pattern of Adventists between 1968 and 1977 and showed that the mean age at death of Adventists was significantly higher than the general Dutch population. The researcher attributed the lower mortality and higher age at death observed amongst the Adventist to the abstinence from smoking and alcohol, but they also noted that the health-conscious diet Adventists widely follow may also confer additional benefits.

Fønnebø (1994) investigated the various health aspects of being a Seventh-day Adventist in Norway. The study showed that infants born to Seventh-day Adventist mothers had a birth weight 99 g heavier on average ($P < 0.001$) compared to babies born of non-Adventist mothers. Additionally, Seventh-day Adventists were also shown to have significantly lower total cholesterol levels compared to matched controls, which were also clinically meaningful (0.86 mmol/L lower for men and 0.48 mmol/L lower in women). Although the incidence rate of cancer was not significantly different between Adventists and non-Adventists, the risk of all-cause mortality was significantly lower among Adventist men. Another study from Scandinavia was conducted in Denmark which followed 11,580 Adventist and Baptist individuals to investigate whether the incidence of cancer was different among these groups as compared to the rest of the Danish population (Thygesen et al., 2012). The study's results showed that out of the three groups, Adventists had the lowest incidence of cancer, especially those cancers which are related to smoking.

Furthermore, Kørup et al. published the results of the Danish Cohort of Religious Societies in 2016, who were followed between 1977 and 2009. The article presented study results concerning sexually transmitted diseases among Adventist and Baptist women. The results showed a significantly lower incidence of sexually transmitted diseases among the two religious groups, which included human papilloma virus infections as well. The authors concluded by stating that the lower rates of sexually transmitted diseases serve as a potential explanation for the lower incidence of cervical, rectal, anal and head and neck cancers observed in religious populations such as the Adventists.

2.2.1.3 Asia and Australia

There are a few published studies involving Adventists from Asia and Oceania, the majority of which have been conducted in Australia.
Lee and Kim (2019) conducted a cross-sectional survey of Korean Adventists and showed that church members had low prevalence rates of chronic diseases and showed a high engagement in healthy lifestyle behaviours.

As mentioned previously, there are a number of studies published in Australia. Craig et al. (2017) recruited 1734 students and investigated whether religious affiliation was associated with health status and student behaviour. Regarding diet, the researchers found that Adventists consumed significantly less energy drinks, soft drinks and coffee, but consumed more servings of vegetables and fruits than non-Adventists, and they also consumed less alcohol and smoked less cigarettes. The use of illegal drugs was significantly lower among

Adventist students with only 5.4% reported ever taking marijuana among the Adventist, while this was 16.6% among the non-religious students ($p<0.01$).

An earlier study published by Hokin and Butler (1999) recruited 340 Adventist ministers for the Adventist Ministers' Health Study and measured their serum vitamin B12 concentrations. The study will be described in greater detail in Chapter 4, but briefly the study showed that 53% of participants had a serum B12 concentration below the reference range (171-850 pmol/L), which falls into the insufficiency classification criteria of the National Institutes of Health, updated in 2017. An even earlier study conducted by Semmens et al. (1983) investigated the potential association between sex hormones and variations in HDL cholesterol levels in 70 Adventists and Mormons. There were no significant differences in the measured variables among men, however Adventist women were shown to have lower cholesterol levels and higher oestradiol levels. The researchers highlighted that both groups were non-drinkers and non-smokers, which they believe helped isolate the influence of hormones, in this case the higher oestrogen due to the vegetarian diet of Adventist women, on HDL-C levels.

More recently, Berg et al. in 2020 investigated the impact of the consumption of plant-based foods on bone mineral density in a Seventh-day Adventist hospital in Sydney, however it could not be determined from the publication whether any or all patients recruited for the study were church members. The results of the study suggested that an increase in the consumption of plant foods was associated with improved bone mineral density markers, but it is important to reemphasize that it cannot be determined if the participants were Adventists or not. Finally, a study measured the DNA-damaging activity of ethanol-soluble faecal extracts among various groups such as Adventists of European heritage, Maoris and Samoans

(Ferguson et al., 1985). There were no detectable samples among the Seventh-day Adventists included in this study, but the Polynesian groups also exhibited low levels. The authors concluded that the diet of Adventists was responsible for the reduced concentrations of ethanol-soluble mutagens, which serves as a potential explanation for their lower risk of bowel cancer.

2.2.1.4 Africa

The quality and number of studies conducted in Africa are similar to those in Asia, which means they are mostly surveys using a cross-sectional design. For instance, Famodu et al. (1998) investigated the blood lipid level of 76 Nigerian Adventists based on their diet. Of the total sample, 40 had an omnivorous diet, whilst 8 and 28 were vegetarians and semi-vegetarians respectively. The average systolic blood pressure in all three diet groups was around 110 mmHg, with no significant differences between any of the groups. These average blood pressure values are especially of interest considering that the mean age of participants was just under 50 years in all three groups. Vegetarians consumed lower amounts of dietary cholesterol, saturated fat as well as protein compared to the other two groups; however, they also consumed more fibre as the other groups. Regarding blood lipids, vegetarians had significantly lower total cholesterol and triglyceride levels than omnivores. In terms of anthropometric measures, the mean weight of vegetarians was significantly lower than that of omnivores (75 kg vs. 79 kg, $p < 0.05$). These results are in agreement with the findings of some of the studies previously cited from other geographical area, where Adventists were shown to have low intakes or levels of cholesterol as well as saturated fats, therefore this study adds to the understanding of how the Adventist lifestyle, particularly dietary habits, impacts health outcomes and that its health benefits are reproducible even in the African setting. Acheanpong et al. (2022) investigated the risk factors of depression and its prevalence among pregnant women who attended an antenatal clinic at an Adventist hospital in the Bekwai Municipality in Ghana, however it could not be determined from the methods section of the study, whether the participants recruited were Adventists themselves as it cannot be assumed that all patients attending an Adventist hospital were in fact Adventists. Similarly, Garrido et al. (2009) conducted a cross-sectional analysis in Botswana to investigate the risk factors and frequency of obesity and metabolic syndrome among 150 workers in Kanya Adventist Hospital, however this article doesn't report what percentage of the sample were members of the Adventist church, therefore the relevance of this study to Adventists cannot be determined.

2.2.2 The potential role of the Adventist diet and lifestyle in the context of COVID-19 immunity

2.2.2.1 The Adventist lifestyle and immune function

Adherence to the Adventist principles has clearly been shown to be an effective strategy to prevent and even treat many of the chronic diseases that are prevalent around the world, especially in western societies, however, little information is known about the potential association between the Adventist lifestyle and the prevalence or incidence of infectious diseases. The nutritional and non-nutritional lifestyle factors present in the Adventist lifestyle have each been associated with better immune function. A healthy diet, and abstinence from smoking and alcohol have all been associated with a lower risk of COVID-19 disease, and these are also fundamental aspects of the Adventist lifestyle. For instance, Paleiron et al. (2021) showed that smoking abstinence is associated with a lower COVID-19 risk in several epidemiological studies. It is suggested that cigarette smoke exacerbates SARS-CoV-2 infection by impairing mucosal innate immunity, thereby increasing the risk and severity of the disease. The authors also highlight that smoking is usually associated with various comorbid conditions, which further increases COVID-19 risk. In addition, a meta-analysis published in 2013 by Wei et al. showed that alcohol consumption also significantly increased the risk of COVID-19 infection and its complications. Importantly, the pooled results of studies recruiting patients in Europe and America, showed significant associations between alcohol consumption and an increased risk of COVID-19 complications such as admission to an intensive care unit (ICU) and needing mechanical ventilation. Another foundational aspect of the Adventist lifestyle is physical activity, which has also been shown to influence COVID-19 risk. Bliss et al. (2022) showed that exercising cancer patients had a significantly lower risk of COVID-19 infection than non-exercising patients. The beneficial effects of exercise were later confirmed by a systematic review, which showed that regular exercise and physical fitness not only showed protective effects against hospitalisation but also against death from COVID-19 (Cardoso et al., 2023).

Moderation in eating and drinking is fundamental to the Adventist lifestyle. De Frel et al. (2020) showed that overconsumption of calories and western diets with high amounts of ultra-processed foods can increase systemic inflammation and suppress immune function. Chronic inflammation doesn't only increase susceptibility to infectious diseases, but it has also been shown to reduce the effectiveness of vaccines (Furman et al., 2019), therefore a healthy diet may indirectly improve infectious disease risk via lowering chronic inflammation.

Furthermore, people who do not regularly exercise have also been shown to have an increased risk of infectious diseases (da Luz Scheffer and Latini, 2020). Given that the principles of the Adventist lifestyle have been shown to have an essential role in immune function and in the prevention of infectious diseases (Smith and McClung, 2021), there is a compelling rationale for investigating the potential association between the Adventist lifestyle and the prevalence of infectious diseases, especially since infectious diseases remain a considerable public health challenge worldwide. Despite the major advancements in medical science, lower respiratory tract infections ranked among the top 6 leading causes of death in the UK based on the World Health Organization's (2021) report. In this report, COVID-19 infection specifically ranked as the second leading cause of mortality, measles as the fifth, lower respiratory infections as sixth, and tuberculosis as tenth. These statistics highlight the burden of these diseases and underscore the importance for further research into the prevention of these diseases, including the potential role of lifestyle interventions.

2.2.2.2 Nutrient intake and immunity

In a survey, including over 63,000 Adventists across the globe, 19% reported consuming a vegetarian or vegan diet (McBride et al., 2021) with over 80% of participants reporting abstinence from alcohol and cigarettes, although there were large geographic differences in the number of vegans and vegetarians such that over 50% of North Americans surveyed reported to be vegan or vegetarian, whereas only 15.4% in Euro-Asia followed a type of plant-based diet. The widespread popularity of plant-based diets among Adventists are further confirmed by the Adventist Health Study 2, which showed that over 50% of the participants followed some variation of the vegetarian diet (Orlich et al., 2013). Vegetarian dietary patterns in the AHS-2 study were linked to a 22% lower risk of mortality compared to a non-vegetarian dietary pattern, and vegetarian participants were shown to have lower rates of smoking and alcohol consumption. However, the popularity of vegetarian and vegan diets among Adventists may be a predisposing factor for nutritional deficiencies since some nutrients which are typically found in animal products, are not as abundant or bioavailable in vegetarian and vegan diets as they are in diets which contain meat and other animal products (Melina et al., 2016). For instance, a recent systematic review has shown that vegans tended to have the lowest intakes of essential nutrients such as vitamins B12 and D, iron, iodine, and calcium compared to meat eaters, although meat eaters were shown to have lower intakes of folate, vitamin D and E, fibre, calcium, and magnesium (Neufingerl and Eilander, 2022), however, these were not specific studies on Adventists.

Vitamin B12 intake is of special importance and its supplementation contributes to the prevention of anaemia and neurocognitive disorders, particularly for those following a meat free diet (Pawlak et al., 2013). People who have serum vitamin B12 levels below 133 pmol/L are considered as vitamin B12 deficient (NICE 2, 2023). However, nutrient deficiencies do not only influence the risk of chronic diseases, but they can significantly compromise the immune system, and increase susceptibility to infectious diseases, including COVID-19 disease. For instance, vitamin A deficiency has been associated with a higher risk of measles infection (Katona and Katona-Apte, 2008), while vitamin D deficiency has been also shown to increase the risk of several infectious diseases such as tuberculosis (Martineau et al., 2007), infectious mononucleosis (Maghzi et al., 2016), hepatitis (Hodges and Lamotte, 2022) and even COVID-19 (Dror et al., 2022). In fact, a meta-analysis of 25 studies showed that the use of vitamin D supplements significantly lowered the risk of acute respiratory tract infections, especially among those participants whose blood vitamin D levels were below 25 nmol/l, which indicates severe deficiency (Martineau et al., 2019). Apart from vitamins A and D, vitamin B12 deficiency is also associated with a higher risk and increased severity of infections, probably due to its critical role in supporting various immune functions such as the activity of phagocytes and production of interferons, which are signalling molecules involved with the activation of immune cells (Batista et al., 2021). Additionally, severe vitamin B12 deficiency causes elevated homocysteine levels, which is a marker of systemic inflammation that can further weaken the body’s immune response and increase vulnerability to infections (Li et al., 2015). Moreover, Erfani et al. (2023) showed that vitamin B12 supplementation can even be useful during active COVID-19 infection. In this study, hospitalised patients with COVID-19 infection were randomly assigned to vitamin B12 supplementation or placebo. The findings showed improvements in inflammatory markers such as CRP and lower ICU admission risk due to vitamin B12 supplementation.

Vitamin E is another essential nutrient which has been shown to improve the function of the immune system, reduce immunosenescence as well as reduce the risk of infections (Wu and Meydani, 2014).

In addition to vitamin deficiencies, mineral deficiencies have also been shown to increase the risk of infectious diseases. Zinc deficiency increases the risk of viral infections due to its key role in the growth of immune cells and its antiviral activity (Iddir et al., 2020).

Since all of these nutrients are mostly found in animal-based foods, they can be difficult to obtain in adequate amounts on plant-based diets without supplements or fortified foods. This could potentially increase the risk of infectious diseases among plant-based eaters, therefore investigating the risk of nutrient deficiencies among plant-based Adventists can provide useful insights for church-based health promotion strategies aiming to focus on infectious disease prevention.

Adventists are an aging population, and they have been shown to have a greater life expectancy than the general US population (Berkel and de Waard, 1983), however this means a large portion of them may be more susceptible to chronic and infectious diseases due to their age. Evidence suggests that the elderly may be more prone to osteoporosis, therefore, the adequate intake of vitamin D, protein and calcium are essential for proper bone health (Weaver et al., 2016), even among omnivores, therefore those following vegetarian or vegan diets must ensure they consume sufficient amounts of these nutrients as they may be at an increased risk of osteoporosis (Hsu, 2020), however, these nutrients may have an influence on immunity and immune function as well. Furthermore, Nieman et al. in 1989 investigated the nutrient intake of elderly Adventist women following different dietary patterns. The participants were recruited from the Adventist Health Study and were grouped into vegetarian and non-vegetarian groups. It was not possible to separately analyse vegan participants due to their low number in the sample (n=4). The mean age of vegetarians (n=23) was 72.2, and the mean age of non-vegetarians was 71.1 (n=14). The sample population's age makes this an important study, since older age may increase the risk of decreased nutritional status, mainly due to a decrease in food intake (Drewnowski and Shultz, 2001), therefore this was an ideal study population to investigate the effect of diets varying in animal food content on participants' nutritional status. The results of the study showed that vegetarians consume significantly more calories (1452 kcal/day) than non-vegetarians (1363 kcal/day) and they also consumed more carbohydrates, dietary fibre, as well as more magnesium, vitamin E, vitamin A, thiamin, and pantothenic acid. On the other hand, vegetarian's protein intake as a percentage of daily calories (12.9%) was significantly less than that of non-vegetarians (16.2%), but they also consumed less saturated fat, dietary cholesterol, and caffeine. The lower reported intake of protein among vegetarians may be a cause for concern, however 12.9% is well above the lower threshold of 10% according to the acceptable macronutrient distribution range (AMDR) (Baum et al., 2016). Bakaloudi et al. (2020) conducted a systematic review to determine if nutrient intake on vegan diets can meet the WHO guidelines for micro- and macronutrient intake recommendations. The systematic literature review identified 48 observational studies, in which the primary focus was to compare the adequacy of nutrient intake of vegan diets to other dietary patterns. Protein intake in the included studies was lower for vegan diets as compared with all other diets. Vegan diets were also associated with lower B2, B3 and B12 as well as vitamin D intakes. In addition, the study found that iron status among long term vegans was lower than among non-vegans. Evidence showed that calcium and vitamin B12 intake in most of the included studies were below the recommended levels for vegans.

2.2.2.3 Dietary supplement use among Adventists

Although Adventists place a large emphasis on diet, the use of dietary supplements among them may be less common than one would expect, especially among those following plant-based diets. For instance, Thorpe et al. (2021) showed that vegan women had a 55% greater risk of hip fracture in their cohort. In subgroup analysis, however, it was revealed that only those females who refrained from using vitamin D and calcium supplements showed an increased risk of bone fractures, highlighting the importance of using certain dietary supplements on a vegan or vegetarian diet. Examining the nutrient intake of vegans in the Adventist Health Study 2 (AHS-2) cohort, they were shown to have higher intakes of vitamin C, magnesium, fibre, folate, vitamin E, and β-carotene from dietary sources, as described in the previous chapter, but the study also showed that strict vegetarians were the least likely to use dietary supplements (Rizzo et al. 2013), which may be somewhat of a concern as nutrients such as vitamin B12 aren't available in wholefood sources on a vegan diet (Niklewicz et al., 2022) but must be acquired through supplements or fortified foods. These data raise questions about the nutrient knowledge and supplementation practices of vegan and vegetarian Adventists since these may influence COVID-19 susceptibility.

2.2.2.4 The role of diet on vaccine efficacy

Public health policies related to infectious diseases mainly focus on vaccines and medical interventions, and there is little or no emphasis on diet and lifestyle. For instance, the infectious diseases strategy for Public Health England (2019) for the period of 2020-2025 does not include any information on the role of lifestyle and diet in the prevention or treatment of infectious diseases. It is perhaps understandable that its top priority is the provision of vaccines to reduce the prevalence of diseases that can be prevented by vaccination, however it is noteworthy that lifestyle behaviours did not get any mention in the report. Similarly, the Nuffield Council on Bioethics (2007) only refers to vaccinations as a preventative strategy against infectious diseases, which may suggest that lifestyle and dietary practices have no role to play in the context of infectious diseases. It is not a surprise that vaccines are at the centre of public health strategies against infectious diseases since they have proved to be highly effective at preventing infections. A meta-analysis by Di Pietrantonj et al. (2020) showed that a single dose of a vaccine against measles reduced its prevalence by 95%. The same study also showed that vaccines against rubella and varicella were 89% and 95% effective respectively. Vaccination can be credited with the eradication and control of several infectious diseases such as smallpox, polio, and measles (World Health Organization, 2020). On the other hand, some vaccines have a lower effectiveness such as the vaccines against seasonal influenza, which has been shown to be 58% effective in older adults (Demicheli et al., 2018) and only 49% effective against influenza like illnesses in the elderly population (Demicheli et al., 2018). In fact, some of the vaccines against typhoid fever are only 50% effective (Milligan et al., 2018). It could therefore be argued that in the cases of infectious diseases for which vaccines are either not available or aren't very effective, lifestyle could play an important role. In these cases, vaccinations and the promotion of healthier lifestyle choices should not be mutually exclusive. This is confirmed by the findings of Miao et al. (2022) which showed that participants who had better lifestyle scores were more likely to be vaccinated against COVID-19 and that healthy lifestyle contributed significantly to vaccination uptake. The authors' conclusion was that a healthy lifestyle, which includes proper nutrition, sleep hygiene, and regular physical activity should be promoted alongside vaccines. The role of vaccines, therefore, should be considered in analyses that investigate potential associations between diets and COVID-19 infection.

Another argument for the importance of a healthy lifestyle in the context of infections is the fact that immune functions are known to decline with age, which includes the diminished response to vaccinations (Hodges and Lamotte, 2022). This age-related immune function decline, which increases susceptibility to infections and reduces the effectiveness of vaccines is also known as immunosenescence (Wu and Meydani, 2014). This serves as an explanation for the reason influenza vaccinations are less effective in the elderly as shown by the previously cited studies by Demicheli et al., however an analysis by Sasaki et al. (2011) further confirms this association between older age and a decline in vaccine effectiveness. The study showed that the efficacy of influenza vaccines can be as low as 17% in those over the age of 65 years due to a reduction in vaccine induced antibodies. Furthermore, Vedhara et al. (2020) conducted a systematic review and meta-analysis to investigate the influence of lifestyle behaviours on improving vaccine effectiveness. The authors identified 79 dietary intervention studies and 12 studies with physical exercise interventions, all of which investigated the impact of these lifestyle interventions on antibody levels following vaccinations. The results of more than half of the included studies showed statistically significant effects on antibody levels, which provides strong evidence for the role of diet and exercise on improving infectious disease outcomes.

With regards to the role of nutrition, the supplementation of certain nutrients also influences vaccine efficacy. It was shown by Duchateau et al. (1981) that the supplementation of zinc significantly improved the antibody response of elderly participants to the tetanus vaccine. In addition, zinc supplementation has also been shown to improve the antibody response to diphtheria vaccination (Kreft et al., 2000), and there is evidence to suggest that it may also reduce the chemotherapy induced antibody decline following vaccination against pneumococcal disease (Braga et al., 2015). Furthermore, vitamin E supplementation has been shown by Meydani (1997) to increase the antibody responses following hepatitis B and tetanus vaccines, and it lowered the risk of skin related adverse reactions. Vedhara et al. (2020) also showed that supplementing probiotics resulted in higher antibody levels compared to controls who did not use probiotics supplements, although probiotics do not count as essential nutrients.

This highlights the role of adequate nutrient intake and shows that healthier lifestyle choices such as consuming a nutrient dense diet, the use of supplements and regular physical activity could help maximise vaccine effectiveness, thereby improving individuals' susceptibility to infections.

Overall, these studies show that dietary and other lifestyle practices can have a role in the prevention of infectious diseases like COVID-19, even as supportive strategies alongside vaccinations.

2.2.3 Research gaps identified in the literature reviews

The first important finding identified through the literature review was the scarcity of research concerning the prevalence and incidence of COVID-19 within religious groups accross Europe and the UK.

There is a clear predominance of research on chronic diseases within Adventist populations and a scarcity of studies addressing the impact of the Adventist lifestyle on infectious diseases, including respiratory infections such as COVID-19. The unprecedented arrival of the COVID-19 pandemic provided a special opportunity to investigate aspects of the Adventist diet and lifestyle in the context of a global infectious disease pandemic.

The literature review showed that no studies have been published, which have explored the lifestyle and dietary behaviours of UK Adventist, which could provide important insights into how they compare to Adventists living in other parts of the world as UK Adventists may have different socio-economic, cultural and ethnic variability than Adventists in other countries.

Although Adventist studies often report on associations between diet and health outcomes, less is known about the adequacy of their nutritional intake, particularly of nutrients that might affect infection risk and immunity.

2.3 Methodology of the thesis

The overarching research question of the thesis was “How do the Adventist dietary and lifestyle practices influence COVID-19 outcomes?”. A quantitative approach was used in order to provide answers to this research questions, incorporating three different types of study designs (1) systematic reviews and meta-analysis, (2) an educational intervention study and (3) a prospective cohort study.

2.3.1.1 Systematic reviews

Firstly, systematic reviews are useful for establishing what is known and unknown about a research topic, identify research gaps and can also be used to inform the research design of new studies (Yuan and Hunt, 2009). Furthermore, systematic reviews that contain a meta-analysis are able to provide a quantitative summary known as the effect size, which allows for the measurement of the strength and direction of an association across multiple studies, thereby enhancing the reliability and generalisability of the findings (Yuan and Hunt, 2009). In this thesis, the two systematic reviews, presented in Chapters 3 and 5, were used that synthesized the available evidence on the association between the Adventist diet and lifestyle and COVID-19 infection risk. They also provided valuable information for the research designs of the prospective cohort study and educational intervention study.

2.3.1.2 Prospective cohort studies

Many of the studies that have involved Adventist participants had an observational design, which has several advantages and disadvantages. Observational studies usually allow for larger sample sizes than randomised controlled trials and can investigate multiple outcomes and exposures at the same time (Wang and Kattan, 2020). The three main types of observational studies are case-control, cross-sectional and prospective cohort. While the first two of these only allow for retrospective data analysis, prospective cohort studies have the added benefit of being able to examine temporal relationships between an outcome and an exposure (Song and Chung, 2010).

Since observational studies usually rely on self-reported data and are not run under controlled conditions, they can be subject to bias, however the use of validated data collection tools, statistical adjustment for confounding factors and the incorporation of an observational period can enhance the quality of these types of studies. Prospective cohort studies tend to have greater internal validity compared to other study designs, especially when they are adequately powered and adjusted for known confounding factors (Song & Chung, 2010). Inspired by the design and quality of the AHS-2 study, a prospective cohort study was carried out as part of this thesis, since this design was deemed the most appropriate and feasable methodology to investigate differences in COVID-19 incidence rates between Adventists and non-Adventists living in the UK.

2.3.1.3 Educational interventions

Lecture-based educational nutritional interventions have been shown to improve participants' nutrition knowledge and are commonly used in nutrition studies. It has been demonstrated through various studies that these interventions can effectively increase individuals' understanding of key concepts relating to diet and nutrition. For instance, a comprehensive systematic review of educational interventions revealed that educational interventions led to significant enhancements in knowledge across a wide range of measures. Out of the 24 measures examined, 16 showed substantial improvements as a direct result of the intervention (Cusack et al., 2018).

Furthermore, another lecture-based intervention delivered to pharmaceutical science students in Japan significantly improved the dietary supplement knowledge of participants (Chiba et al., 2020), however, it is important to note that the researchers did not track the long-term impact of their lecture-based intervention on participants' actual supplementation behaviour. On the other hand, educational interventions have also been shown to effectively lead to behaviour change in addition to increasing knowledge. A study involving American college students demonstrated that a lecture-based intervention not only enhanced knowledge but also resulted in behavioural changes. Specifically, it effectively increased the consumption of whole grains among the participants (Ha and Caine-Bish, 2011). This highlights that well-designed educational interventions are not just a tool for knowledge dissemination but can lead to behaviour change.

To influence behaviour, the educational interventions should be designed to not only address knowledge but also attitudes and beliefs about diet. An educational intervention study involving Adventists showed that interventions which are aimed at changing participants' attitudes towards diet and lifestyle successfully resulted in subsequent behavioural change (Kent et al., 2015), which is further confirmed by a study published by Shepherd et al. (2002) that showed that those interventions that result in belief change are more likely to result in behavioural change.

Additionally, evidence suggests that educational interventions conducted by experts in the relevant fields may contribute to the success of these interventions. A synthesis of the available systematic reviews concerning interventions aimed at leading to behaviour changes related to diet and health showed that expert-led interventions were more likely to result in behaviour change than in peer-led interventions or generic interventions (Baird et al., 2009). Therefore, the objective of this study was to assess the impact of an expert-led lecture-based educational intervention, specifically tailored for vegan and vegetarian Seventh-day Adventists, on their general and COVID-19 specific nutritional knowledge and behaviour.

2.4 Research aim and objectives

The literature reviewed in this chapter highlights the health-promoting aspects of the Adventist lifestyle, particularly regarding chronic disease prevention. However, there is a significant gap in the literature concerning the influence of the Adventist dietary and lifestyle practices on COVID-19 disease risk, particularly in the context of nutrient intake and vaccination behaviour.

These gaps in the literature informed the structure of this thesis, which includes two chapters with systematic reviews, a longitudinal observational study, and an educational intervention study. The systematic reviews were used to synthesize the existing evidence and identify knowledge gaps, the cohort study in Chapter 4 was designed to generate original data concerning the COVID-19 incidence among Adventists and non-Adventists in the UK over a 2 year period. Finally, the educational intervention study in Chapter 6 was deemed an appropriate choice of study design to assess and improve the nutrition and supplement knowledge and behaviour of plant-based Adventists. The methodological choices were informed by the evidence gaps identified during the literature reviews presented in this chapter.

2.4.1 Research Aim:

The aim of this research was to investigate the influence of the dietary practices of Adventists, in the context of their lifestyle, on COVID-19 outcomes, such as disease incidence and symptom severity, to gain knowledge about whether the Adventist lifestyle may offer protection against an infectious disease like COVID-19 in addition to its beneficial role against chronic diseases.

2.4.2 Research Objectives:

1. Conduct a systematic literature review to synthesize the evidence concerning the association between the Adventist dietary and lifestyle practices and the risk of COVID-19.
2. Compare the COVID-19 infection risk of Adventists and non-Adventists living in the UK and assess how factors such as diet and vaccination status mediate the risk.
3. Evaluate potential associations between nutrient intake and risk of COVID-19 among plant-based Adventists.
4. Assess the nutritional knowledge and supplementation practices of vegan and vegetarian Adventists in the context of COVID-19 disease prevention and treatment and test the efficacy of an educational intervention to improve their nutritional knowledge and behaviour in order to reduce susceptibility to COVID-19 infection due to inadequate nutritional intake.

While this chapter provided an overview of the literature concerning the Adventist studies regarding chronic diseases, Chapter 3 narrows the focus to investigate the prevalence of COVID-19 and other infectious diseases among Adventist populations. The rationale for this shift is based on the research gap highlighted in Chapter 2, which is overwhelming emphasis on chronic disease related outcomes in Adventist cohorts.

3 Chapter 3. The prevalence of COVID-19 and other infectious diseases among Seventh-day Adventist cohorts: A Systematic Review

3.1 INTRODUCTION

The aim of this study was to synthesize the available evidence regarding the risk of COVID-19 among Seventh-day Adventists. Due to the low expected number of studies focusing on COVID-19 disease, all other types of infectious diseases were also considered in this systematic review as they can provide important information about the role of the Adventist lifestyle on immunity against infections, which may provide relevant data for COVID-19 disease. Findings from such a systematic review of the scientific literature could primarily inform church-based health promotion strategies, which focus on the prevention and management of COVID-19 and other infections among Adventist populations.

3.2 METHODS

This systematic review has followed the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guideline and is registered on PROSPERO under CRD42024502363.

3.2.1 Eligibility Criteria

Studies published in the English language were searched in PubMed, Google Scholar and Scopus. Articles were included in this systematic review if they recruited Seventh-day Adventist participants and reported on the prevalence or incidence of COVID-19 disease or any infectious disease or a disease caused by infectious agents. All types of infectious diseases and diseases caused by infections agents were considered, including respiratory tract infections, gastrointestinal infections, and vector-borne diseases. The reason to include studies reporting on other types of infectious diseases was made due to the fact that COVID-19 infection is a relatively recent disease, therefore only a low number of studies were expected to be identified in the literature search. Furthermore, research on the Adventist lifestyle in the context of other types of infections can provide valuable insights into the role of the diet and lifestyle Adventists have on their immunity against infectious diseases. COVID-19 disease is similar to other types of respiratory tract infections such as the common cold or influenza. Bai and Tao (2021) highlighted that although there are important differences between COVID-19 disease, influenza and the common cold, they also share common symptoms such as fever, cough, fatigue, and body aches, while both influenza and COVID-19 can result in more serious complications such as pneumonia. In fact, the authors showed that most individuals experience mild symptoms of COVID-19, which is similar to infections like the common cold. The CDC have also confirmed the similarities that exist between COVID-19 disease and influenza such as the fact that both of these are viral infections which spread through respiratory droplets (CDC, 2024). Moreover, the CDC notes that the two infections cannot be differentiated based on symptoms only and suggest that testing is necessary to establish the correct diagnosis. According to the WHO, diet and lifestyle can influence the risk of COVID-19 disease similar to other infectious diseases (World Health Organization, 2020), therefore, studies which investigated the risk of other infectious diseases were included in this systematic review for the above-mentioned reasons.

Studies focusing on chronic diseases only or studies where no distinguishable data for Adventists were reported were excluded. Studies performed at Adventist hospitals were generally excluded, unless they specifically reported that participants were Seventh-day Adventist as it cannot be assumed that all patients treated at Adventist health institutions were Seventh-day Adventist. Given the anticipated low number of studies, both qualitative and quantitative studies were included in this systematic review.

3.2.2 Search Strategy

The above-mentioned databases were searched using the following search strategy: (Adventist OR Seventh Day Adventist OR SDA) AND (infection OR infectious OR "infectious disease" OR infected OR virus OR bacteria OR "bacterial infection" OR "viral infection").

Articles were initially screened after retrieval from the databases by reading their titles and abstracts, and those that were deemed relevant were subsequently read in their entirety. Studies were included if they met the prespecified inclusion criteria.

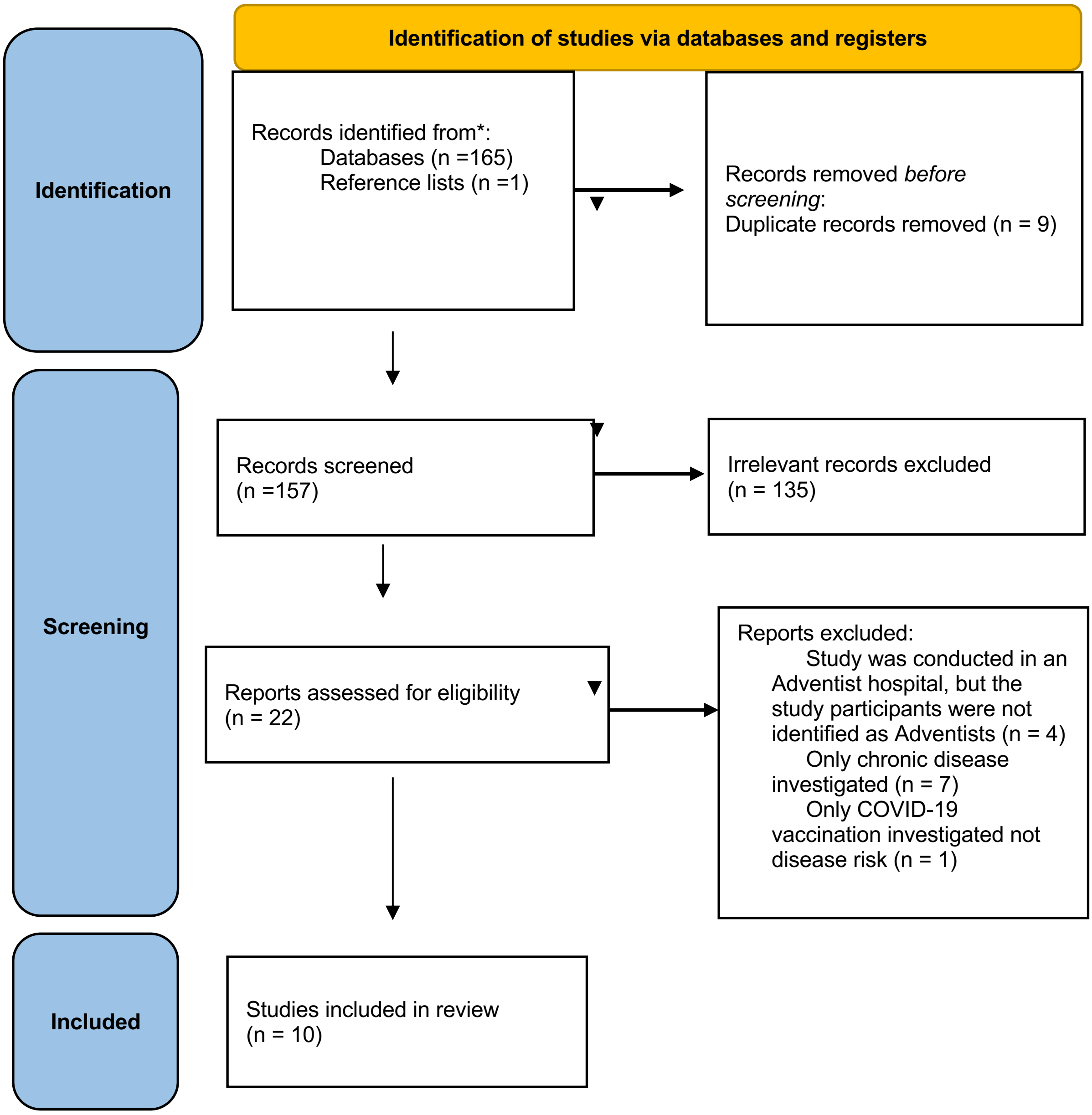
3.2.3 Data Extraction

Relevant data were extracted from the included studies using a standardised data extraction form (Appendix 13). Bibliographic information, study characteristics data (e.g., study design and duration), participant demographics, specific lifestyle factors assessed (e.g., diet, physical activity, smoking), the presence of a control group, infectious disease outcomes, prevalence or incidence rates, and information concerning statistical analyses were extracted. The evidence from the available studies was synthesised in the form of a narrative synthesis. Studies were grouped based on geographical location, the type of infectious disease investigated and study design in line with the Synthesis Without Meta-analysis (SWiM) guidelines (Campbell et al., 2020). The studies' results were summarised in a table format as well as descriptively, highlighting the incidence or prevalence rate of the infectious disease investigated. Where possible, comparisons were made across studies investigating the same outcome. However, significant heterogeneity in the investigated outcomes prevented a statistical summary of the results.

3.2.4 Risk of Bias Assessment

The quality and potential bias that may be present in the studies that met the inclusion criteria were assessed with the Newcastle-Ottawa Scale (NOS) (included in Appendix 11), which is an instrument used to evaluate the risk of bias relating to aspects of selection, comparability, and outcome assessment in the included research studies and uses a scoring system between 0 to 9, where the higher scores represent a lower risk of bias (Wells et al., 2021). A version of the NOS modified specifically for cross-sectional study designs validated by Modesti et al. (2016) was also used. This modified version of the NOS is included in Appendix 12.

Figure 1. Prisma flow diagram on study screening and selection



3.4 RESULTS

One hundred and sixty-three articles were retrieved after the initial search of the literature. Of these, 19 were read in full and ten have been included in this systematic review (Figure 1). A study conducted by Botabara-Yap et al. (2023) was excluded since it only focused on COVID-19 vaccination and did not contain any information about COVID-19 disease. The main characteristics of the studies included, and their main results are presented in Table 1.

Of the included studies, one study was conducted in Germany, one in Indonesia, and eight in the United States. Eight of the included studies used a cross-sectional design, whilst one was a commentary that included a report of H1N1 infection rates from a Seventh-day Adventist seminary (Kahleova and Barnard, 2022), and another a longitudinal study (Abris et al., 2024).

3.4.1 COVID-19 infection

One of the studies that dealt with a type of respiratory tract infection was that published by Widiani and Djula (2022), in which the authors interviewed 10 Seventh-day Adventists in Indonesia about their experiences with COVID-19 infection. No statistical analysis was conducted in this study to assess potential associations between COVID-19 severity and lifestyle as the article simply described the experiences of COVID-19 related symptoms of the participants in a qualitative manner. The most common mild symptoms of COVID-19 reported by participants were fever and loss of taste, and the most severe symptoms were shortness of breath and loss of smell. Similarly, Riedel and Trecartin's (2024) study also qualitatively explored the lived experiences of elderly Adventists in relation to the COVID-19 pandemic and mainly focused on the pandemic's impact on participants' spiritual and religious lives. However, this study did not report incidence or prevalence data regarding COVID-19 infection either.

Only one of the included studies reported COVID-19 infection prevalence data, however the authors did not conduct any subgroup analysis relating to the prevalence of COVID-19 infection based on various lifestyle characteristics such as diet. Furthermore, the study did not recruit any non-Adventists as controls (Büssing et al., 2022).

3.4.2 Toxoplasma gondii

Two of the included investigated Toxoplasma gondii (T. gondii) infections. Roghmann et al. (1999) investigated the seroprevalence of Toxoplasma gondii (T. gondii) among Adventists and non-Adventists living in Maryland, US. The researchers hypothesised that Adventists would have a lower T. gondii infection prevalence as a large portion of Adventists do not consume meat and it was anticipated that meat exposure would increase disease risk. The study recruited 251 participants in total, 105 of whom were Adventists and 146 non-Adventists. The control group included local fishermen, workers at a seafood processing plant, and seafood festival visitors. Both Adventists and non-Adventists were required to undergo a blood draw to allow for the determination of blood antibody levels against T. gondii. Of the 250 samples analysed, 31% had evidence of a previous T. gondii infection. Seroprevalence of T. gondii was shown to be significantly lower among Adventists in all age groups compared to the controls (OR 0.21, 95% confidence interval 0.09–0.46, $P < 0.01$). According to the unadjusted analysis, 18% of Adventists and 40% of non-Adventists were seropositive for T. gondii ($p=0.001$). The age-adjusted analysis showed that those over the age of 60 years had the highest seroprevalence; however, those in the Adventist group had a seroprevalence of 30%, whereas those in the control group had a 71% seroprevalence ($p<0.01$). Overall, this study concluded that being a Seventh-day Adventist was linked to a significantly lower risk of T. gondii infection. The major limitation of this study was that it assessed the seroprevalence of antibodies related to shellfish pathogens, therefore the prevalence of T. gondii infection related to other meat products could not be determined from this study.

The results of a previous T. gondii seroprevalence survey published by Leon Jacobs in 1957 found a somewhat higher seroprevalence (21.6%) among vegetarian Seventh-day Adventists, however this earlier study had a smaller sample size (n=46) and did not have a control group, although the author believed that the seroprevalence of the infection among this sample of Adventists was lower than in the general population. The certainty of evidence for the study published by Roghmann et al. (1999) can be considered moderate due to the robust statistical analysis and narrow confidence intervals. In contrast, the evidence certainty for Jacobs (1956) is low because of the absence of a control group and the lack of reported confidence intervals.

3.4.3 *Norwalk virus*, *Vibrio cholerae* and *Vibrio vulnific* seroprevalence

Another serosurvey that was included in this systematic review investigated the prevalence of antibodies against the shellfish associated pathogens Norwalk virus, Vibrio cholerae and Vibrio vulnific (Lefkowitz et al., 1992). Participants were fisherman and Seventh-day Adventists who served as the low-contact or low-consumption group. Of the shellfish workers, 83.7% reported occupational contact with raw shellfish at least once a week, as opposed to only 6% in the Adventist group. The study did not find a significant difference in the seroprevalence of V. vibrio or the Norwalk virus between the two groups, however shellfish workers were found to have a higher seroprevalence of the unencapsulated phase variant of V. vulnificus compared with the Adventist group. Seropositivity was highest for the Norwalk virus in the overall sample at 70%. The certainty of evidence for *Norwalk virus*, *Vibrio cholerae*, and *Vibrio vulnificus* seropositivity is low due to the absence of confidence intervals and insufficient statistical power to detect small differences in seroprevalence.

3.4.4 Helicobacter pylori

The third serosurvey in this systematic review compared the seroprevalence of Helicobacter pylori (H. pylori) among Seventh-day Adventists and two groups of non-Adventists by Hopkins et al. (1990). The recruited Adventists were selected from six congregations on the eastern shore of Maryland, with one of the control groups geographically matched, whilst the other based in Baltimore-Washington. The authors hypothesised that the Adventists' abstention from meat might result in a lower seroprevalence of H. pylori, however the results did not show a difference in the H. pylori seroprevalence between the Adventists (35%) and the non-Adventist controls (35%). This constitutes a low level of certainty due to the lack of confidence intervals and insufficient statistical power.

3.4.5 Other upper respiratory tract infections

The study with the largest sample size included in this systematic review recruited 41,725 participants, all of whom were part of the AHS-2 cohort (Liao et al., 2006). The authors of this study analysed upper respiratory tract infection (URI) risk within a 12-month period and found that there was a 25% reduction in the odds of having a URI (OR 0.75, 95% CI: 0.69–0.82) among those eating seven or more servings of fresh fruits compared to those consuming them once a day or less. Similarly, eating seven or more servings of vegetables was linked to a 20% reduced risk of URIs (OR 0.80, 95% CI: 0.75–0.85) compared to eating two or less servings per day. Importantly, the associations remained unchanged in the models that used statistical adjustments for important confounding variables. The authors concluded that a diet rich in fresh fruits, vegetables and water decreased the risk of URIs. The large sample size, precise effect estimates as reflected by the narrow confidence intervals, and robust statistical adjustments support the certainty of the findings.

A commentary published by Kahleova and Barnard (2022) has also been included in this systematic review as it presents data relating to a Seventh-day Adventist seminary in Minnesota from H1N1 influenza pandemic. The seminary housed 120 students and staff, 90 of whom developed symptoms of H1N1 influenza infection. Infected patients were advised to apply warm compresses on their neck and chest, and they received plant-based meals, which was part of the usual diet provided by the seminary. The diet contained high amounts of fruits and vegetables but also included grains and nuts. None of the infected patients died or developed pneumonia. The article compares the 0% mortality rate to data obtained from U.S. Army camps, where the mortality rate during the H1N1 influenza pandemic was 6.7%, and the rate of pneumonia was 16.7%. The authors conclude that the habitual plant-based diet of the Adventists living at the institution may have contributed to their better survival rate. Furthermore, the article presents data from 10 Adventist hospitals from the same time, where similarly low rates of mortality and pneumonia were observed, however the proportion of Adventists among the treated patients is unknown.

Finally, the latest publication of the AHS-2 cohort included data on infectious disease mortality in Adventists aged 65 and 85, stratified by dietary status (Abris et al., 2024). Vegetarians in the 65-year age group had a significantly lower mortality rate due to infectious diseases than nonvegetarians, however, the study did not specify the exact infectious disease.

Table 1 Characteristics of included studies

Author(s)/year of publication	Location/setting	Study Design	Sample Size	Adventist Lifestyle Characteristics (if mentioned)	Infectious Disease(s) Investigated	Prevalence / Incidence Rates	Key Findings (related to Adventist lifestyle)
Jacobs, 1956	United States of America	Cross-sectional seroprevalence survey	46	Vegetarian diet with no meat	T. gondii	21.6% among Adventists.	No comparison group recruited.
Hopkins et al. 1990	United States of America	Cross-sectional study	262	Vegetarian diet and abstinence from alcohol, caffeine, and meat.	Helicobacter pylori infection	Overall seropositivity rate was 35% in both Adventists and controls.	No difference in seroprevalence, even after multivariate adjustment.
Lefkowitz et al. 1992	United States of America	Cross-sectional seroprevalence survey	258	Abstinence from shellfish, smoking, and alcohol; adherence to a lacto-ovo-vegetarian diet.	Antibodies to Vibrio species and Norwalk virus	Not specified	No significant association between shellfish consumption or contact and Vibrio cholerae O1 or Norwalk virus.antibody response.

Roghmann et al. 1999	United States of America	Cross-sectional seroprevalence study	251	Vegetarian diet	Toxoplasma gondii infection	Adventists: 18% for SDA under 40 years, 19% for 40-60 years, 30% for over 60 years. Control Group: 9% for controls under 40 years, 44% for 40-60 years, 71% for over 60 years.	T. gondii infection risk was significantly lower among Adventists compared with the controls.
Liao et al 2006	United States of America	Cross-sectional analysis using a sample of the AHS-2 cohort	41,725	Not specified	Upper Respiratory Infections (URI)	Fruit, vegetables, and water intake lowered the odds of a URI.	Higher intake of plant foods and regular water consumption is associated with a decreased risk of URI. OR for 7+ servings of fruits (compared to 1 or less) = 0.75 (95% CI: 0.69–0.82) OR for 7+ servings (compared to less than 2) of vegetables = 0.80 (95% CI: 0.75–0.85)
Widiani and Djula 2022	Indonesia	Cross-sectional (interview based qualitative study)	10	Not specified	COVID-19 disease	Not relevant as the study only involved 10 church members, who had COVID-19.	The study describes the common COVID-19 symptoms experienced by church members.
Kahleova and Barnard 2022	United States of America	Report of a Seventh-day Adventist seminary during the H1N1 pandemic	120	Plant-based diet.	H1N1 influenza	No deaths or pneumonia among 90 infected Adventist faculty staff and students.	Lower H1N1 mortality among Adventists than among the US army.

Büssing et al. 2022	Germany	Cross-Sectional Survey	1,494	None	COVID-19	19% of participants reported having had the infection.	No comparison group recruited.
Riedel and Trecartin, 2024	United States of America	Cross-Sectional interviews	10	None	COVID-19	N/a as the study was a qualitative study of 10 elderly Adventists of their experience of the pandemic	No disease prevalance data reported
Abris et al., 2024	United States of America	Longitudinal cohort study of the AHS-2 sample.	12,515	Vegetarian	Infectious disease mortality	HR for vegetarians of mortality due to infectious diseases was 0.57 (95% CI: 0.40, 0.82) as compared with non-vegetarian Adventists	Lower infectious disease mortality observed among vegetarians.

The risk of bias assessment utilizing the Newcastle-Ottawa Scale (NOS) is presented in Table 2, which indicates great variance in the quality and risk of bias among the studies. The study published by Lefkowitz et al. (1992) appears to have the lowest risk of bias with a score of 8. In contrast, Kahleova and Barnard (2022), Riedel and Trecartin (2024) and Widiani and Djula (2022) scored the lowest with only 1, 1 and 0 stars each respectively, indicating a higher risk of bias, particularly due to the low scores obtained in the selection and comparability domains. The rest of the included studies fall in between, with scores ranging from 3 to 7 stars suggesting an overall moderate risk of bias in the reviewed articles.

Table 2 Risk of bias assessment

Study ID	**Selection (max 5 stars)**	**Comparability (max 2 stars)**	**Outcome/Exposure (max 3 stars)**	**Total (max 10 stars)**
Leon Jacobs 1957	1	0	1	2
Hopkins et al., 1990	2	1	2	5
Lefkowitz et al. 1992	3	2	3	8
Roghmann et al., 1999	1	2	2	5
Liao et al., 2006	2	2	2	6
Widiani and Djula 2022	0	0	1	1
Kahleova and Barnard 2022	0	0	1	1
Büssing et al., 2022	1	1	1	3

Riedel and Trecartin, 2024	0	0	1	1
Abris et al., 2024	3	2	2	7

3.5 DISCUSSION

This was the first systematic review that investigated the prevalence of COVID-19 disease and other infectious diseases among Adventists. Due to the presence of significant heterogeneity and the low number of studies focusing on the same infectious disease, quantitative analysis in the form of a meta-analysis was not possible.

Two of the studies assessed the prevalence of T. gondii infection among Seventh-day Adventists, but only one of them had a control group (Roghmann et al. 1999). Seroprevalence of T. gondii, in this study, was lower among the Adventists than among the control group (OR 0.21, 95% CI 0.09–0.46, P 0.0001). The authors' conclusion highlights the potentially protective effect of meat abstinence against T. gondii, which is confirmed by a meta-analysis (Belluco et al., 2017) which showed that eating raw or undercooked meat greatly increases the risk of T. gondii infection. Interestingly, the meta-analysis did not find a significant association between the consumption of unpasteurized milk or raw eggs and the seroprevalence of T. gondii, which may explain how vegetarian Adventists in the included studies, who presumably consume dairy products and eggs, had a lower risk of infection. Household exposure to raw meat and the duration of time on a vegetarian diet among the

Adventists were not assessed in the included studies, both of which are important factors that could have influenced the results.

Furthermore, Roghmann et al. (1999) showed T. gondii seroprevalence was highest among those over the age of 60 in both groups, which is in agreement with the results of a recently published study (Cook et al., 2021) of non-Adventists, which reported that age was a significant risk factor for T. gondii exposure.
The other two seroprevalence studies included in this systematic review did not find evidence for lower seroprevalence among the recruited Adventists as compared to controls. One of the studies investigated the seroprevalence of H. pylori (Hopkins et al., 1990) while the other Vibrio cholera and Norwalk virus (Lefkowitz et al., 1992). Common factors associated with the Adventist lifestyle such as a vegetarian diet, abstinence from smoking, caffeine and alcohol were not shown to be protective. Some have criticized (Sturges, 1991) the findings of Hopkins et al. (1990) as the study did not actually assess the diet of participants so some of the participants may have consumed meat as not all Adventists are vegetarians or vegans.

Of the studies that focused on COVID-19 infection, one of them only recruited Adventists who had already been infected with the virus (Widiani and Djula, 2022), whilst the other recruited a larger sample, 19% of whom had reported a previous COVID-19 infection (Büssing et al., 2022). The latter did not recruit a control group, nor did it conduct a subgroup analysis based on lifestyle factors such as diet since the lower intake of animal-based foods and the consumption of vegan or vegetarian diets have been associated with lower COVID-19 incidence rates (Acosta-Navarro et al., 2024). Furthermore, vegetarian diets have been shown to lower the risk of severe COVID-19 disease (Kim et al., 2021). However, the Adventist lifestyle does not just recommend a vegetarian or plant-based diet, it also advises against alcohol consumption and smoking, both of which have been shown to associate with a lower prevalence of COVID-19 disease and a lower severity of infection (Wei et al., 2023 and Santenna et al., 2023).

Although, it is worth noting that lifestyle adherence, especially in regard to the consumption of a plant-based diet may not be uniform among Adventists. This is confirmed by the findings of McBride et al. (2021) who conducted a global survey of 63,756 Adventists to assess adherence to principles of the Adventist lifestyle. The study showed that only 19% of participants consumed a vegetarian diet, although adherence rates for alcohol and smoking abstinence were over 90%. These findings demonstrate that Adventists, despite some variability in lifestyle, differ from the general American or Western populations, particularly in their higher rates of abstinence from alcohol and smoking. In addition, the AHS-2 cohort showed that over 50% of participants adhered to an either fully or semi-vegetarian diet, which is in great contrast to the estimated 1-4% prevalence rate of vegetarianism in the general population. In fact, the available evidence suggests that non-vegetarian Adventists eat low amounts of red and processed meat compared to the general American population, which indicates that Adventists, in general, maintain healthier lifestyles. However, there may be other factors contributing to the lower disease risk. For instance, Zollinger et al (1984) showed that Adventist women had better breast cancer survival due to their earlier diagnosis, which suggests that Adventists may be more likely to seek medical assistance. However, this has not been confirmed in studies investigating the risk of infectious diseases among Adventists.

The study that had the largest sample size among the included studies showed that the high intake of plant foods and water was associated with a lower risk of URI (Liao et al. 2006). This finding has been confirmed by **latter** studies such as Li and Werler (2009), who reported fruit and vegetable intake was associated with a lower URI incidence among pregnant non-Adventist women.

Finally, the systematic review included a commentary, which reported data from a Seventh-day Adventist seminary with regard to H1N1 influenza prevalence (Kahleova and Barnard, 2022). While this commentary is not a formal scientific study and its results should be considered with caution, the findings reported a lower rate of mortality among the students and staff housed at the seminary compared to the general U.S. population and the U.S. Army. The authors attribute the lower mortality rate in part to the plant-based diet that was provided to everyone at the seminary, this finding has not been confirmed in actual research studies; however, plant-based diets in general can lower the risk of obesity (Turner-McGrievy et al., 2017), which is pertinent since obesity has been linked to an increased risk of respiratory infections (Mancuso, 2013). Future research should prioritize longitudinal cohort studies that stratify Adventists based on their adherence to lifestyle principles such as diet and exercise, along with the timing of diagnosis. This approach would allow for the accurate measurement of the impact of both lifestyle and non-lifestyle factors on the incidence of infectious diseases.

3.5.1 The dual role of religion in the context of infectious diseases

Since religious beliefs and organisations may exert a significant influence on public health, especially during infectious disease outbreaks such as the COVID-19 pandemic, they sometimes have a twofold influence in public health acting as both a force for good and a potential source of challenges. Among the positive contributions are that religious communities can play a major role in addressing infectious disease outbreaks because of their organizational structures, influence, and networks to disseminate public health information and promote adherence to preventive measures. Adventism's influence on aspects of public health related to chronic disease prevention is overwhelmingly positive as evidenced by the numerous research studies showing a lower chronic disease risk among Adventists. The lifestyle characteristics promoted by the church may also help against infectious diseases, however this remains unknown. This lack of research into COVID-19 prevalence among Adventists informed the study outlined in Chapter 4 of this thesis, which was designed to be the first study to investigate the association between the lifestyle and diet of UK Adventists and their risk of COVID-19 disease.

On the other hand, vaccinations are a key variable to be considered in the context of infectious diseases as they can profoundly impact disease risk, however none of the included studies analysed infectious disease prevalence based on vaccination status. In this regard, Olowu (2015) also argues that faith-based organisations (FBOs) often promote less effective HIV prevention strategies such as abstinence or monogamous relationships rather than advocating for the use of condoms and appropriate sexual education. This shows that religion can sometimes hinder public health efforts, especially in the context of infectious diseases, when religious doctrines or teachings conflict with evidence-based practices. On the other hand, the various government departments and agencies involved with public health response to pandemic worked closely and effectively during the Zika virus outbreak, which was an especially sensitive topic as education regarding the sexual transmission of the virus to pregnant women had to be highlighted (Santibañez et al., 2017). For this purpose, the Centres for Disease Control and Prevention (CDC) and US Department of Health and Human Services (USDA) created useful resources for religious leaders such as Priests, Pastors, Rabbis, and Imams, which were to be used to educate their communities about the Zika virus. In fact, faith-based communities were offered the possibility of creating and developing their own informational materials, which could be reviewed by public health officials. The government recognised that because religious leaders usually have close ties with their communities, they have detailed knowledge of their congregations, making them essential partners in emergency response during infectious disease outbreaks, which also applies to Adventist pastors and leaders. Santibañez et al. (2017) believe that Puerto Rico serves as a positive example of the collaboration between health departments and faith-based groups since religious leaders played a key role in identifying pregnant mothers and providing education about the virus within their communities during the Zika virus outbreak, however the study does not mention Adventists specifically. Raising awareness about the use of condoms and even their free distribution to the communities were also part of the collaborative efforts, however not all religious communities were willing to take part in these activities. Again, a compromise was reached, and areas of shared goals were identified, which led to effective collaboration, which further highlights the importance of finding common ground with faith-based communities and utilising their influence in public health. Vaccination has been a controversial topic, where religion and public health guidance have often been at conflict. Although Williams et al. (2020) showed in a study involving U.S. religious leaders that most of their participants held positive attitudes toward vaccination and were open to advocating for vaccines, only half of the clergy promoted vaccination to their congregations. Moreover, the use of ingredients in vaccines that are derived from pork have been shown to be a major barrier to both Muslims (Kibongani Volet et al., 2022) and Jews (Bokek-Cohen and Tarabeih, 2022). Religious exemptions for vaccinations have been more common in recent years, which has led to a steady increase in measles cases since 2014 (Nimblett-Clarke, 2021). Muravsky et al. (2021) argues that the anti-vaccine sentiments against human papillomavirus (HPV), measles and COVID-19 vaccines among religious Jewish communities is not founded upon Biblical principles since the authors argue that principles behind the support for vaccination is rooted in Jewish law as also confirmed by many poskim, who are Jewish legal scholars who decide on the applications of Biblical laws. Most of the studies included in this systematic review did not report on vaccinations, although many of the diseases investigated such as H. pylori or Norwalk virus were not vaccine preventable diseases. The only study included in the systematic review that investigated COVID-19 outcomes reported 70% vaccination rate among the Adventists recruited, which is not an alarmingly low rate, especially considering the fact that the study was published in May of 2022. On the other hand, Botabara-Yap et al. (2023) reported that Adventists had low belief in the vaccine. Support for vaccination from religious leaders has traditionally been a key facilitating factor according to Jacobson et al. (2023), which underlines the importance of involving the topic of vaccinations by Adventist health leaders as part of the church's health promotion activities.

Among the biblical religions, Judaism provides detailed teachings, based on the Bible, with regard to addressing contagious diseases, particularly in the five books of Moses, often called the Torah. Although written thousands of years ago, the Torah outlines measures for identifying and managing infectious diseases such as the use of quarantine and isolation to prevent the spread of these diseases. For instance, the thirteenth chapter in the book of Leviticus states that people who were identified with a specific type of sores were to self-isolate and live outside of the camp of Israel until the sores disappeared. These instructions may be considered one of the earliest documented public health practices.

The cases and examples mentioned in this section serve as historical examples of the beneficial and potentially harmful roles religion has played in infectious disease outbreaks, however Adventism's impact in the UK during the recent COVID-19 pandemic remains mostly unknown. The absence of studies examining the prevalence or incidence of COVID-19 among UK Adventists highlights a clear gap in the literature and underscores the need for further research. Since religion sometimes can have a negative impact in the context of public health as discussed previously, the studies outlined in Chapters 4 and 6 did not only report on COVID-19 incidence among Adventists and non-Adventists but they investigated vaccine uptake, perceptions of vaccine acceptance and views about natural remedies against COVID-19 since these factors are essential for understanding the broader impact of the Adventist diet and lifestyle on COVID-19 outcomes.

3.5.2 Strengths and Limitations

A major limitation of this study is that all of the included studies were cross-sectional in nature, which does not allow for the assessment of disease incidence rates.
Many of the included studies relied on self-reported data concerning dietary habits, whilst one of the studies did not even assess dietary intake, it just assumed the Adventists were all non-meat-eaters (Hopkins et al. 1990), which generally limits the validity of the results.
There are only a limited number of studies investigating infectious disease prevalence rates, which is another potential limitation of this study as it prevents us from drawing robust conclusions. Furthermore, most of the included studies utilised convenience sampling instead of random sampling which could have introduced selection bias in the studies.
In addition, studies investigating T. gondii infection (Roghmann et al. 1999 and Jacobs, 1957) did not assess household exposure to raw meat, which may have led to an underestimation of the exposure's true effect on the outcome.
The limited number of studies and their heterogeneity, especially in terms of the infectious diseases studied, make it very difficult to draw meaningful conclusions. No single infectious

disease was the subject of more than two studies in this systematic review, therefore it was not possible to conduct a meta-analysis. In addition, the review included a qualitative study by Widiani and Djula (2022) which lacked quantitative analysis; however, no restrictions were imposed on the inclusion of qualitative studies, as the number of anticipated articles was expected to be low. Furthermore, the inclusion of the study broadens the scope of the review and provides complimentary information to the quantitative data derived from the other studies.

Most of the included studies were conducted in the U.S. which calls into question the generalisability of the findings to Adventists outside of the United States since the prevalence of infectious diseases might be different outside of the United States. In addition, adherence to the Adventist lifestyle may vary across the globe as it is known that the consuming a plant-based diet is more common in the U.S among Adventist than in other parts of the world (McBride et al., 2021), therefore further studies are required on Adventist populations from outside of the United States.

On the other hand, this was the first attempt to systematically review the literature to synthesize the available evidence concerning the Adventist lifestyle and its potential association with infectious diseases, which provides a broad perspective on this topic and highlights the need for further studies. The synthesis process adhered to systematic principles outlined in the SWiM guidelines (Campbell et al., 2020) and PRISMA guidelines to ensure transparency and reproducibility.

For the above-mentioned reasons, firm conclusions cannot be drawn from this systematic review due to the high heterogeneity and high risk of bias owing mostly to the lack of observational period inherent to cross-sectional study designs, the absence of control groups in many cases, and the lack of rigour in the statistical analyses. Surprisingly, none of the most common respiratory diseases that are caused by infectious agents such as seasonal influenza, pneumonia or the common cold have been investigated among Adventist populations, therefore the potential association between the Adventist diet and lifestyle and the risk of these common infectious diseases, including COVID-19, should be further explored in future studies. Furthermore, future studies should aim to incorporate subgroup analyses based on various aspects of the Adventist lifestyle and contain a duration of follow-up in their designs to allow for the investigation of infectious disease prevalence and incidence rates between Adventists and non-Adventists. Due to the lack of data concerning the risk of COVID-19 among Adventists, the next chapter presents the findings of the first prospective cohort study from the UK, which investigated the risk of COVID-19 infection among Adventists and non-Adventists. The findings of this systematic review informed the design of the study described in the next chapter and several important factors missing from most of the studies evaluated in this systematic review were incorporated to improve the study's quality.

3.6 CONCLUSION

The findings of this systematic review suggest that there may be a potential association between the Adventist lifestyle and a lower prevalence of certain infectious diseases, partly due to the adherence to key aspects of the Adventist lifestyle, such as a plant-based diet and abstention from smoking and alcohol, however data regarding COVID-19 specifically is scarce. This study provides important answers to the overarching aim of this thesis as well as its first objective, which was to investigate how the diet and lifestyle of Adventists may influence COVID-19. The small number of studies and their generally low-quality limit our ability to draw definitive conclusions. Further studies are needed with more robust study designs to confirm if any possible association exists between the Adventist lifestyle and the risk of infectious diseases, particularly COVID-19. Such research could have significant implications for church-based health promotion and could inform the church's health promotion strategies to help in the prevention or management of COVID-19 disease and potentially other infections. However, as this systematic review identified an absence of studies involving UK Adventists, this gap in the search led to the design of a prospective cohort study in Chapter 4, which aimed to compare COVID-19 incidence and prevalence rates among UK Adventists and non-Adventists.

4 Chapter 4. A longitudinal investigation of the incidence of self-reported COVID-19 disease and the pandemic's impact on the lifestyle of Seventh-day Adventists and non-Adventists living in the United Kingdom.

4.1 INTRODUCTION

The aim of this study was to comprehensively assess the potential difference in COVID-19 infection risk between Adventist and non-Adventist participants in order to provide potentially important insights into whether the Adventist lifestyle is associated with a lower risk of COVID-19 infection, thereby providing important answers to the aim of this thesis, which was to assess the impact of the Adventist diet on COVID-19 incidence. There were almost 60,000 deaths caused by COVID-19 disease in the UK between March and December in 2020 and ethnic minority groups were disproportionately affected (Brown et al., 2021). This is relevant as the majority of Adventist church members in the UK are of black ethnicity (Tomlinson, 2018), which means that investigating the risk of COVID-19 disease among UK Adventists may provide important insights for church-based health promotion.

This study also assessed how the global pandemic and the government restrictions associated with COVID-19, which resulted in church closures around the United Kingdom for over a year, have affected the lifestyle and practises of Adventists compared to non-religious people, and whether Adventists were more or less likely to report changes to their diet, bodyweight, and lifestyle during the pandemic. The unexpected occurrence of the COVID-19 pandemic and the lockdowns imposed by governments around the world led to disruptions in food supplies and caused major issues with food availability and accessibility (Jafri et al., 2021) and had a significant impact on people's eating habits and mental health. Freedman et al. (2022) showed that adults in the US gained more weight during the COVID-19 pandemic than in previous years, but it is unknown whether Adventists in the UK experienced the same trend in weight gain or if they were protected from it due to their health-conscious lifestyle. Therefore, this study investigated how these factors associated with the COVID-19 pandemic impacted the lifestyle and health of Adventist and non-Adventists.

Thereby, this study relates to the overarching theme of this thesis, by directly assessing the relationship between the Adventist diet and lifestyle and COVID-19 infection risk and fulfils the second objective of the thesis as highlighted in Chapter 1, which was to compare the COVID-19 infection risk of Adventists and non-Adventists living in the UK and assess how diet and vaccination status mediate the risk.

4.2 METHODS

4.2.1 Participants

Initial data collection for this study began in September 2021 and closed in March 2022. The follow-up survey was sent to consenting participants via email in February of 2024.

At the time of recruitment, Adventist churches were under nationwide closures due to the COVID-19 pandemic, therefore the survey was disseminated online, and it also meant that the study used a convenience sampling method, such that any Adventist who wished to participate by filling out the online survey was allowed to do so.

The minimum sample size required for each group of Adventists and non-Adventists was determined to be 38, which allowed for the detection of clinically significant difference in the risk of COVID-19 infection between Adventists and non-Adventists with 80% power at the level of significance of 5%. This was based on the results of a systematic review which suggested that participants following healthy dietary patterns such as the Mediterranean diet, healthy plant-based diets, or the DASH (Dietary Approaches to Stop Hypertension) diet had an up to 77% decreased risk of COVID-19 infection (Sharma et al., 2023). Since Adventists are also encouraged to eat a healthy diet, it was assumed that the effects observed for the healthy diets in the systematic review could reasonably be expected in the Adventist population as well, therefore the results of this systematic review were deemed appropriate for the power calculation.

The sample size was calculated using the below formula taken from Sakpal (2010), which is suitable for comparing two proportions:

$$n = [(Z_{\alpha/2} + Z_{\beta})^2 \times \{(p1\ (1\text{-}p1) + (p2\ (1\text{-}p2))\}]/(p1 - p2)^2$$

In this formula, $Z_{\alpha/2}$ (1.96) and Z_{β} (0.85) are critical values related to the statistical power and significance level used, whereas p1 represents the estimated proportion of COVID-19 infection in Adventists, and p2 is the same risk among non-Adventists. The estimated COVID-19 infection rate for non-Adventists was based on the results of a cohort study of UK healthcare workers who had a COVID-19 infection prevalence of 31.6% (Grant et al., 2020), which may not have correctly represented the COVID-19 risk of Adventists since healthcare professionals were at a higher risk of infection, however comprehensive data on COVID-19 infection rates within the general UK population were limited at the time of study design and Grant et al. (2020) offered a concrete and accessible estimate. This approach was a pragmatic decision based on the best available prevalence data at the time.

The questionnaire was created electronically using the website onlinesurveys.co.uk. The survey included a food frequency questionnaire (FFQ) and a 24-hour diet recall. Additionally, participants were asked to provide information regarding their general medical history and lifestyle through a series of questions. The survey link was disseminated on various social media platforms, including Facebook groups and Instagram. Furthermore, the survey was also made available in the Adventist church news magazine known as the 'Adventist News'. The online survey was self-administered by the participants as Adventist churches were still closed at survey launch and the survey took an estimated 10 minutes to complete.

Non-Adventists were recruited to serve as a comparison group. They were also recruited on social media platforms such as Facebook and Instagram, and they filled in the same survey by accessing the same link.

4.2.2 Ethical approval

This study was approved by the Faculty of Health, Education and Life Sciences Ethics Committee at Birmingham City University. Participants were given a Participant Information Sheet, included in Appendix 3, which informed them of the details of the study, and the data privacy measures that would be used to handle their data. Participants' informed consent was obtained for this study. The consent form for this study is included in Appendix 4.

4.2.3 Questionnaire Development

The food frequency questionnaire utilised in this research was adapted from the validated FFQ, which was used in the EPIC-Norfolk Study (Epic-Norfolk (no date)) since participants in that study were also from the UK and were asked questions regarding the frequency of consumption of various animal- and plant-based products. The food frequency questionnaire of the survey consisted of three sections. The first section included common food items, whereas the second part of the FFQ measured the consumption of meat and meat alternatives. The final section assessed the frequency of nutritional supplement use as well as the consumption of alcoholic and non-alcoholic beverages. The full questionnaire is included in Appendix 1 and 2 of this thesis.

Moreover, participants' lifestyle habits and behaviours during the COVID-19 pandemic were also evaluated by utilizing a questionnaire developed by Visser et al. (2020), which aimed to assess the impact of the pandemic on participants' nutritional habits and physical activity. The Participant Information Sheet provided detailed instructions about how participants were to measure their waist and hip circumferences, ensuring accurate data collection for further analysis.

This study also assessed COVID-19 vaccination status for two key reasons. The first is that vaccines are a major confounding variable when investigating the relationship between the risk of COVID-19 and the Adventist lifestyle, therefore it needs to be taken into account during statistical analysis. The second reason is there have not been any published studies in the United Kingdom that investigated the prevalence of vaccine hesitancy among Adventist church members. Vaccination practices are decisions influenced by personal beliefs and attitudes about health, which are closely related to the lifestyle of Adventists, therefore analysing vaccine acceptance could provide valuable insights into how lifestyle factors may influence vaccination practices among Adventists. Given that the Seventh-day Adventist church is considered to be a conservative Christian denomination that interprets the Bible in a literal sense, its teachings could significantly impact the views and beliefs of church members, including their attitude towards vaccinations. For instance, the uptake of vaccines developed with the use of aborted foetal cell lines have been reported as a potential moral issue for Christians (McKenna, 2018), which may also be the case for some Adventists. Investigating vaccine uptake between Adventists and non-Adventists could provide useful information in the context of the Health Belief Model, which is the theoretical framework of this thesis, which would suggest that perceptions of vaccine benefits and dangers would influence vaccine uptake.

In order to determine the waist-to-hip ratio (WHR) values for each participant, the self-reported measures of waist and hip circumferences were used. These values were then calculated, following the cut-off values recommended by the World Health Organisation (WHO) in 2016 (Fauziana et al., 2016). This comprehensive approach allowed for the collection of detailed self-reported information about participants' dietary patterns, supplement intake, and lifestyle factors, providing valuable insights into their overall health status.

4.2.4 Statistical Analysis

All statistical analysis was conducted in SPSS version 29.0.1.1. The Kolmogorov-Smirnov test of normality was used to assess the distribution of continuous variables since this test is more appropriate for samples with over 50 participants than the Shapiro-Wilks test (Mishra et al., 2019). The distribution of continuous variables was also assessed visually using a histogram and in the case of the variables age, BMI and weight normal distributions were determined by the visual assessment of the variable, which showed a normally shaped bell-shaped curve, rather than relying on the probability values, which in these cases were $p<.05$. This is an acceptable practice as normality tests can sometimes be overly sensitive and graphical assessment of the histograms in certain cases may be more advantageous (Mishra et al., 2019). For the rest of the continuous variables both the Kolmogorov-Smirnov test and the visual assessment of the histograms confirmed normal distributions.

Independent-samples t-test was used to compare the mean of a continuous variable between the two categories of a categorical variable, whereas analysis of variance (ANOVA) was used if the categorical variable had more than 2 groups. For these tests, the equality of variances was tested with Levene’s test (Levene, 1960).

Multivariate ANOVA (MANOVA) was used to test whether there were any differences in the mean BMI, WHR and waist circumference values between Adventist and non-Adventist participants. Pillai’s trace was used in place of Box’s M to test the equality of covariance matrices for the MANOVA test as Pillai’s trace is less sensitive to departures from the assumption of normality.

The Pearson Chi-square test of independence was utilised to test for potential associations between categorical variables with at least 2 categories. Fisher's exact test was used if the expected count in any cell was less than 5. Phi was used as an effect size indicator, where 0.1 counted as a small effect, 0.3 as a medium effect, and 0.5 as a large effect. For variables with more than 2 categories Cramer’s V was used as an effect size.

Potential linear associations between two continuous variables were investigated using the Pearson correlation. Assumptions such as homogeneity of variances and linearity were checked before conducting the test.

Odds ratios for COVID-19 infection with corresponding 95% confidence intervals were calculated for specific food items with sufficient contrasts in intake from the FFQ data. Vegans, vegetarians and pescatarians were combined into a single variable 'plant-based' in some of the statistical analyses. Currently, there is not a uniform definition of a plant-based diet in the scientific literature. According to a review, 50% of the studies that have used the term referred to a vegan diet, which excludes all animal products. On the other hand, the rest of the studies have used the term to define a diet without the regular use of meat products, which may include vegetarian diets, which allow for the consumption of dairy and eggs, pescatarian diets, that can include the consumption of fish, and semi-vegetarian diets, which may allow the infrequent consumption of any kind of animal product (Storz, 2021). For the purposes of this study, the term plant-based was used to include vegan, vegetarian or pescatarian diets.

COVID-19 disease incidence rates for Adventists and non-Adventists were calculated from the follow-up data collected at 2 years using the below formula and were expressed as a rate per 1,000 person-years:

Incidence rate= (number of new cases/person years) x 1,000

Last Observation Carried Forward (LOCF) imputation was used for missing data on the follow-up questionnaire to account for the missing values, which is a method used in longitudinal designs where the last observed non-missing value is used for a participant as the LOCF method assumes that the responses provided are constant.

Multinomial logistic regression analysis was used to assess the potential association between COVID-19 symptom severity and plant-based dietary status. Furthermore, logistic regression was used to test whether diet status, religious affiliation and vaccination status predicted COVID-19 infection risk.

For regression analysis, the assumptions of multicollinearity were checked using the collinearity statistics variance inflation factor (VIF) and tolerance. Evidence of significant multicollinearity was concluded if the VIF value was above 10 or the Tolerance below 0.2, however this was not the case in any of the analyses.

4.3 RESULTS

4.3.1 Characteristics of Adventist vs. Non-Adventist Participants

Participants' characteristics are summarized in Table 3. In total 170 participants filled in the online survey at baseline, 86 of whom were Adventists and 84 were non-Adventists. Adventists were significantly older (36.5 years, SD 13.3)) than non-Adventists (28.3 years, SD 5.9 ($p<0.001$), but their weight ($p=0.69$) or BMI ($p=0.69$) was not significantly different from non-Adventists'.

Table 3 Participant characteristics comparing Adventists to non-Adventists

Characteristic	**Adventists**	**Non-Adventists**
Gender (n)		
Female	63	59
Male	23	25
Age (years)		
Mean ± SD	36.55 (13.34)	28.34 (5.92)
Weight (kg)		
Mean ± SD	68.12 (17.35)	70.43 (17.76)
BMI		
Mean ± SD	23.68 (4.59)	23.80 (5.17)
Education Level (n)		
GCSEs or below	8	9
A-levels or equivalent	10	13
Undergraduate degree	32	35
Masters degree	25	20
Doctorate	5	1
Ethnicity (n)		

African Black	9	0
Black Caribbean	29	16
White British	4	27
White European	37	30
White Other	2	0
Asian Other	2	11
Salary (n)		
£0-£29000	40	64
£29000-£49000	26	9
£50000+	12	2
Plant-based, n=163 (%)	57 (70)	33 (41)

The rate of smokers was similarly low in both groups (p=0.16).

Fifty percent of Adventists were lifelong Adventists, meaning they were born into an Adventist family, and have remained Adventist ever since.

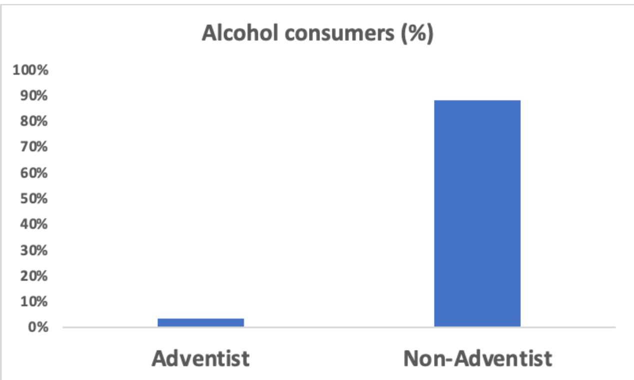


Figure 2. Percentage of respondents ever consuming alcohol among Adventists and non-Adventists.

Alcohol consumption was strongly correlated with being a non-Adventist ($p<0.001$) as indicated by the large effect size of Phi = 0.85 (Figure 2), however it was not dependent on male and female genders ($p=0.916$). Furthermore, Adventists were also significantly less likely to drink coffee compared to non-Adventists ($p=0.001$, Phi 0.46).

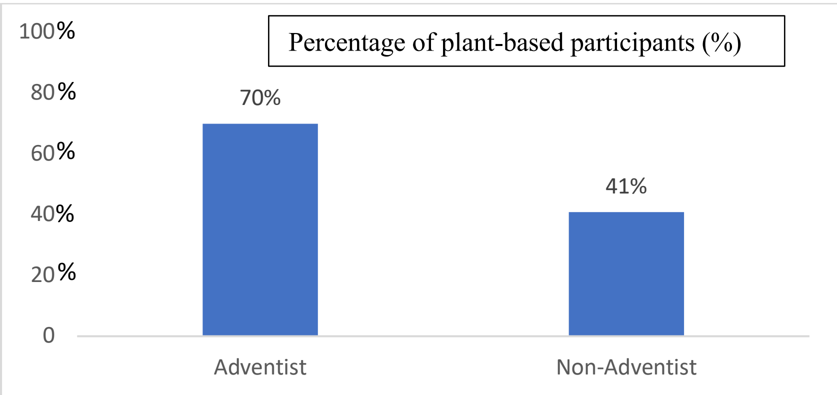


Figure 3. Percentage of respondents (%) following a plant-based diet among Adventists and non-Adventists.

There was a significant association ($p = 0.02$, Phi 0.263) between being an Adventist and the consumption of a plant-based diet as revealed by the Pearson Chi-square test (Figure 3), however following a plant-based diet was not significantly associated with the prevalence of COVID-19 infection at baseline (OR 0.79, 95% CI 0.41, 1.51), although incidence was significantly influenced by dietary status, which will be discussed in a later section of this thesis.

Forty-nine percent of Adventists indicated that they practised fasting and were shown to be significantly more likely to practice 24-hour fasts at least once a year than non-Adventists ($p=0.001$, Phi 0.34). Fasting, however, was not associated with a lower bodyweight. Including all participants in the analysis, the BMI of those that fasted regularly (Mean 24.6, SD 5.2) was not significantly different than that of participants who did not practise fasting (Mean 23.3, SD 4.7) ($p=0.10$). Compared to participants who never fasted, those in the third quintile (once every 2 months) of fasting frequency had a significantly lower risk of COVID-19 at baseline (OR 0.26, 95% CI 0.07-0.094, p=0,039), however fasting frequency only explained 5.4% of the variance in COVID-19 infection (Nagelkerke R Squared: 0.054). Other fasting frequencies were not significantly associated with the risk of COVID-19 infection.

4.3.2 Plant-based vs. non-vegetarian

Of the survey participants, 17.3% consumed meat every day and 25% at least 3 times a week. In contrast, 39.9% of the participants said they did not eat meat at all.

The percentage of adherents to various diet patterns is shown in Figure 4 below. As the figure indicates, the largest group consisted of participants who ate a varied diet of plant and animal foods (n=50). The second most popular dietary pattern among participants was the vegan (n=42) diet, followed by flexitarians (n=27) and vegetarians (n=25).

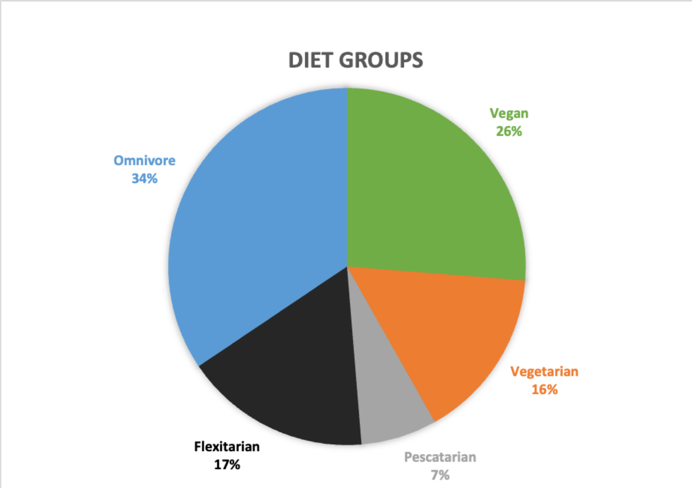


Figure 4. Percentage of participants (%) following various dietary patterns in the whole sample.

Multivariate ANOVA showed that Adventists' body mass index (BMI) (23.2, SD 4.6) was not significantly different from that of non-Adventist participants (23.2, SD 5.1) (p=0.99). Similarly, there were no differences in the waist-to-hip ratios between Adventist (mean 0.83, SD 0.14) and non-Adventist (mean 0.83, SD 0.11) participants either (p=0.89) and neither were there any significant differences in the waist circumference values between Adventists (mean 74 cm, SD 15.4 cm) and non-Adventists (mean 78.7 cm, SD 12.7 cm) (p=0.09, Pillai's trace p=0.146).

We also compared the mean BMI and waist circumference values between plant-based and omnivore participants. For this, participants following various dietary patterns were grouped into two categories of plant-based and non-plant-based groups (Figure 5).

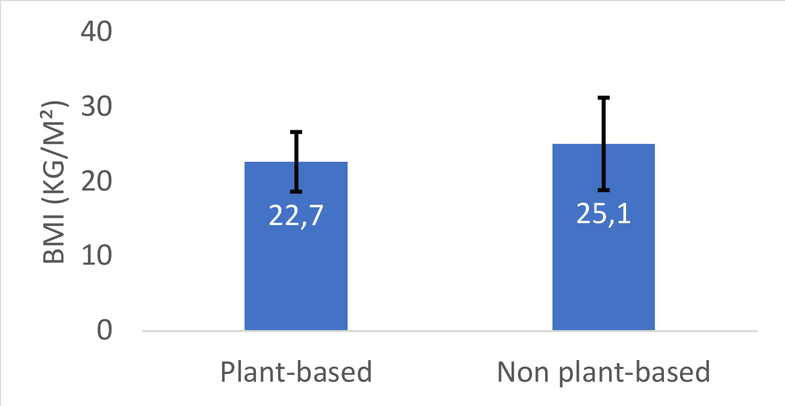


Figure 5. Comparison of mean Body Mass Index (BMI) between those following plant-based vs. omnivorous diets.

The independent-samples t-test showed that the mean BMI of those eating a plant-based diet was (22.51, SD 3.9) significantly lower than that of those eating a more animal-based diet (25.06, SD 5.7) ($p=0.001$) and there was no evidence of a linear association between age and BMI (Pearson's $r = [0.11]$, $p = [0.16]$). The Levene's test confirmed equal variances across both groups ($p=0.11$)

4.3.3 The consumption of meat and meat alternatives

The most consumed meat product amongst the study participants was chicken, which was consumed by 10% of respondents at least once a day. Fish, pork, and other red meat such as beef or lamb were consumed by 1.9% of participants at least once a day. Over 40% of participants did not consume meat in this sample.

4.3.4 Physical Exercise

Figure 6 presents the percentage of participants engaging in regular exercise. Of the 78 Adventists, who answered the question regarding physical exercise, 68% confirmed that they had engaged in regular physical activity, as opposed to 64% among non-Adventist. Adventists were just as likely to exercise regularly as non-Adventists (p=0.62). Exercising regularly at least three days a week was not associated with BMI (p=0.90). Of the participants, 160 responded to the question assessing the use of an activity tracking device. Just over 43% reported to have used an activity tracking device, however users of these devices did not have a significantly different BMI than non-users (p=0.59). Furthermore, being sedentary did not have an influence on participants' waist circumference size (p= 0.84).

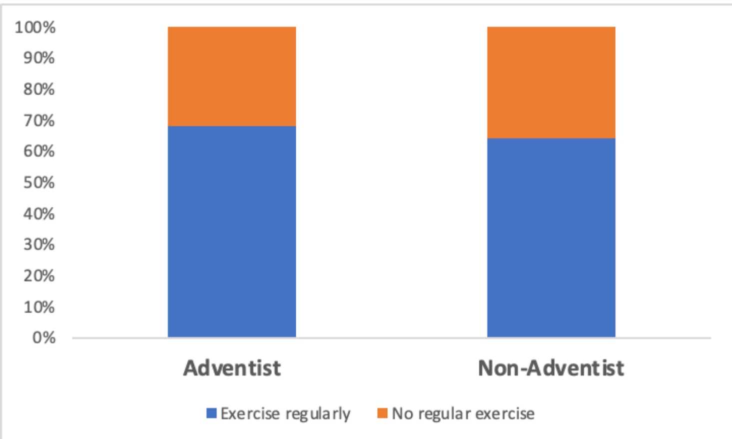


Figure 6. Frequency (%) of regular exercise between Adventists and Non-Adventists

4.3.5 Meal Timing

No associations between gender and consuming dinner after 6 pm (p=0.31) were shown, however Adventists were more likely to consume dinner before 6 pm than non-Adventists (p=0.002). Participants consuming breakfast regularly before 10:00 am had a lower BMI (Mean 19.3, SD 11) than those consuming breakfast later than 10:00 am (Mean 24.4, SD 4.8), however the association was not significant (p=0.50). On the other hand, those participants who regularly consumed dinner after 6 pm had a significantly (p=0.05) greater BMI (25.2, SD 5.1) than those eating dinner before 6 pm (23.3, SD 4.8) as shown on Figure 7.

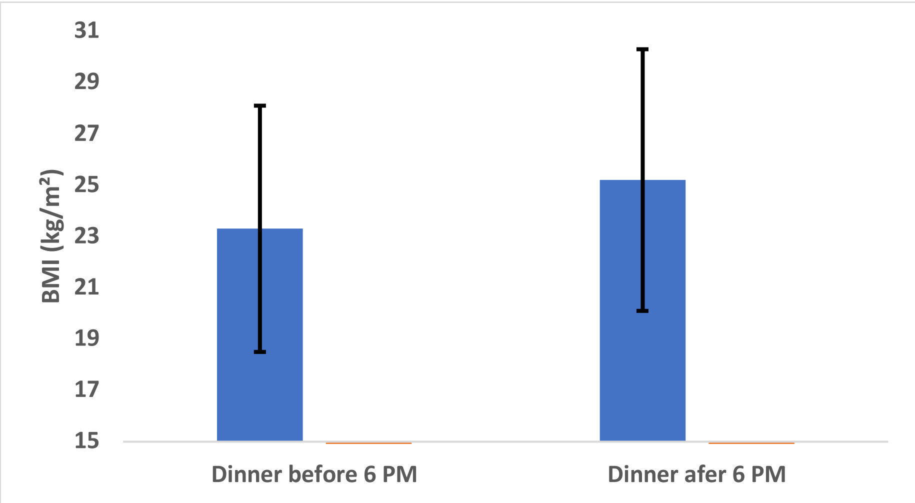


Figure 7. Mean BMI of participants eating dinner before vs. after 6 PM

4.3.6 COVID-19 pandemic

At baseline, 165 respondents provided information about previous COVID-19 infection, of whom 64% stated that they had not been diagnosed with COVID-19 disease, and 36% of respondents stated that they had been diagnosed with the disease before completing the survey as shown in Figure 8.

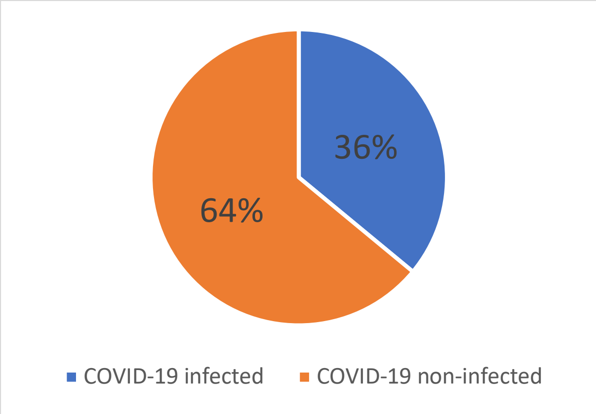


Figure 8. Prevalence of COVID-19 infection at baseline (expressed as a percentage of the total sample)

Of those who had tested positive for COVID-19, 84% of participants suffered mild symptoms and 6% of participants reported no symptoms. It was not possible to examine whether vaccinated participants had milder symptoms than unvaccinated participants because information on the date of infection and vaccination was not obtained, so temporality could not be determined.

The mean BMI of participants with a COVID-19 diagnosis at baseline was 24.4 (SD 4.7), while the mean BMI of participants who did not have a COVID-19 diagnosis was 23.4 (SD 5.0), but the difference between groups was not significant ($p=0.94$).

4.3.7 Vaccination rate

Of the 170 participants, 158 answered the questions about COVID-19 vaccinations. At the time of the baseline survey, 67% of respondents confirmed that they had received at least one dose of a COVID-19 vaccine, while 33% of respondents had not been vaccinated against COVID-19. A weak negative association was shown between being an Adventist and having at least one COVID-19 vaccination (p=0.05, Phi -0.15) such that Adventists were 23% less likely to have been vaccinated compared to non-Adventists (OR 0.77, 95% CI 0.54, 0.96), however ethnicity was not associated with vaccination status (p=0.21). Of all the Adventists recruited, 45% had not received a COVID-19 vaccine at baseline as shown in Figure 9.

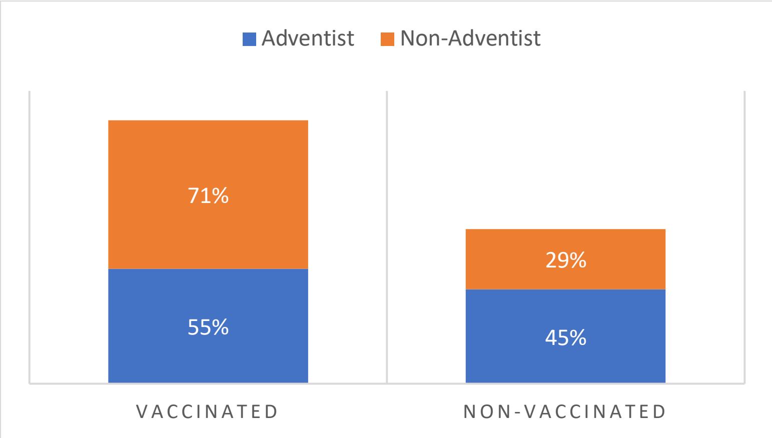


Figure 9. Proportion of vaccinated and non-vaccinated individuals among Adventists and non-Adventists.

4.3.8 Education and Vaccination Status

Vaccination status was not dependent on education level, as there were no differences in vaccination rates between those who had at least a university degree and those who did not attend university (Pearson's chi-square test p=0.791). Furthermore, vaccination status was also not dependent on gender (p=0.86). Of the 106 vaccinated persons, 76 were female and 30 were male.

4.3.9 Vaccination and Self-Reported Adverse Events

Among those who had reported receiving a COVID-19 vaccine at baseline, 49.5% reported experiencing an adverse reaction. The most common adverse effects were fatigue (8 reports), fever (26 reports), pain at the injection site (21), but menstrual cycle changes were also reported by 8 women, representing 7.5% of all vaccinees or 10.5% of vaccinated women, as well as 6 reports of dizziness and 4 reports of abnormal heart rate.

4.3.10 Health Impact of Pandemic Measures

The impact of the pandemic measures on participants' mental health and daily lives were assessed. Four and a half percent of respondents confirmed a diagnosis of anxiety or depression after the start of the COVID-19 pandemic and 47.1% of respondents stated that they had experienced more anxiety than before the pandemic. Furthermore, 37.3% of participants confirmed that they had felt more depressed after the start of the pandemic than before. Fifty percent of all respondents answered 'yes' to the question "Do you use meditation as a stress management technique", and 47% of participants reported to have used prayer for the same purpose, however all of the Adventists selected prayer as a stress management technique. Furthermore, there was a significant association between being an Adventist and practising praying for stress relief ($p<0.001$, Phi 0.61). Singing ($p<0.001$, Phi 0.32), reading ($p<0.001$, Phi 0.741) the Bible as stress management practices were also associated with being an Adventist. Other commonly used stress management techniques were exercise, which was practised by 87% of those responding to this question, and talking to someone, which was utilised by 89% of respondents.

The Pearson Chi-Square test did not reveal a significant relationship between being an Adventist and feeling more depressed ($p=0.19$) during the pandemic. It was tested whether exercise frequency was associated with the risk of experiencing depression, however there was not any evidence of an association (p=0.49).

Adventists were 37% less likely to experience increased anxiety than non-Adventists (OR 0.63 95% CI 0.45-0.86) due to the pandemic. Including Adventist status and plant-based status in the model, only being an Adventist was significantly associated with the lower odds of anxiety during the pandemic (p=0.005), while dietary status was not (p=0.636) (Nagelkerke R Square: 0.76).

Logistic regression confirmed that age was significantly negatively associated with anxiety experienced during the pandemic such that for each one-year increase in age, there was a 5.4% decrease in the odds of experiencing more anxiety (OR 0.946, 95% CI 0.912-0.982). Females were almost three times as likely to experience more anxiety in the same model (OR 2.96, 95% CI 1.38-6.37).

Participants' spiritual lives did not seem to be impacted by the pandemic due to church closures (p=0.63).

In the overall analysis, being an Adventist was not associated with weight gain during the pandemic (p=0.31), however vegetarian Adventists were significantly less likely than non-vegetarian Adventists to increase their weight during the pandemic (OR 0.38, 95% CI 0.17, 0.85). Calorie intake did not seem to impact Adventists and non-Adventists differently (p=0.97) as most (n=130) participants reported no change in calorie intake during the pandemic. Only 30 participants stated that they consumed more calories because of the pandemic, however they were evenly distributed between the two groups.

In general, regular meat eaters in the whole sample were 43% less likely to maintain or lose weight during the pandemic (OR 0.57, 95% CI 0.42, 0.78).

No significant association was observed between the COVID-19 pandemic and sleep time (p=0.69).

Food availability during the COVID-19 pandemic is an important factor that could have influenced diet and lifestyle since limited access to groceries and commonly consumed food items may have caused significant changes to participants' usual lifestyles, potentially impacting their dietary habits and thus indirectly influencing COVID-19 infection risk. At baseline, 41% of participants reported that they sometimes faced increased difficulties in obtaining groceries during the pandemic, and this was not influenced by socioeconomic status when comparing those with an annual household income of below £29000 to those with higher income (p=0.34). In addition, food availability did not disproportionately impact Adventists (p=0.08). By reporting on food availability challenges experienced by participants during the pandemic, the thesis provides a broader understanding of the external factors that may have impacted the dietary habits of Adventists and non-Adventists, thereby providing relevant context for interpreting outcomes relating to COVID-19 disease risk during this period.

4.3.11 Supplement use and COVID-19

The prevalence of self-reported COVID-19 disease was significantly lower among those participants who used daily multivitamin supplementation (OR 0.46, 95% CI 0.24, 0.89, p=0.03). This association shows that multivitamin use might improve immunity and overall health, thereby lowering susceptibility to infections, including COVID-19. However, it is important to note that this association does not infer causality, since the association relies on cross-sectional data and there may be other confounding factors, such as healthier lifestyle choices among multivitamin users, which might influence COVID-19 risk. Logistic regression showed that the fifth quintile, representing daily use of multivitamins, showed a significant protective effect (p=0.012) with an odds ratio of 0.246 (95% CI 0.08-0.734, Nagelkerke R Squared 0.119).

Furthermore, supplementing vitamin D at least 2-4 times a week to daily was not associated with significantly reduced odds of COVID-19 disease (OR 0.510, CI 0.21-1.22). In addition, vitamin D supplementation did not have a significant effect on self-reported COVID-19 disease severity (OR 3.2, 95% CI 0.735, 13.94) either. Finally, vitamin B12 supplementation was not associated in any way with the odds of COVID-19 disease (OR 0.97, 95% 0.5, 1.9). The insignificant findings for vitamin D and B12 could partially be attributed to the lack of statistical power to detect a significant difference owing to the low number of individuals in the first quintile of intake (n=23). Also, the questionnaire did not ask participants to provide the exact doses used of these nutrients, which can also influence the results as certain doses may not be sufficient to provide protection against the disease.

Only 28% of Adventists supplemented vitamin D, and only 32% used some form of vitamin B12 supplementation. Adventists were significantly less likely to take vitamin D supplements (OR 0.72, 95% CI 0.59, 0.88). In addition, Adventists were significantly less likely to use protein powders (OR 0.59, 95% CI 0.38, 0.92). Only 10% of Adventist subjects reported using them regularly. Thirty-four percent of all participants who responded to the question about protein supplementation stated that they regularly consumed protein supplements (2 days/week to daily). There was a significant association between regular exercise and protein supplementation, such that those who exercised regularly were significantly more likely to supplement protein ($p < 0.001$, Phi=0.340). Multivitamins were used daily by 64 participants. Adventists were not more likely to use dietary supplements (p=0.58), however subgroup analysis suggested that plant-based Adventists were significantly less likely to take multivitamin (OR 0.33, 95% CI 0.12, 0.91) supplements than omnivore Adventists

Plant-based participants used more B12 supplementation than those eating meat on a regular basis ($p<0.001$, Phi=0.332) when considering all participants in the analysis.
Finally, almost a third of the Adventist respondents used herbal supplements regularly ($p=0.51$).

4.3.12 Food Items and the risk of COVID-19 disease

The risk of COVID-19 disease among the highest and the lowest consumers of specific food items is included in Table 4. These food items were selected because they showed sufficient contrast in consumption patterns, with enough participants falling into the extreme high and low consumption categories. In other words, these were the food items that had enough participants in the extreme categories based on the frequency of consumption to be able to compare disease outcome rates between the highest vs. lowest groups, whereas the rest of the food and drink items did not have sufficient contrasts, and most consumers tended to fall into the same quintile or quantile of consumption.
Most foods and beverages did not have a statistically significant influence on the risk of COVID-19 as indicated by the 95% CIs crossing 1, however red meat and alcohol consumption were significantly associated with COVID-19 risk. Participants who 'ever' consumed alcohol had a 34% increased risk of disease compared to those who reported never consuming alcohol, whilst consuming red meat at least on a weekly basis had almost a two-and-a-half-times higher risk of having a COVID-19 diagnosis than those consuming it less often.
Including both alcohol consumption and red meat intake in the logistic regression model showed that 8.9% of the variance in COVID-19 infection could be explained by these two variables (Nagelkerke R Square: 0.089).

Table 4 Odds Ratios (OR with 95% confidence intervals) of highest vs. lowest consumers of food items and the risk of COVID-19 disease

Food item	**COVID-19 disease (OR, 95% CI)**
Cow's Milk	0.97 (95% CI 0.36, 2.65)
Whole Grain bread	0.94 (95% CI 0.32, 2.77)
Oats	2.83 (95% CI 0.55, 14.72)
Lentils and pulses	1.57 (95% CI 0.52, 4.71)
Fruits	0.62 (95% CI 0.16, 2.49)
Nuts	2.50 (95% CI 0.91, 6.80)
Alcohol	**1.34 (95% CI 1.13, 1.50)**
Chicken	1.70 (95% CI 0.81, 3.55)
Fish	0.90 (95% CI 0.28, 2.92)
Coffee	1.80 (95% CI 0.74, 4.37)
Herbal Tea	0.75 (95% CI 0.46, 1.92)
Red meat	**2.37 (95% CI 1.06, 5.29)**
Butter	1.21 (95% CI 0.41, 3.56)

4.3.13 2-year follow-up

The follow-up survey was sent to all consenting participants via email and contained 11 questions, mostly collecting information about COVID-19 infection incidence and symptom severity, change in dietary supplement use, and uptake of additional COVID-19 vaccination during the follow-up period. The full list of questions included in the follow-up survey is shown in Appendix 8. The questionnaire was filled in by 154 out of the 170 individuals who completed the baseline questionnaire, which means 16 were lost to follow-up. Of those participants who did not respond to the follow-up survey, 4 were Adventists and 12 were non-Adventists, which means data were available for 82 Adventists and 72 non-Adventists in total.

4.3.13.1 Infection incidence

With regard to COVID-19 disease risk, there were no significant differences in COVID-19 prevalence between the two groups (p=0.13), however 11 Adventists and 19 non-Adventists reported having had a COVID-19 infection during the observational period, which represents a significantly lower infection incidence among Adventists (OR 0.45, 95% CI 0.2, 1.0, p=0.05). This meant that the disease incidence rate among Adventists was 65.48 per 1,000 person-years and 121.79 per 1,000 person-years among the non-Adventists. Ethnicity was not associated with COVID-19 risk among Adventists (p=0.19).

Ten participants (33.3%) were plant-based, and twenty (66.7%) were meat-eaters of those who reported a COVID-19 infection during follow-up. Using logistic regression analysis, we analysed the risk of COVID-19 infection with diet (vegetarian vs. omnivore) and religious affiliation (Adventist or not) included in the model, which showed that 92% of the variance in COVID-19 infection could be attributed to these two predictor variables (Nagelkerke R Square 0.92). The results of the logistic regression analysis showed that diet was the only significant predictor of COVID-19 infection (OR 0.39, 95% CI 0.16, 0.94), whilst being an Adventist wasn't (OR 0.55, 95% CI 0.23, 1.3). Furthermore, in a separate model including dietary status (plant-based vs. omnivore), religious affiliation (Adventist vs. non-Adventist) and vaccination status (vaccinated vs. unvaccinated), the only significant association found was for a lower risk of COVID-19 among plant-based participants (p=0.03, OR 0.38 95% CI 0.16-0.93), whereas the effects of religious affiliation (p=0.17) and vaccination status (p=0.79) were not significant. There was no evidence of multicollinearity as the highest VIF value was 1.14 and the lowest Tolerance value was 0.88.

4.3.13.2 Vaccine uptake

During follow-up, 6 of the Adventists and 9 of the non-Adventists took a new dose of a vaccine against COVID-19 infection, but the difference was not statistically significant between the groups (p=0.28). Moreover, no differences in vaccination rates were found between vegetarians and non-vegetarians (p=0.89).

4.3.13.3 Symptom severity

The proportion of participants experiencing mild, moderate, and severe symptoms of the infection are presented in Figure 10.

Ten participants reported mild symptoms such as a slight cough, mild fever, or fatigue. Eight participants reported experiencing moderate symptoms that included persistent cough, moderate fever, and noticeable fatigue that limited daily activities. Finally, 12 participants reported experiencing severe symptoms such as difficulty breathing, high fever, severe fatigue, and chest pain. A borderline statistically significant negative association was shown between vegetarian status and severe COVID-19 by multinomial logistic regression with a chi-square of 5.828 (2 df, n=30, p=0.05). Nagelkerke's R-squared value showed that 19.9% of the variance in COVID-19 symptom severity could be explained by plant-based or omnivore status. However, the odds ratios were non-significant for vegetarian status and mild ((Exp(B) = 0.222, 95% CI 0.02, 2.42) or moderate symptoms ((Exp(B) = 3.33, 95% CI 0.515 to 21.584) compared to severe symptoms in comparison to meat-eaters.

4.3.13.4 Long COVID symptoms

Participants were also asked whether they experienced any persistent symptoms of COVID-19 following infection. Eight Adventists and twenty non-Adventists reported suffering from symptoms that persisted and remained for a longer period after the initial infection, a difference which was significant between the groups (OR 0.30, 95% CI 0.12, 0.78, p=0.01). The most common of these persistent and longer lasting symptoms of COVID-19 were shortness of breath, pain in the chest, difficulty breathing, decreased performance in the gym, and less energy.

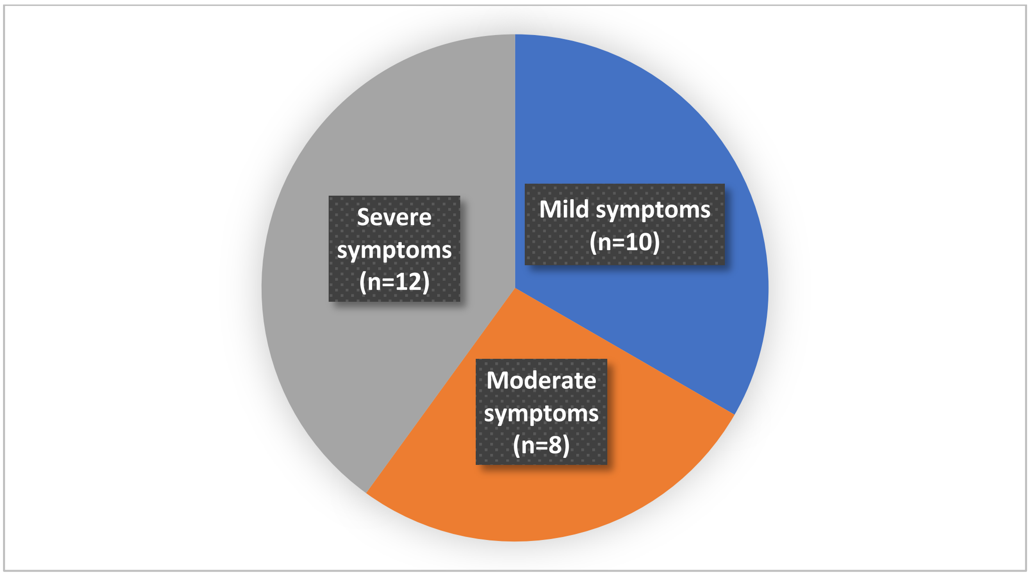


Figure 10. Number of participants reporting mild, moderate, and severe COVID-19 symptoms during follow-up.

4.3.13.5 Diet supplement use

Participants were asked whether they had started taking any new dietary supplement since the first survey. In total, 55 individuals started taking dietary supplements between the first and second surveys. Adventist status was not associated with taking new supplements (p=0.47), however plant-based participants were almost 4 times more likely to start taking new supplements than omnivores (OR 3.88, 95% CI 1.87, 8.07, $p<0.01$). Twenty-eight of the respondents confirmed having started taking vitamin D during the follow-up period, whilst eight began using vitamin B12 and ten started taking a type of multivitamin. Zinc supplementation was started by 7 participants, but the rest of the reported new supplements such as NAD, probiotics, creatine, nattokinase, iodine, omega 3, ashwagandha or vitamin C were each started by less than 5 individuals.

4.4 DISCUSSION

This is the first study to investigate the prevalence and incidence of COVID-19 infection among Adventists living in the United Kingdom.

4.4.1 Plant-based diet and COVID-19 risk

This study showed that being an Adventist and following a plant-based diet were associated with a lower risk of COVID-19 disease, however the usefulness of restrictive diets such as a vegan diet is often called into question due to potential concerns regarding long-term adherence, however 81% of vegans included in this study reported to have followed their diet for over a year, with 38% of them eating this way for over 3 years. This is in line with the results previously published of 292 adults following restrictive diets and found that vegans and vegetarians showed particularly high adherence (Cruwys et al., 2020). According to this study, social identity positively predicted adherence, whereas weight loss management was a negative predictor. Vegan and plant-based diets are a moral choice for many, which is a likely contributor to long-term dietary adherence. This is also relevant in the context of COVID-19 disease prevention, since evidence suggests that consuming the diet for a longer period is associated with greater effects on inflammation (Menzel et al., 2020). In the study by Menzel et al. (2020) vegetarians who followed their diet for longer than 10 years had significantly lower CRP levels than omnivores who had been eating an omnivorous diet for over 10 years, with the effect showing weaker association for less than 10 years.

The follow-up questionnaire revealed that a number of participants experienced persisting symptoms of COVID-19, also known as long COVID. The study showed that one of the most frequently reported symptoms of long COVID was fatigue and breathing difficulties. This finding agrees with the results of the study conducted by Kim et al. (2023), who surveyed 132 participants and showed that the most common long COVID symptom experienced by participants was fatigue (34.8%).

4.4.2 Food items and disease risk

This study showed a potential association between a higher risk of self-reported COVID-19 infection and alcohol consumption and red meat intake. It is evident from the published research studies that diet quality can modulate the risk of COVID-19 disease. Data from over half a million participants showed that the risk of severe COVID-19 disease was 41% lower for participants following a healthy plant-based diet, although this study did not investigate the relationship between COVID-19 infection and specific food items (Merino et al., 2021). Although the risk of COVID-19 was not significantly associated with fruit consumption, previous studies suggest a potential link. Merino et al. (2021) in their prospective cohort study examined the potential association between COVID-19 disease risk and severity and diet quality. With regard to fruits and vegetables, the study showed COVID-19 infection risk was 9% lower among the highest consumers of fruits and vegetables, and it also showed a reduction in severe COVID-19 infection risk by 41% among the same individuals.

On the other hand, a recent study from the UK Biobank cohort (Vu et al., 2021) specifically reported on the association between the consumption of food items and the prevalence of COVID-19 and it showed that individuals who consumed processed meat had a 9% higher risk of testing positive for COVID-19. However, the study also revealed that those who regularly consumed coffee and vegetables as part of their diet appeared to have a lower risk of contracting the virus. In addition, Kim et al. (2021) conducted an online survey among healthcare professionals from 5 major European countries as well as the USA, who were heavily exposed to patients with confirmed COVID-19, based on sharing information about their demographics, diet, and COVID-19 status. The study assessed how the risk, severity, and duration of COVID-19 are associated with differences in diet quality. There was a total of 568 confirmed COVID-19 cases, 138 of whom had a moderate to severe course, while the remaining 430 presented with mild symptoms. The results indicated that poor adherence to plant-based or pescatarian dietary patterns was linked to a 73% and 59% increased risk of moderate to severe symptoms, while adherence to low carbohydrate diets, which are also high in protein content, was associated with a significantly increased risk of experiencing moderate to severe COVID-19 infection (OR 3.86, 95% CI 1.13 to 13.24). However, no association was found between diet and the risk of COVID-19 infection or the duration of the disease.

These findings shed further light on the potential impact of dietary choices on the susceptibility to COVID-19 infection and suggest that dietary choices may have an impact on the severity and duration of COVID-19 infection as well as on the risk of contracting the virus. Several studies have been conducted to assess the diet and nutrient status of Seventh-day Adventists. The results of these studies consistently reported that Seventh-day Adventists had higher intakes of fruits, vegetables, whole grains, and legumes and consumed less meat and dairy products compared to the general population which may contribute to their overall health, which has been confirmed in this study as well by the lower COVID-19 incidence observed among Adventists.

4.4.3 Alcohol Consumption and Smoking

The Adventist lifestyle places great emphasis on abstaining from cigarettes and alcohol and it is a condition of church membership. Of the Adventists surveyed in this study, only one person reported being a current smoker, but the majority of Adventists were non-smokers. Most alcohol consumers were non-Adventists. This is consistent with the findings of Leibow and Morton (2020) who confirmed that Adventists have a low smoking rate based on available data.

Despite the low number of individuals in this cohort, who regularly consumed alcohol, alcohol intake was still significantly associated with increased COVID-19 risk when comparing 'ever' consumers to 'never' consumers, which shows that a potential mechanism for the lower COVID-19 incidence among Adventists observed in this study may be related to their low alcohol intake. Data about the association between alcohol consumption and the risk of infectious diseases and COVID-19 are somewhat mixed. For instance, data from the large-scale UK Biobank study showed that being an ex-drinker compared to a never drinker was associated with increased risk of death of both infectious disease (HR: 1.29, 95% CI 1.06–1.57) and pneumonia (HR 1.35, 95% CI 1.07–1.70), but not COVID-19 disease (Huang et al., 2022). However, current drinkers who did not consume more alcohol than defined in the guidelines had a lower risk of death from COVID-19. Another large-scale cohort study in agreement with the UK Biobank data showed that alcohol consumption was not associated with higher COVID-19 infection risk, although drinking above the guideline limits increased the risk (Hamer et al., 2020). This study showed that the most significant lifestyle factors that were associated with an increased COVID-19 risk were smoking, lack of physical activity and obesity, all of which are lifestyle factors associated with Adventism.

It may be that not all alcoholic beverages have the same impact as suggested by the result of Dai et al., (2022), which showed in a cohort of almost half a million participants that wine and champagne seemed to be protective against COVID-19 disease, whereas beer, spirits and cider showed negative effects, although long-term alcohol consumption also showed negative effects on the risk of COVID-19 disease and mortality. Considering all of the studies, it seems likely that alcohol consumption increases the risk and severity of COVID-19 infection based on the results of the meta-analysis published by Wei et al. (2023).

The results of this study suggest that Adventists widely adhere to their health principles of abstaining from harmful substances such as cigarettes and alcohol. Their commitment to a healthy lifestyle through the avoidance of smoking and alcohol is evident in the data collected for this study and in the studies cited previously, and they may partly be responsible for the lower COVID-19 incidence observed in this study.

Despite a number of similarly designed studies (Booranasuksakul et al., 2019 and O'Donovan et al., 2021) also reporting that alcohol consumers had a higher BMI and waist-to-hip ratio, this present study did not find such an association. As most alcohol consumers in this sample were non-Adventists, this result is mainly driven by them, however a potential reason for the lack of association between BMI and alcohol consumption is that even the non-Adventists practised healthy lifestyle habits, which may have protected participants against the harmful effects of alcohol. Moreover, of the participants who drank alcohol, only 2 individuals reported consuming alcohol 3-5 times a week, the rest (n=103) only consumed it on special occasions, which likely poses a lesser risk for an increased BMI.

4.4.4 Supplements

Of the Adventists surveyed in this study, only 32% reported having taken B12 supplements. This is somewhat of a concern as vitamin B12 deficiency can result in severe neurological and haematological disorders (Ankar and Kumar, 2022). However, many of these participants may not have been vegans, so vitamin B12 supplementation may not have been important for the majority of Adventists. The results of a cross-sectional study published in 1999 (Hokin and Butler, 1999) found that of the 340 Australian Seventh-day Adventist ministers surveyed, 245 ate a plant-based diet and did not regularly take vitamin B12 supplements. In this study, 53% of plant-based participants were identified as having vitamin B12 concentrations below the reference range (171-850 pmol/L).

A previous analysis of 728 members of the AHS-2 cohort published in 2018 examined the association between serum vitamin B12 levels and its intake from different food sources (Damayanti et al., 2018).

Vegans had an average vitamin B12 intake from supplements of 96.0 mcg/day, meaning that their daily intake was almost double that of non-vegetarians. Despite the lower total daily intake of vitamin B12 among non-vegetarians, it was still orders of magnitude higher than the recommended daily intake of 1.5 mcg - 2.4 mcg/day set out in international guidelines (National Institutes of Health, 2022 and NHS Choices, 2020).

The serum vitamin B12 concentrations of participants in this study were not determined, which means that the percentage of participants in this sample who were vitamin B12 deficient could not be assessed, as the low prevalence of vitamin B12 supplement intake does not necessarily mean that participants are not consuming adequate amounts of the vitamin from animal and fortified foods, as was found in the study with participants from the AHS -2 cohort discussed previously.

4.4.4.1 Supplement use and COVID-19 risk

Regular vitamin D supplementation did not reduce the likelihood of COVID-19 disease or the severity of disease in those who tested positive, although participants were not asked the exact dosage of vitamin D they used. In addition, participants' vitamin D levels in serum could not be measured, which would have been important as Kaya et al. (2021) previously showed that low levels of vitamin D in serum increased the risk of COVID-19 by 64% (OR: 1.64 95% CI: 1.32-2.04; $p < 0.001$). The most commonly recommended dose of vitamin D in the UK for prevention purposes being 400 international units (IU) (NHS West Essex, n.d.), which may not be sufficient to correct deficiencies and prevent the more serious complications of COVID-19. A review article published in Nutrients early in the pandemic suggested that 10,000 IU of vitamin D should be taken daily at least for a few weeks to increase serum concentrations of 25(OH)D to 40-60 ng/mL, followed by 5,000 IU as a maintenance dose (Grant et al., 2020). As participants were only asked about how often they supplemented vitamin D and not the specific dose, we were not able to determine the average vitamin D dose used by the participants in this sample.

A quasi-experimental study published in 2020 (Cedric et al., 2020) administered a single dose of 80000 IU vitamin D as an intervention to elderly patients who had tested positive for Sars-Cov-2 virus suggesting that the administration of a 80000 IU dose of vitamin D had a positive impact on the mortality rate of elderly patients infected with the virus. During the 36-day follow-up period, the intervention group (17.5%) was reported to have experienced a significantly lower mortality from COVID-19 compared to the control group (55.56%) ($p=0.023$). Although it is worth highlighting quasi-experimental studies have important limitations that may impact the validity and generalizability of their findings, therefore results from well-designed randomized controlled trials are needed to provide evidence on the potential benefits of vitamin D supplementation in COVID-19 patients.

Furthermore, Shah et al., (2022) synthesized the available evidence in the form of a systematic review on the potential association between vitamin D supplementation and the risk of COVID-19 infection and mortality and showed a 52% reduction in mortality as a result of vitamin D supplementation (OR: 0.48, 95% CI: 0.346-0.664; $P < 0.001$). Additionally, the review also highlighted that vitamin D supplementation reduced the need for mechanical ventilation by 46% (OR: 0.54; 95% CI: 0.411-0.708; $P < 0.001$) indicating that individuals receiving vitamin D supplementation were less likely to require respiratory support. Furthermore, Nikniaz et al. (2021) provided further support for the beneficial effects of vitamin D supplementation. The meta-analysis included data from 4 different clinical trials and revealed that vitamin D supplementation reduced mortality by 76.3% (OR 0.264, 95% CI=0.099-0.708).

Given the importance of maintaining appropriate levels of vitamin D in mitigating COVID-19 risk the minimal effective dose should be established for COVID-19 disease prevention with special consideration for correcting deficiencies, therefore, studies in the future should focus on evaluating the effectiveness of various dosage strategies in preventing COVID-19 complications and improving survival rates.

4.4.5 Vaccination

This study showed that Adventists had a significantly lower likelihood to be vaccinated than non-Adventists as nearly 62% of all participants received two doses of a COVID-19 vaccine, however 45% of Adventists were not vaccinated against the infection at baseline. Therefore, 62% vaccination rate at baseline in this sample demonstrates a significant level of vaccine uptake, but it is mostly driven by non-Adventists. These results agree with the observations of Kasstan (2021), who found that members of minority religious groups tend to have lower vaccination rates. This observed disparity regarding vaccine uptake between Adventists and non-Adventists, could possibly be due to potential differences in beliefs, attitudes, or access to vaccination between the two groups. A previous study with data from over 24 million individuals living in the UK showed that vaccination rates were lowest among Black Africans and Caribbeans (Gaughan et al., 2022), however ethnicity in this cohort was not associated with vaccination status. This is relevant since the majority of Adventists in this cohort were of Black African and Caribbean ethnicities, which may partly explain the lower vaccination rate observed for Adventists. In addition, religious beliefs have also been shown to negatively influence intention to vaccinate, especially among Christian groups (Tiwana and Smith, 2024). Furthermore, data from other studies suggests that Adventists may have a low perception of threat of COVID-19 disease (Botabara-Yap et al., 2023), which may negatively influence vaccination rates according to the Health Belief Model. The relationship between willingness to be vaccinated and perception of COVID-19 susceptibility has been investigated in a recent meta-analysis, which showed that parents who had perceived COVID-19 infection to pose a greater threat were more willing to vaccinate their children against the disease (Galanis et al., 2022). This meta-analysis also revealed that confidence in the vaccine was another important predictor of vaccination, however perceptions of the

COVID-19 vaccines were not assessed in this study. These potential factors influencing vaccine related decisions among Adventists warrant the need for further investigation in future research, which could highlight the importance of targeted approaches to addressing concerns and potential misconceptions held by members of this group concerning COVID-19 vaccines. Vaccine hesitancy due to a fear of side-effects have been shown in other studies (Ljajić et al., 2022 and Candio et al., 2023). However, these findings are in somewhat of a contrast with the results of some studies which have recruited other religious groups. An article published in Science Advisor by Wadman (2020) showed that senior Catholic leaders living in the US and Canada opposed the COVID-19 vaccines, which were still in development, because of the use of human aborted fetal cell lines used during the manufacturing and development process, which constitutes an ethical or moral objection rather than a safety concern. Moreover, a study involving Malaysian muslims showed that the majority of participants viewed halal certification of the COVID-19 vaccine as a more significant factor influencing their vaccination decision than concerns about vaccine safety (Wong et al., 2022). Jewish participants in the study conducted by Kasstan (2021) expressed concerns about the perceived coercive nature of the public health initiatives surrounding COVID-19 vaccination campaigns, although concerns about possible side-effects were also common.

As seen above, there is a wide range of potential reasons behind vaccine hesitancy, therefore perceptions of UK based Adventists were further explored in the educational intervention study described in Chapter 6 of this thesis.

Regarding vaccine side effects, almost half of the participants receiving at least one dose of a COVID-19 vaccine reported experiencing an adverse event. Another cross-sectional study

(Büssing et al., 2022) conducted in Poland found that 25% of Adventists rejected COVID-19 vaccination, however less than 1% of all study participants experienced such severe symptoms of COVID-19 that they required hospital treatment, which suggest that despite the lower vaccination rate, the majority of Adventists did not experience severe symptoms of COVID-19 infection, which confirms the findings of this present study.

Most adverse events related to the vaccine were mild, however the reports of abnormal menstruation could be considered somewhat of a concern. The results regarding to the increased rates of abnormal menstruation following vaccination are confirmed by Edelman et al. (2022) study published in The British Medical Journal, which analysed data on 19,622 females, who used an application for menstrual cycle tracking. The results of the study showed that COVID-19 vaccination was linked to a change in the length of the menstrual cycle. Furthermore, a report (Wong et al., 2022) sponsored by the Centres for Disease Control and Prevention (CDC) of the United States, published in September 2022 described that 63 815 of the respondents in the v-safe surveillance system, which has been set up to monitor COVID-19 vaccine safety, reported irregularities in menstruation or vaginal bleeding.

4.4.6 Anthropometric measures and infection risk

Although COVID-19 infection prevalence and BMI were not associated significantly in this study, other observational studies have suggested a potential association, including a systematic review and meta-analysis (Malik et al., 2020) published early in the pandemic in July 2020, which found that the prevalence of COVID-19 disease among patients with a BMI of 25 kg/m2 or higher was almost two times higher than amongst the patients with a BMI of less than 25 kg/m2.

The present study showed that the BMI of plant-based eaters were lower than that of participants consuming a diet inclusive of animal products, which is in agreement with other previous studies that included Adventist populations, and it may be an important factor that is responsible for the apparent lower COVID-19 infection risk among Adventists. A cross-sectional analysis of AHS-2 (Jaceldo-Siegl et al., 2019), which only included Hispanic/Latino Adventists found that among the 3475 participants surveyed, vegans and vegetarians had significantly lower BMI (23.58 and 25.24 respectively) than non-vegetarians (BMI 27.50). Lower BMI is particularly relevant in the context of COVID-19 disease, as obesity has been identified as a major risk factor for infectious diseases, including COVID-19 (Albashir, 2020). Although, the BMI in this study was not significantly different between Adventists and non-Adventists, likely due to the fact that both groups included health-conscious individuals since both groups' mean BMI was under 24, which is considered normal weight (Weir and Jan, 2023). Therefore, it is not a surprise that BMI was not significantly associated with COVID-19 infection prevalence in this sample.

In terms of COVID-19 and the severity of its symptoms, a large-scale analysis (Gao et al., 2021) involving data from over 6.9 million participants who had tested positive for the disease, revealed that there was a linear increase in hospitalisation, mortality, and ICU admission rates as BMI increased from 23 kg/m2. At follow-up, Adventists had a lower infection incidence, and vegetarians had a borderline statistically significantly lower risk of experiencing severe symptoms of COVID-19. This confirms previous findings such as the study published by (Kim et al., 2021), which showed that eating a plant-based diet was associated with 73% lower odds of experiencing moderate to severe symptoms of COVID-19 infection. Plant-based diets have been shown to reduce the levels of pro-inflammatory cytokines, which may explain the potential protective effects of plant-based diets concerning COVID-19 severity (Storz, 2021).

These studies suggest that the maintenance of a healthy body weight may play a role in mitigating the severity and risk of COVID-19. Therefore, adherence to the principles of the Adventist lifestyle may provide protection against the infection as it prioritizes a healthy lifestyle, with principles that include regular exercise and the consumption of a balanced diet in order to maintain a healthy BMI, which has been shown to reduce the likelihood of experiencing severe complications caused to COVID-19.

An important lifestyle habit that may have contributed to the Adventists' normal BMI is fasting as they were shown to be more likely to practise fasting as compared with the non-Adventists. Fasting is mentioned a number of times in the Holy Bible and has been practised by adherents of both of the Biblical religions, Judaism and Christianity. Adventists are also encouraged to practise fasting (Wilson, 2021), albeit it is not a requirement of membership. Church members are often made aware of the potential dangers of going without any food for an entire day or longer, therefore meal skipping is practised even more widely by church members. In fact, Ellen G. White advocated for the practice of intermittent fasting as a natural health remedy, although she did not use the exact term. However, she did emphasize that periods of abstinence from food can alleviate the burden on digestive organs and promote recovery, even in the form of skipping a meal or two (White, 1905), which aligns with the definition of intermittent fasting if done intentionally (Zeballos and Todd, 2020). In the same book, Ellen White further suggested that adopting a simple diet of fruits, whilst excluding stimulants, for a short period of a few days could bring healthful relief, which can also be considered a version of intermittent fasting with a more severe restriction of calories. Fasting and intermittent fasting have both been associated with a number of positive health outcomes such as the prevention of chronic diseases like hypertension or metabolic syndrome

(Michalsen and Li, 2013) as well infectious diseases like COVID-19 (Horne et al., 2022). In this cohort of US adults, those fasting periodically had an almost 40% lower risk of death or hospitalisation due to COVID-19 infection (HR=0.61, 95% CI 0.42 to 0.90) compared to participants who never fasted (Horne et al., 2022). These findings confirm the results of this study, since we showed a significantly lower COVID-19 disease risk among those who fasted every other month compared to non-fasters. These findings suggest that the positive effects of the Adventist lifestyle observed in the scientific literature may partly be explained by the common practise of fasting.

4.4.7 The influence of the Adventist diet and lifestyle on mental health during the pandemic

It is important to emphasize that plant-based diets in this present study were not shown to have an impact on the risk of depression or anxiety experienced during the pandemic, which is in agreement with the results of a previous systematic review of 13 studies (Askari et al., 2020), which did not show any associations between vegetarian diets and depression or anxiety. On the other hand, a cross-sectional study (Beezhold et al., 2010) found that vegetarians reported fewer negative emotions despite the lower intake of EPA and DHA, both of which are omega 3 fats. These results may be relevant in the context of a plant-based diets that exclude fish which are direct sources of these long chain fatty acids.

Another meta-analysis (Nucci et al., 2020) showed that higher red meat consumption increased the risk of depression, while a systematic review found that abstaining from meat was linked to a higher risk of psychological health in some studies, however this study was funded by the Beef Checkoff (Dobesek et al., 2021), which may raise some concerns about sponsorship bias in the study. Alpha-linolenic acid (ALA) intake is a major source of omega 3 fats in plant-based diets, and it may play a role in mitigating the risk for mental health problems among vegans since higher intakes of the nutrient have been shown to lower the risk of depression (Lucas et al., 2011), but further intervention trials are needed in order to investigate causality.

This present study found that Adventists experienced less anxiety during the COVID-19 pandemic. Although not in the context of COVID-19, but Beezhold et al. (2010) investigated the relationship between mood states among vegetarian and non-vegetarian Adventists and it showed that vegetarian Adventists were significantly less likely to report negative emotions than omnivores, which suggest that the plant-based diet followed by Adventists has an important role in their emotional well-being.

Furthermore, the practice of prayer was found to be a prominent stress management technique, and it was widely practised among the participants, which may have contributed to the lower anxiety experienced by Adventists during the pandemic. There have been studies investigating the potential effects of prayer on anxiety, with some studies suggesting a reduction in anxiety symptoms among individuals who prayed on a regular basis (Shultz, 2015). Therefore, it is possible that the combination of the Adventist lifestyle, with its emphasis on vegetarianism and prayer, may have worked synergistically to alleviate anxiety in the face of the COVID-19 pandemic. It is worth considering that these findings expand our knowledge of the impact of the Adventist lifestyle on anxiety by suggesting that in addition to diet and lifestyle, prayer as a stress management technique alleviate anxiety symptoms and these findings may have implications beyond the context of the COVID-19 pandemic. In addition to a healthy diet and prayer, a strong social support network may also be a key factor in a pandemic.

The lower anxiety observed among the Adventists could have also contributed to their lower COVID-19 incidence as suggested by Ayling et al. (2022), who showed that greater psychological distress during the pandemic was associated with higher risk of COVID-19 infection.

In this regard, it may be somewhat of a surprise, but this study found that the spiritual life of Adventists was not impacted negatively by the church closures. A potential explanation for this phenomenon is that churches utilised digital media platforms for sermons, bible studies and regular meetings to help church members stay connected and engaged as suggested by a study conducted in Poland. That particular study showed that the pandemic led to a notable increase in media production and in use of some digital media formats produced by the church. These efforts were implemented in response to the challenging social circumstances created by the pandemic and in response to discriminatory laws that restricted the ability of churches to congregate (Kołodziejska, 2021). The beneficial impact of attending religious activities online during the pandemic were further confirmed by Shiba et al., 2022, who showed that attending religious activities online during lockdown was associated with higher life satisfaction and a lower risk of thoughts about self-harming.

4.4.8 Meal timing

The survey contained questions pertaining to meal timing to investigate whether energy intake in the morning or in the evening was associated with BMI in the sample as data on meal timing could also provide important insights into the lifestyle and dietary behaviours of Adventists. The results showed that those consuming breakfast before 10:00 am had lower BMI than those who consumed breakfast later or skipped it entirely, however the results were not statistically significant. Consuming dinner after 6 pm, however, was associated with a higher BMI. A meta-analysis published in 2022 summarised the results of observational studies and showed similar results (Zou et al., 2022). The review included 17 cross-sectional surveys, as well as a case-control study, and 2 cohort studies, and the results revealed that higher energy intake around bedtime was associated with a 19% increased risk of adiposity. Breakfast consumption has been linked to better satiation (Castro, 2004) and a reduction in overall energy intake throughout the day as compared to late night eating (Cahill et al., 2013). These factors are thought to contribute to the positive effect of consuming breakfast on body weight. Cahill et al. (2013) et al. showed that skipping breakfast was associated with a 27% increased risk of CHD, however it may also influence COVID-19 infection risk. Yokoro et al. (2021) showed among 146 female university students that the risk of COVID-19 was greater among those who skipped breakfast, with the authors also raising concerns about the negative effect of breakfast skipping on muscle mass.

Obesity and metabolic disorders have been shown to impair immune response and increase the severity of infectious diseases, including COVID-19. These findings suggest that meal timing, as part of the Adventist lifestyle, could have indirect effects on infectious disease risk by promoting metabolic health.

4.4.9 Meal frequency

Eating more than 3 meals a day has been linked to an increase in chronic disease risk factors (Paoli et al., 2019), possibly due to it leading to excessive caloric intake. A re-analysis of the AHS-2 study with data of 50,660 adult church members showed that eating no more than 2 meals a day was linked to yearly reductions in BMI (Kahleova et al., 2017). On the other hand, a cross-sectional analysis published in 2001 (Titan et al., 2001) suggested that consuming 6 or more meals a day was associated with lower total and LDL cholesterol levels, although the actual difference in cholesterol values between participants was 0.15 mmol/L after adjusting for confounders, which may not have clinical relevance. Furthermore, a cross-sectional analysis of a subsample of the Malmö Diet and Cancer cohort (Holmbäck et al., 2010) showed that eating more meals in a day was associated with a lower BMI, however the authors noted that those eating more meals in a day consumed significantly more fibre, carbohydrates, and protein as well as less fat and alcohol. In this cohort, the consumption of more than 3 meals a day was associated with less snacking.

Diet quality and the prevalence of snacking may explain the seeming contradiction between the association of meal frequency and adiposity such that higher meal frequency is only associated with adiposity if the meals contain more snacks, and dietary fat and fewer protein and carbohydrates. Meal frequency may also be a relevant component of the Adventist lifestyle, even in the context of COVID-19 prevention, since it can prevent excessive caloric intake and may improve metabolism, factors which are important in immune function (Doctrow, 2022). By contrast, the emphasis within the Adventist lifestyle on moderation in eating, including fasting, meal skipping and lowering the frequency of meals, may offer benefits for both metabolic health and immunity, potentially contributing to lower risks of infectious diseases.

4.4.10 Physical Exercise

The rate of regular physical exercise was similar in both non-Adventists and Adventists. The 68% who reported to have exercised regularly among the Adventist participants is in great contrast with the results of a cross-sectional study by Galvez et al. who surveyed Seventh-day Adventist living in Manilla, Philippines, and showed that only 0.3% of Adventists indicated that they thought regular exercise was necessary (Galvez et al., 2021).

Regular physical exercise is certainly a fundamental tenet of the Adventist lifestyle, and in cohorts where it is widely practised, it is linked to a significantly lower risk of mortality. The Adventist Mortality Study recruited 9484 males in the 1960s and a lower all-cause and disease-specific mortality rates were observed for those engaging in moderate exercise at the 26-year follow-up (Lindsted et al., 1991). Regular physical activity has been shown to lower the risk of COVID-19 infection by 11% and lower the risk of mortality by over 40% (Sallis et al., 2023), which highlights the potentially protective effect of this important aspect of the Adventist lifestyle against COVID-19. However, there have not been any published studies on this association in Adventist cohorts.

A useful tool for tracking physical activity is the use of an activity tracking device, however the results did not provide evidence that the use of an activity tracking device is associated with lower BMI in this study. This is somewhat surprising as a recent meta-analysis found that health wearable devices are an effective intervention to reduce body weight and BMI in randomised controlled trials (McDonough et al., 2021). Information from cross-sectional studies such as the data in this present study concerning activity devices, where follow up information for participants was not available may explain the lack of association observed in this study. In addition to the lack of observational period, participants were not asked about the length of time they had been using the activity tracking device, and it is likely that some participants had only begun to use the device not long before study launch. It could further be hypothesized that already overweight or obese subjects were likely recommended to start using an activity device as part of a weight-loss program (Følling, et al., 2021).

Furthermore, activity tracking devices such as wearable smart watches can be useful in the context of COVID-19 disease as they are often able to monitor heart rate, oxygen saturation and body temperature and have even been tested for their accuracy of identifying early phase COVID-19 infections as well as for patient monitoring (Channa et al., 2021).

4.4.11 Food availability during the pandemic

Over 40% of the sample population surveyed reported experiencing difficulties with food availability, defined as facing challenges in accessing an adequate supply of food, during the pandemic, with no differences between Adventists and non-Adventists. This is relevant since food availability can greatly impact the diet people usually follow. In fact, having limited or no access to affordable and healthy food are linked to lower diet quality and a higher risk of chronic diseases such as cardiovascular disease, diabetes, and even cancer (Odoms-Young et al., 2023). Tyrväinen and Karjaluoto (2022) showed that people's shopping habits changed during the pandemic such that shopping online became more popular and there was an increased reliance on large supermarkets since smaller grocery shops, in many places, were forced to be closed. On the other hand, foods purchased at larger supermarkets tend to be cheaper and often healthier than those purchased from smaller shops (Canales, 2021), which may provide a possible explanation for this study's findings concerning the lack of impact of socioeconomic status on access to food during lockdowns. Similarly designed studies have reported similar results from around the world. For instance, a cross-sectional analysis (Head et al., 2022) involving 1122 participants reported that 36.6% of respondents experienced a noticeable decline in food availability in 2020 after the beginning of the global pandemic. Although income did not have an influence on participants experiencing a lack of food availability, other studies (Jafri et al., 2021) have revealed that price increases during the pandemic of staple foods were one of the major factors driving decreased food availability. The fact that Adventists and non-Adventists in this sample were equally affected by food insecurity during lockdowns, yet vegetarian Adventists were more protected against pandemic related weight gain, shows that their diet and lifestyle were sustainable during these critical times. This highlights the resilience of the Adventist dietary pattern and its potential health benefits even in the context of a global infectious disease pandemic, particularly in mitigating weight gain as well as potentially contributing to the lower COVID-19 incidence rate.

4.5 Strengths and Limitations

The study utilised a modified version of the validated FFQ used in the Epic-Norfolk study, thereby improving the validity of the findings. Furthermore, it is worth highlighting that the FFQ used in the AHS-2 cohort was shown to have high validity coefficients for macro- and micronutrients (Jaceldo-Siegl et al., 2009) as the FFQ used in this study was partly based on the AHS-2 FFQ, and this validation ensures the accuracy and reliability of the dietary data collected, even if not the exact FFQ but an adaption of it was used.

Another strength of the study is the determination of sample size, which increases its statistical power for establishing a difference in risk of COVID-19 infection among Adventists and non-Adventists.

Furthermore, the food frequency questionnaire information was further validated by the data gathered from the 24-hour dietary recalls. The recruitment of non-Adventists as controls further adds to the credibility of this study. The study revealed a number of meaningful differences between the Adventists and non-Adventists even in the context of the COVID-19 pandemic, which may offer useful insights into the impact diet and lifestyle may have on people’s ability to cope with a global health crisis. The study confirms Adventists' tendency towards eating a plant-based diet, as well as their abstention from alcohol and coffee, and the practice of fasting, all of which are in agreement with the findings of other cohort studies involving Adventists living in other geographical areas. Moreover, the study used comprehensive statistical methods as part of data analysis, which adds to the validity and reliability of the findings.

An important limitation of this study is that the online survey was self-administered by the participants, which could potentially introduce measurement error for self-reported anthropometric measures such as waist or hip circumference (Bauhoff, 2014). On the other hand, the FFQ used in this study was an adoption of two previously validated food frequency questionnaires, and even though FFQs have been reported to potentially overestimate energy and nutrient intake (Noor et al., 2019), the FFQ data in this study were not used to calculate exact values of energy or nutrient intake. Instead, the use of an FFQ in this study was for the sole purpose of being able to identify and distinguish between participants following various dietary patterns such as omnivores and vegetarians and to compare the prevalence of COVID-19 disease among high vs. low consumers of specific food and drink items.

Other important limitations are that most respondents were female and had a total household income of under £29 000, therefore the results may not be representative as males and those with higher income are underrepresented in the sample, however it was not possible to ensure that both genders and all income groups are equally represented in the sample due to the online survey being shared on social media because Adventist churches were still under closures.

Moreover, another limitation is the potential dietary misclassification of participants into the dietary categories because of the self-reports which could potentially affect associations between diet and COVID-19 disease risk. However, to address this limitation, the study also gathered dietary data in the form of the FFQ as well as the 24-hour recall, both of which provided further validation to the self-reported dietary pattern followed by participants.

Furthermore, the study used the convenience sampling method as part of the recruitment procedure which may have introduced selection bias, as participants were chosen based on their availability rather than being randomly selected, thereby limiting the generalizability of the findings, however both Adventists and non-Adventists were recruited using this sampling method, therefore one group was not impacted more than the other, and the study used robust statistical techniques such as MANOVA as well as transparent reporting to mitigate this bias. Another potential limitation of the study in relation to sample size is the potential for a lack of statistical power due to the small sample size in some of the diet groups such as pescatarians (n=11). To mitigate the effect of small sample size, multiple diet groups were combined in the statistical analyses such that there were two main groups of plant-based and omnivores.

COVID-19 disease prevalence was based on self-reports; therefore, it was not possible to confirm whether COVID-19 positivity was based on rapid antigen tests or RT-PCR (real-time polymerase chain reaction) as the questionnaire did not ask for this detail, nor did it ask about whether the COVID-19 test was carried out whilst having any symptoms associated with COVID-19 infection. In addition, medical records or laboratory test results were not available to validate the self-reported infections. A recent Cochrane analysis (www.cochrane.org, n.d.) evaluated the sensitivity and reliability of COVID-19 tests and revealed that antigen tests were only correct in 55% of asymptomatic people and 73% of the time in people with symptoms, therefore confirming the type of COVID-19 test would have provided useful information. This is further confirmed by an analysis published from the UK which showed antigen tests had a sensitivity of 57% (Mytton et al., 2021). The results of these studies confirm the importance of considering different testing methods as their validity and reliability may vary greatly.

Initially, the study utilised a cross-sectional survey design, which could only investigate COVID-19 disease prevalence rates, which is the proportion of individuals in a population with the disease at a specific point in time, however disease incidence rates, which measure the number of newly diagnosed cases in a given period of time, could not be calculated due to the lack of observational period. Therefore, the results of the initial survey cannot infer causality as it was not possible to establish temporal associations between the investigated exposures and outcomes, which would be an essential part of establishing causality according to the Bradford-Hill criteria (Rothman and Greenland, 2005). Therefore, a follow-up survey was sent to participants at 2 years, which transformed the study to a longitudinal design with a sufficient follow-up period. The follow-up survey was only filled in by 154 participants, which meant 16 participants were lost to follow-up, thereby reducing the sample size. In addition, attrition was not evenly distributed between the groups (4 Adventists vs. 12 non-Adventists). To mitigate the potential bias introduced by the loss of participants to follow-up in the two groups, the Last Observation Carried Forward (LOCF) imputation was used to account for the missing data.

While plant-based participants were shown to have begun using dietary supplements in significantly greater numbers than non-vegetarians, the small frequencies of specific supplements such as probiotics, omega 3 fats or iodine limit the statistical analysis that can be conducted regarding the impact of these supplements on COVID-19 disease incidence.

Furthermore, although the study found that COVID-19 incidence was lower among Adventists, this may be due to a lower testing rate than among non-Adventists, which may be a form of surveillance bias (Tancredi et al., 2022), although the study did not ask participants to indicate if they had been tested against COVID-19. On the other hand, previous research by Zollinger et al. (1984) showed that Adventist women were more likely to have a breast cancer diagnosis at an earlier stage than non-Adventists suggesting that Adventists may in fact be more likely to seek medical care, however no such results are available in the context of COVID-19 testing. However, based on the Health Belief Model, which is the guiding framework of this thesis, it would not be unexpected if Adventists had been tested against COVID-19 less frequently because they did not perceive the risks of COVID-19 infection to be sufficient to justify more frequent testing. Evidence for this can be indirectly derived from the study published by Botabara-Yap et al. (2023), who showed that the majority of the Adventist respondents had a low perception of COVID-19 seriousness, although the study did not investigate how this belief might have influenced testing behaviour.

4.5.1 Implications and future research

Considering the lower vaccination rates among Adventists, targeted health education campaigns could be developed and utilised to address concerns Adventists may have regarding vaccine hesitancy. Future research should focus on exploring potential barriers and provide accurate information in addressing their specific concerns. These findings may also inform the health promotion campaigns of the church. Churches should use targeted health education campaigns by health experts to improve the dietary and vaccine knowledge of church members.

In addition, the finding that plant-based Adventists were less likely to use certain dietary supplements such as multivitamin or vitamin D also warrants further investigation, since some of these nutrients are mainly found in animal products, however plant-based diets are quite common amongst Adventists, therefore their risk of nutritional deficiencies and dietary knowledge with a focus on essential nutrients in the context of plant-based diets should be further explored. This is especially relevant in the context of infectious diseases, including COVID-19 infection risk, given the role of essential nutrients in supporting immune function and protection against infectious diseases. While being a plant-based Adventist was associated with a lower COVID-19 disease risk in this study, most vegans included in this study (81%) followed their diet for less than 3 years, which may not accurately reflect the true impact of inadequate intake of critical nutrients such as vitamin B12, iron, and zinc on COVID-19 disease risk. Deficiencies in these nutrients could potentially compromise immune functions, as suggested by early studies (Chandra, 1979). In fact, it is suggested by Locks et al., (2024) that the main non-genetic cause of immunodeficiency worldwide is malnutrition, therefore the questions concerning nutrient intake among plant-based Adventists are further investigated in the next two chapters of this thesis. As such, the next chapter will present the findings of a systematic review, which investigated the essential nutrient intake and blood levels of plant-based Adventists in order to identify any type of nutrient deficiency that may be more prevalent among Adventist vegans and vegetarians, which could also make them susceptible to COVID-19 infection. These findings could also provide important context for the results observed in this present study regarding a lower risk of COVID-19 infection among plant-based Adventists since the presence of nutritional deficiencies would be expected to increase disease risk.

4.6 CONCLUSION

Adventists were significantly older in this sample and had a lower vaccination rate than non-Adventists, yet they had a significantly lower incidence of COVID-19 disease, which provides valuable information to the overarching research question. This study showed that the highest intakes of red meat and alcohol were linked to a higher risk of COVID-19, thereby highlighting the specific dietary factors that could have played a significant protective role against COVID-19 as part of the Adventist diet. This is further confirmed by the fact that plant-based status was a significant predictor variable in the association between the lower COVID-19 incidence observed among Adventists, which provides important answers to the research question of this thesis. At the end of follow-up, Adventists were also shown to have experienced fewer symptoms of long COVID and had a lower infection incidence.

This study identified that Adventists seemed to have been more protected from the potentially harmful impact of the pandemic on people's mental health, which may partly be explained by the social support networks maintained during the pandemic as well as the widespread use of prayer and other spiritual exercises for stress management among Adventist. The lower anxiety could have also contributed to the lower COVID-19 incidence observed among Adventists. Furthermore, the Adventist lifestyle with its emphasis of a healthy diet and regular physical exercise proved to be associated with better weight management during the pandemic, therefore some of the principles from the Adventist lifestyle could potentially be generalised to other groups or populations.

However, the lower use of dietary supplements among plant-based Adventist raised important questions about the nutritional status of vegan and vegetarian Adventists. Therefore, a systematic review was undertaken in the next chapter with the aim of investigating the intake and status of essential nutrients among plant-based Adventist cohorts in order to identify if they are at an increased risk of nutrient deficiencies that may negatively influence susceptibility to infectious diseases.

5 Chapter 5. Essential nutrient intake and blood status in vegan and vegetarian Seventh-day Adventists: A systematic review and meta-analysis

5.1 INTRODUCTION

The potential nutritional inadequacies associated with vegan and vegetarian diets, which are commonly consumed among Adventists, highlight the importance of understanding the dietary intake and supplementation practices of Adventists, especially in the context of COVID-19 disease risk, however, there are no published systematic reviews summarising the available evidence on the intake and serum levels of essential nutrients among plant-based Adventists, which could identify potential nutritional inadequcies among the group.

According to a global survey of Adventists over 80% of the participants confirmed belief in the health message held by the church and thought that it was holistic and resulted in a longer life (McBride et al., 2021), however, the study did not investigate the perceptions and beliefs Adventists hold regarding the nutritional sufficiency of plant-based diets and the use of dietary supplements.

As mentioned in Chapter 3 of this thesis, diet doesn't only impact COVID-19 risk, but dietary intervention studies have been shown to increase the effectiveness of vaccinations against infectious diseases (Vedhara et al., 2020), which highlights the multiconnected relationship between diet and immunity in the context of infectious diseases.

Therefore, this study aimed to gather and synthesize the existing research concerning vegan and vegetarian Adventists' dietary intake and status of essential micronutrients and minerals such as vitamins D and B12, calcium, iron, and iodine, that may be low on a vegan or plant-based diet and could influence susceptibility to infections like COVID-19 disease, thereby aiming to provide answers to the overarching research question of the thesis. By examining the available literature, this review intends to identify key findings, patterns, and research gaps related to the dietary practices of vegan and vegetarian Seventh-day Adventists and their impact on nutritional status.

5.2 METHODS

This systematic review has been performed in adherence to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and has been registered on PROSPERO (CRD42024511290).

A comprehensive search was conducted in the following databases from inception to 2024: PubMed, Scopus, Google Scholar. The search terms for the database search were devised using the PICO method. The keywords used for the search were as follows:

(Adventist OR "Seventh Day Adventist" OR “SDA”) AND ("vitamin B12" OR B12 OR Cobalamin OR Cyanocobalamin OR Hydroxocobalamin OR Methylcobalamin).

In addition, a separate database search was conducted in the above-mentioned databases to identify studies that have reported on the intake or status of other essential nutrients among Adventist populations. The below keywords were used for the search strategy:

("Seventh Day Adventists" OR "SDA") AND ("Plant-based diet" OR "vegetarian diet" OR "vegan diet") AND ("Nutrient intake" OR "dietary nutrients" OR "nutrition assessment" OR Nutrient or Nutrients) AND ("Nutritional supplements" OR "dietary supplements" OR "vitamin supplements" OR vitamin) AND ("Micronutrients" OR "macronutrients").

5.2.1 Inclusion and exclusion criteria

Observational studies such as cross-sectional, cohort, and case-control studies as well as intervention studies published in English language were included if they recruited plant-based Seventh-day Adventist participants, preferably vegan, and reported on either their vitamin B12 status or intake. Studies were only included if they also recruited omnivore participants.

Only studies that presented group averages of vitamin B12 intake or status for plant based and omnivores separately were included. Studies that did not present distinguishable results for vegetarian or vegan Adventists from omnivores were excluded. Plant-based for this review was defined as either vegan or vegetarian, however vegan groups were the preferred choice since they do not consume any form of animal products, therefore the risk of vitamin B12 deficiency might be higher in this group. Studies which only reported on the intake of food items such as dairy or meat were excluded if they did not report on exact intake or serum status of vitamin B12.

Furthermore, studies that reported on the intake or status of any of the following essential nutrients were also included in this systematic review: Omega 3 and 6 fatty acids, vitamins A, C, D and E, as well as vitamin K, B vitamins, and essential minerals such as calcium, iron, zinc, potassium and protein.

5.2.2 Study Selection

Study selection utilised a two-step screening process. Titles and abstracts were read in the first instances, and the full text articles were read if the article was deemed relevant based on the initial screening step. Two reviewers reviewed studies independently, and there was an option for a third reviewer to be consulted in cases of disagreement. The full text articles were read in their entirety if the article was deemed relevant based on the initial screening step. This was done in order to determine if the full text article presented specific information about any of the essential nutrients of interest such as vitamin B12 intake or status for vegan or vegetarian Adventists and a non-vegetarian comparison group. During the full-text review, articles were screened to determine if they presented specific results for nutrient intake or serum levels for plant-based and omnivore participants.

5.2.3 Data Extraction

A customised data extraction form was used to extract the following information from the included studies: author and year of publishing, study design, sample size, location/country, type of plant-based diet followed by Adventists, controls, vitamin B12 intake or serum level assessed, result. Results were extracted as means and standard deviation unless otherwise presented (i.e., median, and interquartile range). If a study presented separate results for vegans and vegetarians, the results relating to vegans were extracted and used in the meta-analysis, since vegans are at a greater risk of vitamin deficiencies as vegetarians consume animal products such as dairy which contain vitamin B12 or even vitamin D.

5.2.4 Risk of Bias Assessment

A version of the Newcastle-Ottawa Scale (NOS) validated by Modesti et al. (2016), employing a scoring range from 0 to 10, was used to assess the quality and potential risk of bias of the included cross-sectional studies, with higher scores indicating a reduced risk of bias. Studies scoring 7-10 were considered to have a low risk of bias. Studies with a score between 4-6 were judged as having a moderate risk of bias, and studies scoring 5 or below were considered to have a high risk of bias.

5.2.5 Data Synthesis

Some of the extracted data had to be converted to the desired format to allow for the data to be analysed in the form of a meta-analysis. Continuous data were used for the meta-analyses concerning the intake and serum levels of vitamin B12. One of the included studies presented group averages as medians and interquartile ranges (Haddad et al., 2020), therefore the sample mean was estimated using the formula proposed by Luo et al (2018) and standard deviation was estimated using the formula proposed by Wan et al. (2014).

Hokin and Botler (1999) presented their results concerning the serum vitamin B12 level of participants as mean and standard error. The standard deviation was estimated by multiplying the standard error of the mean (SEM) by the square root of the sample size in that group ($\sqrt{n}$) as shown in the following formula (Higgins and Green, 2011):

$$SD = SEM \times \sqrt{n}$$

Furthermore, Harman and Parnell (1998) presented separate results for males and females; therefore, the group means for males and females among both vegetarians and omnivores were combined using the formula suggested by the Cochrane handbook (Higgins and Green, 2011).

A random-effect meta-analysis was carried out in Review Manager (RevMan version 5.3) instead of a fixed-effect meta-analysis due to the expected heterogeneity between the included studies owing to differences in sample size, the use of vitamin B12 supplements by participants and the fact that some studies grouped vegans and vegetarians together (Harman and Parnell, 1998 and Hokin and Buttler, 1999), whilst in other studies results were separately available for vegans (Damayanti et al., 2018 and Haddad et al., 2020). The heterogeneity among the studies was evaluated through the Chi^2 test and quantified using the I^2 statistic. An I^2 value greater than 50% indicated substantial heterogeneity.

For the effect size, the mean difference (MD) together with 95% confidence intervals (CIs) was calculated. The outcomes of the individual meta-analyses were presented using forest plots, which illustrated the estimated overall effects.

Sensitivity analysis was conducted by investigating the effect of each individual study on the overall effect size by removing each study from the analysis. A subgroup analysis could not be conducted because of the limited number of included studies.

Regarding the other essential nutrients apart from vitamin B12, the results were synthesized in a narrative synthesis as a meta-analysis was not possible for any of the other nutrients due to the lack of standardized reporting and low number of studies focusing on any given nutrient.

Figure 11. PRISMA Flow Diagram of Study Selection

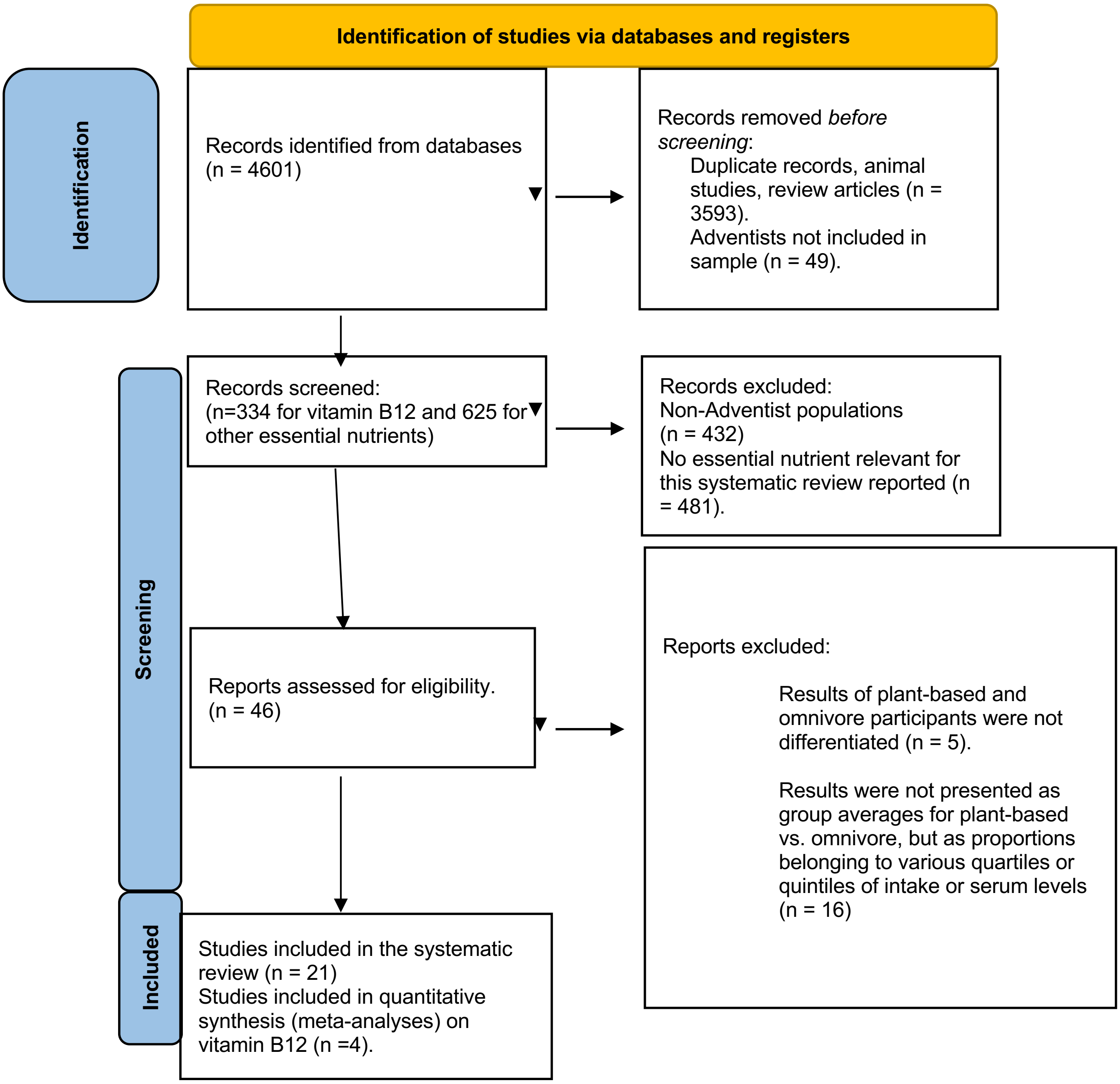


Table 5 Study Characteristics and Results Table for Vitamin B12

Author and year	Study Design	Sample Size	Location/Country	Type of plant-based diet followed by Adventists	Controls	What was assessed in the study? (Serum level of intake)	Results
Damayanti et al., 2018	Cross-sectional analysis of AHS-2 calibration study	728	United States	Semi- and pesco-vegetarians, lacto-ovo-vegetarians, and vegans.	Non-vegetarians	The intake of and serum levels of vitamin B12 and holotranscobalamin (holoTC)	Serum vitamin B12 (mean, SD): Vegan: 292.3 (214.5) pmol/L Omnivores: 256 (163.3) pmol/L Vitamin B12 intake: (mean, SD): Plant-based: 101.2 (202.9) mcg/d Omnivores: 48.3 (197.5) mcg/d
Haddad et al., 2020	Cross-sectional survey	785	United States	Vegan and lacto-ovo-vegetarian,	Non-vegetarian group	Circulating methylmalonic acid (MMA) and serum vitamin B12, holotranscobalamin (holoTC), and homocysteine (Hcy) levels.	Serum vitamin B12 (mean, SD): Vegan: 308.7 (25.4) pmol/L Omnivore: 316.2 (17.4) pmol/L Vitamin B12 intake: (mean, SD): Plant-based: 13.65 (15.95) mcg/d Omnivores: 7.46 (2.59) mcg/d
Harman et al., 1998	Cross-sectional survey	141	New-Zealand	Vegetarian	Non-vegetarian Adventists	Serum vitamin and dietary intake of vitamin B12 but it also reported on the dietary intake of vitamin C, folate, vitamin A, zinc, iron, calcium and PUFA were assessed. Serum ferritin were also assessed.	Serum vitamin B12 (mean, SD): Vegan: 186 (88.9) pmol/L Omnivore: 245 (112.7) pmol/L Vitamin B12 intake: (mean, SD): Plant-based: 1.25 (0.95) mcg/d Omnivores: 2.69 (1.8) mcg/d
Hokin and Buttler, 1999	Cross-sectional	340	Australia	Lacto-ovo-vegetarian or vegan	Nonvegetarians consuming more than one serving of flesh foods per week.	Serum vitamin B12 status	Serum vitamin B12 (mean, SD): Vegan: 166 (245.4) pmol/L Omnivore: 292 (1055) pmol/L

Table 6 Study Characteristics and Results Table for other essential nutrients

Author and year	Study Design	Sample Size	Location/ Country	Type of plant-based diet followed by Adventists	Controls	Nutrients Assessed	Key Findings
Anderson et al., 1981	Cross-sectional	56	Canada	Vegetarian	None	The study assessed dietary fibre, iron, and zinc intakes. It also measured haemoglobin, serum iron, total iron-binding capacity (TIBC), serum transferrin saturation, serum zinc, and hair zinc concentrations	The mean dietary iron intake was 12.5 mg, zinc intake (9.2 mg/day) Haemoglobin, serum iron, TIBC, and serum transferrin saturation levels showed no statistically significant differences among vegetarians with and without iron supplements
Armstrong et al. 1974	Cross-sectional	562	Australia	Vegetarian	Non-vegetarian Adventists	Serum vitamin B12 and folate levels.	Folate serum levels were higher in vegetarians.
Beezhold et al., 2010	Cross-sectional	138	United States	Vegetarians	Non-vegetarian Adventists	Dietary intake of EPA, DHA, AA, ALA, and LA	Vegetarians were shown to have significantly lower intakes of EPA, DHA and AA but they also showed higher intakes of ALA, total n-3, and LA. The vegetarians experienced less negative emotion than omnivores.

Calkins et al. 1984	Cross-sectional study	168	United States	Pure Vegetarian (Vegan) and lacto-ovo vegetarian.	Non-Adventist omnivores.	The study assesses nutrients such as calories, protein, fat, vitamins A, B, C, calcium, phosphorus, and iron.	All groups consumed adequate or excess amounts of levels of protein, and fat. Higher calorie intake among nonvegetarians was due to higher intake of fat and protein. Vitamin levels (A, B, C) were adequate for both vegetarians and omnivores with and without supplements. Calcium and phosphorous intakes were below the recommended levels for females who consumed a vegetarian diet. Iron intake was low for all females, but the intake of haem iron did not improve intake levels for nonvegetarian females. All groups were shown to consume adequate or excess amounts of protein.
Chan et al., 2009	Cross-sectional analysis of the AHS-2 cohort	428	United States	Vegans, lacto-ovo-vegetarians, and partial vegetarians such as pesco-vegetarians and semi-vegetarians.	Non-vegetarian Adventists	Serum 25-hydroxyvitamin D levels	There weren't any significant differences in serum 25(OH)D concentrations based on vegetarian status.
Miles et al., 2019	Cross-sectional analysis of AHS-2	840	United States	Vegan, lacto-ovo-vegetarian, pesco-vegetarian, semi-vegetarian,	Non-vegetarian Adventists	The biomarkers analysed included polyunsaturated fatty acids, and vitamins in plasma, urine, and adipose tissue.	Vegans had higher plasma concentrations of total carotenoids and urinary levels of isoflavones and enterolactone compared with non-vegetarians. Vegans also had a lower intake of saturated fats and higher proportions of linoleic acid (omega-6) and total omega-3 fatty acids compared to non-vegetarians. Similar results were found for lacto-ovo- and pesco-vegetarians.
Harman et al., 1998	Cross-sectional survey	141	New Zealand	Vegetarian	Non-vegetarian Adventists	Serum vitamin B12 and dietary intake as well as the intake of essential nutrients such as vitamin C, folate,	Non-vegetarian males had higher intakes of vitamin B12 (3 vs. 1.4 mcg) and calcium (943 vs. 721 mg) than vegetarian males. Non-vegetarian females showed higher intakes of protein and vitamin B12. Vegetarian females

						vitamin A, zinc, iron, calcium and PUFA were assessed. Serum ferritin were also assessed.	had higher intakes of vitamin C. No significant differences in the serum folate, ferritin, and vitamin B12 levels were shown between vegetarians and non-vegetarians.
Hunt et al., 1988	Cross-sectional	290	United States	Vegetarian	Methodist omnivore	Dietary intake of zinc, folate, vitamin B-6, vitamin E, folate, thiamine, vitamin C, vitamin A, total fat, saturated fatty acids, cholesterol, and dietary fibre.	Neither groups consumed enough zinc, folate, vitamin B 6, and vitamin E to meet the RDA. Vegetarians consumed more folate, thiamine, as well as vitamins C and A, ate lower amounts of fat and cholesterol, and higher dietary fibre compared to omnivores.
Orlich and Fraser, 2014	Prospective cohort study	96,000 (AHS-2 chort)	North America	Various vegetarian diets including vegan, lacto-ovo-vegetarian, pesco-vegetarian, and semi-vegetarian.	Non-vegetarian Adventists	The study investigated the intake of a number of nutrients, but only protein is relevant for this systematic review.	The mean intake of protein as a percentage of daily energy was 13.6 among vegans, and 14.7 among non-vegetarians.
Reddy et al. 1980	Cross-sectional study.	44	Finland and New York	Vegetarians	Non-Adventist omnivores	The study investigated the intake of a number of nutrients, but only protein is relevant for this systematic review.	Protein intake was similar across all groups (86g among vegetarians and 92g and 95g among non-vegetarians).
Rizzo et al., 2013	Cross-sectional	71,751 subjects from the AHS-2 cohort	North America	Various vegetarian diets including vegan, lacto-ovo-vegetarian, pesco-vegetarian, and semi-vegetarian.	Non-vegetarian Adventists	Major nutrients, vitamins, and minerals, including plant proteins, fibre, beta carotene, magnesium, saturated, trans, arachidonic and docosahexaenoic fatty acids.	Strict vegetarians consumed the most amounts of fibre, soy protein, and vitamins C, folate, beta carotene, and vitamin E, and the lowest intakes of saturated, trans-fat, and arachidonic acid.
Rouse et al., 1983	Cross-sectional	331	Australia	Lacto-ovo vegetarian Adventists and	Mormons	Nutrients of relevance assessed: Protein, polyunsaturated fat,	Mormon omnivores consumed significantly less magnesium and potassium than Adventists (including vegetarians). They also

				omnivore Adventists.		potassium and magnesium	consumed less polyunsaturated fat than Adventist vegetarians. There were no differences in protein intake among Adventist vegetarians.
Shultz and Leklem, 1983	Cross-sectional study	128	United States	Vegetarian diet	Non-Adventist omnivores	Whole blood selenium levels, dietary protein, riboflavin, niacin, oleic and linoleic acids.	No significant difference in blood selenium values was found between the vegetarian Adventists and the non-vegetarian non-Adventist groups
Shultz and Leklem, 1987	Cross-sectional	29	United States	The vegetarian group included 10 lacto-ovo-vegetarians and 3 vegans	Non-Adventist omnivores	The study investigated the intake of the following nutrients of interest: protein, fat, calcium, iron, vitamin A, and B vitamins.	There were no differences in the intakes of protein, iron, vitamins A and C, the B vitamins between vegetarian and non-vegetarian groups. Furthermore, the plasma concentration of pyridoxal 5'-phosphate (vitamin B6 was the same between vegetarians and non-vegetarians who did not use supplements.
Shultz and Leklem, 1982	Cross-sectional study	23	United Kingdom	Vegetarian	Non-Adventist omnivores	Dietary intakes of fat (especially saturated fat), carbohydrate, cholesterol, protein, linoleic acid, and oleic acid	There were no differences in the intakes of protein and the essential fatty acid linoleic acid.
Stich et al., 1986	Cross-sectional study	202	Canada	Lacto-vegetarian Adventists and blievers of the International Society for Krishna Consciousness.	Heavy consumers of alcoholic beverages and individuals with a “Western” lifestyle pattern.	Beta-carotene concentrations in the exfoliated mucosa cells.	Adventists and ISKC members, who abstain from alcohol, smoking, and were vegetarians, had significantly higher levels of beta-carotene in exfoliated mucosa cells compared to heavy consumers of alcoholic beverages and individuals with a “Western” lifestyle pattern.

Thorpe et al., 2021	Prospective cohort study using a sample of the Adventist Health Study-2 (AHS-2)	34,542	North America	Vegan, vegetarians, as well as pesco-vegetarians.	Non-vegetarian Adventists	Dietary and supplementary intake of calcium and vitamin D.	Vegan females had a 55% higher risk of hip fractures in comparison to non-vegetarians, but no differences were shown in males. Supplementing vegans did not have a greater risk of hip fracture than followers of other dietary patterns.

5.3 RESULTS

The initial database search yielded 4601 articles as presented in Figure 11. Of these, 3642 were identified as duplicates or were deemed irrelevant. The title and abstract review excluded a further 906 articles, which meant that 56 articles were read in full. Twenty-one of the articles were deemed relevant after full-text search and were included in this systematic review and meta-analysis. Furthermore, 4 of the studies were included in the quantitative synthesis in the form of a meta-analysis.

The results and individual study characteristics for the studies that reported on vitamin B12 are presented in Table 5. Two of the four included studies were conducted in the United States of America, whilst the other two studies were carried out in New-Zealand and Australia. The included studies recruited 1994 participants in total.

In addition, the results and study characteristics of studies reporting on the intake or status of other essential nutrients are reported in Table 6.

5.3.1 Vitamin B12

Vitamin B12 intake was estimated using food frequency questionnaires and dietary recalls in the included studies. The average age of participants in the included studies were between 40 and 58 years. There were 24 females and 23 males in the study conducted by Harman and Parnell (1998), whereas 331 of the 340 participants were male in the study conducted by Hokin and Butler (1999). In contrast, 65.4% of participants recruited by Damayanti et al. (2018) and 521 of 785 (66.35%) recruited by Haddad et al. (2020) were female.

The studies conducted by Damayanti et al. (2018) and Haddad et al. (2020) presented separate group averages for vegan and vegetarians, whereas the other two studies grouped vegans and vegetarians together, although Hoking and Butler (1999) stated that there were no significant differences between vegans and vegetarians.

Of the studies included, 4 evaluated serum vitamin B12 concentrations (pmol/L), and 3 of these also reported daily intake of vitamin B12 as mcg/day. Only one of the included studies reported the average duration of time the vegetarian group followed their diet (Hokin and Butler, 1999).

5.3.1.1 Serum vitamin B12 concentrations between plant-based Adventists and omnivore controls

The results of the meta-analysis concerning the serum vitamin B12 concentrations between plant-based Adventists and omnivore controls is presented in Figure 12. According to the pooled results, the serum vitamin B12 levels of plant-based Adventists and omnivore controls did not differ significantly (MD: −9.85 pmol/L; 95% CI: −45.64 to 25.94 pmol/L; p = 0.54, I2 = 50%). In the sensitivity analysis, the removal of the study with the highest risk of bias (Harman and Parnell, 1998) lowered heterogeneity (I^2=34%).

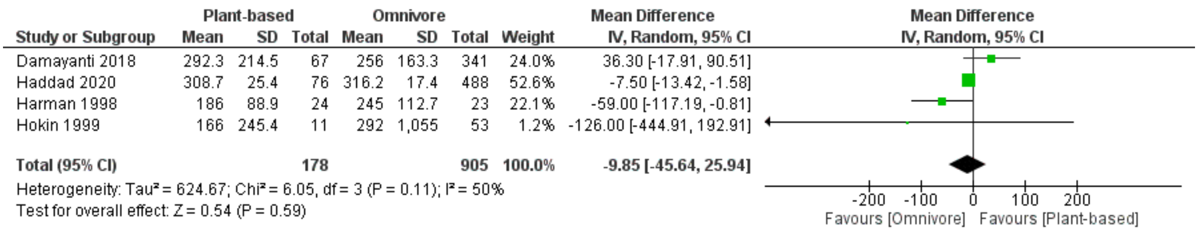


Figure 12. Vitamin B12 serum levels in plant-based Adventists and omnivore controls.

The average serum vitamin B12 concentration of vegans was above the deficiency criteria of 133 pmol/L as defined by the National Institute for Health and Care Excellence (2023) guidelines in all four included studies.

5.3.1.2 Vitamin B12 intake among plant-based Adventists and omnivore controls

There were no significant differences in the daily intake of vitamin B12 among plant-based Adventists and omnivore controls (MD: 3.31 mcg/d; 95% CI: −4.70 to 11.32 mcg/d; p = 0.42, I^2 = 90%) as shown in Figure 13. In the sensitivity analysis, the exclusion of any single study did not change the result. There was significant heterogeneity between the studies as indicated by the high I^2 value. To explore the source of heterogeneity, sensitivity analysis was conducted by removing each study from the analysis. The exclusion of the study by Harman and Parnell (1998) decreased the I^2 value to 66% as this was the study with the highest risk of bias as presented in Table 4 and had the lowest sample size. This study grouped vegetarian and vegan participants together in the analysis, whereas the other studies presented separate results for these two groups.

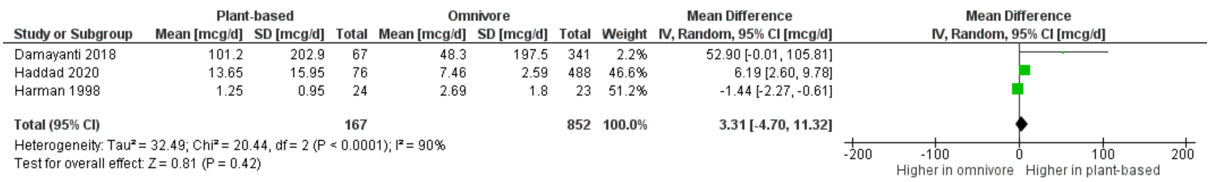


Figure 13. Daily vitamin B12 intake among plant-based Adventists and omnivore controls.

A potential source of heterogeneity in the included studies is the use of vitamin B12 supplements, however a subgroup analysis could not be carried out as the included studies did not report separate results for vegans who used supplements and those who didn't. However, the study published by Damayanti et al. (2018) reported the average dietary intake of vitamin B12 from food sources and supplements separately, and it shows that the mean total daily vitamin B12 intake among vegans was 101.2 (SD 202.9) mcg/d, 96 (SD 196.2) mcg of which was consumed in the form of supplements. Therefore, it can be concluded that vitamin B12 supplements provided almost all of the vitamin B12 vegans consumed in this study.

5.3.2 Publication bias

Publication bias was assessed visually using a funnel plot (Figure 14, Figure 15); however, asymmetry could not be reliably assessed due to the limited number of datapoints. Figure 14 depicts the distribution of studies that assessed the serum vitamin B12 of participants. There is a relatively even distribution around the mean difference (MD), represented by the dotted vertical line, since one of the studies is on the right side of the dotted line, one is on the left side, and one is almost on the line, in the middle. The same is true for Figure 15, where studies are evenly distributed around the mean difference.

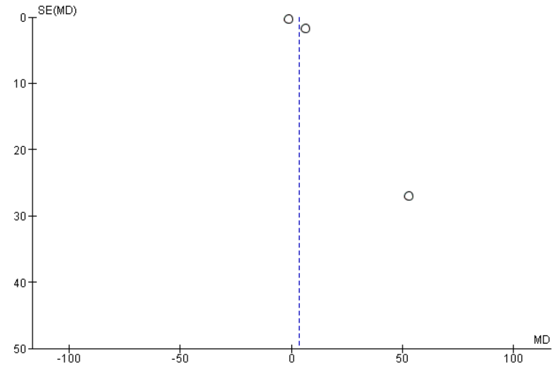


Figure 14. Funnel plot of studies reporting results on the serum vitamin B12 of plant-based Adventists and controls.

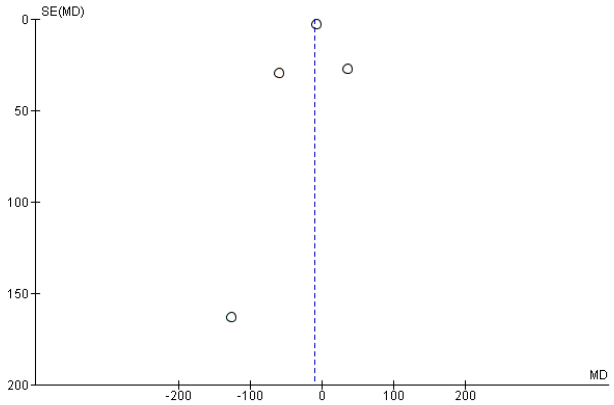


Figure 15. Funnel plot of studies reporting results on the intake of vitamin B12 of plant-based Adventists and controls.

5.3.3 Risk of Bias Assessment

The results of the risk of bias assessment for the studies reporting on vitamin B12 are presented in Table 7. In the analysis of the four studies, it was observed that two of the included studies demonstrated a high level of bias as identified by the adjusted NOS criteria (Modesti et al., 2016). However, the remaining two studies by Damayanti et al. (2018) and

Haddad et al. (2020) achieved scores of 7 and 8, respectively, indicating a significantly lower risk of bias in their results.

Table 7 Risk of bias assessment of the included studies reporting on vitamin B12 intake or status using the NOS

Study	**Selection (max 5 stars)**	**Comparability (max 2 stars)**	**Outcome (max 3 stars)**	**Total (max 10 stars)**
Damayanti 2018	3	2	2	7
Haddad, 2020	3	2	3	8
Harman, 1998	2	0	2	4
Hokin, 1999	3	0	2	5

The risk of bias assessment of the studies that reported on other essential nutrients are presented in Table 8. All studies were assessed using the NOS adapted for cross-sectional studies by Modesti et al. (2016) except for the study by Orlich and Fraser (2014) since it was a prospective cohort study, therefore the NOS originally developed for cohort studies could be used. The earlier studies which were published before the year 2000 showed a high risk of bias due to achieving lower scores in the domains of comparability owing to the fact that they have not used statistical adjustment methods to control for confounding factors. The studies that reported cross-sectional data using a sample of the AHS-2 cohort generally showed a low risk of bias (Chan et al., 2009; Miles et al., 2019; Rizzo et al. 2013; Thorpe et al., 2021) reflected in the high score of 8 achieved.

Table 8 Risk of bias assessment of the included studies reporting on essential nutrient intake or status

Study	**Selection (max 5 stars)**	**Comparability (max 2 stars)**	**Outcome (max 3 stars)**	**Total (max 10 stars)**
Anderson et al., 1981	1	2	2	5
Armstrong et al. 1974	3	1	2	6
Beezhold et al., 2010	3	2	2	7
Calkins et al. 1984	2	1	1	4
Chan et al., 2009	3	2	3	8
Miles et al., 2019	3	2	3	8
Harman et al., 1998	2	0	2	4
Hunt et al., 1988	2	0	1	3
Orlich and Fraser, 2014	2	2	2	6
Reddy et al. 1980	2	0	1	3
Rizzo et al., 2013	3	2	3	8
Rouse et al., 1983	2	1	2	5

Shultz and Leklem, 1983	2	0	2	4
Shultz and Leklem, 1987	2	0	2	4
Shultz and Leklem, 1982	2	0	2	4
Stich et al., 1986	2	1	1	4
Thorpe et al., 2021	3	2	3	8

5.3.4 Results for other vitamins

Twelve of the seventeen studies reporting on the nutrient intake and status of Adventists were conducted in North America, whilst two of the studies were conducted in Australia (Rouse et al., 1983 and Armstrong et al. 1974), another one in New Zealand (Harman et al., 1998), and the study by Reddy et al. (1980) recruited a control group from Finland. With regard to the comparison groups recruited in the included studies, vegans and vegetarians were compared to non-vegetarian Adventists in 8 of the included studies, whilst the comparison group was composed of non-Adventists in 9 of the included studies. Of the studies that used non-Adventists as a comparator, 2 recruited members of other religious groups such as Mormons (Rouse et al., 1983) and Methodists (Hunt et al., 1988), whilst one of the studies (Stich et al., 1986) recruited members of the International Society for Krishna Consciousness (ISKC) as part of the plant-based group in their study.

Fifteen out of the sixteen included studies were cross-sectional analyses, however the study published by Orlich and Fraser (2014) was a prospective cohort study, namely the Adventist Health Study 2. Furthermore, the studies by Thorpe et al. (2021), Miles et al. (2019), Chan et al. (2009) and Rizzo et al., (2013) also reported data from the AHS-2 cohort, however they all focused on different nutrients. For instance, Thorpe et al. (2021) investigated the association between 5 dietary patterns (vegan, vegetarian, pesco-vegetarian, semi-vegetarian and omnivore) and the risk of hip fractures with a focus on calcium and vitamin D supplementation. The study found that vegan women had a 55% higher risk of hip fracture (HR 1.55, 95% CI 1.06, 2.26), however subgroup analysis showed that this association was not present among vegan women who supplemented both vitamin D and calcium, highlighting the importance of calcium and vitamin D supplementation among vegan females. Vitamin D status within the AHS-2 cohort was also investigated by Chan et al. (2009) who after adjusting for age and sex did not find a significant difference in the vitamin D status of black and white Adventists based on vegetarian status.

Finally, Rizzo et al. (2013) compared the nutrient intake of Adventists following various dietary patterns in the AHS-2 cohort. Importantly, the results showed that vegans and vegetarians consumed the lowest median intake of vitamin B12. Vitamin C intake was highest among pesco-vegetarians, with vegans consuming the second highest amount of vitamin C. Vegans consumed more folate than non-vegetarians but ate less vitamin D (2.4 mcg/day) and vitamin E (18.5 mg/day), whilst omnivores consumed 6.1 mcg of vitamin D daily. Sodium intake was lowest among vegans with 3066 mg/day and highest among vegetarians at 3432 mg/day, whilst beta-carotene intake was highest among vegans with 13.300 mcg/day. It is worth mentioning that the levels of beta-carotene were also assessed by

Stich et al. (1986) in exfoliated oral mucosa cells. The levels were significantly lower in alcohol consuming controls than in Adventists who did not consume alcohol. Finally, Miles et al. (2019) investigated the levels of diet-related biomarkers in blood, urine, and adipose tissue in 840 individuals from the AHS-2 cohort. The study showed that the concentration of plasma carotenoids increased with decreasing consumption of animal foods such that vegans had the highest levels of beta-carotene, lutein, zeaxanthin, cryptoxanthin, and omnivores had the lowest concentrations. Vegans and vegetarians also had lower levels of saturated fats.

5.3.4.1 Non-AHS 2 cohorts

Nutrient intake or status was reported by studies not involving participants from the AHS-2 cohort. For instance, Hunt et al. in 1988 compared the nutrient intake of Adventist vegetarians to Mormons consuming a non-vegetarian diet. With regard to vitamin intake, neither group met the RDA for folate, vitamin B6, vitamin E. Vegetarian Adventists consumed more dietary fibre, and slightly more thiamine, vitamins A and C and folate.
Of the B vitamins, serum folate and vitamin B12 were investigated by Armstrong et al. (1974). The study showed that Adventist vegetarians had significantly higher folate levels in their serum than non-vegetarian Adventists. The levels of vitamin B12 correlated strongly with the intake of animal products such as meat and eggs, however, vegetarians were not at an increased risk of vitamin B12 deficiency. Only a single participant was shown to have vitamin B12 deficiency, but the article does not mention whether the person was vegetarian or not, and the authors stated that the deficiency was corrected by intrinsic factor, suggesting a malabsorption issue, rather than a dietary intake issue. Another study which investigated the status and intake of a type of B vitamin was published by Shultz and Leklem (1987), who assessed the vitamin B6 intake and plasma levels of vegetarian Adventists and non-Adventist

omnivores. The results showed no significant difference in vitamin B6 intake or serum levels between the two groups.

Calkins et al. in 1984 investigated the intake of several nutrients among Adventist vegetarians and non-vegetarians as well as non-Adventists. There were no significant differences in the intakes of vitamins C and A, thiamine, riboflavin, and niacin.

5.3.4.2 Protein

Seven of the included studies reported data concerning protein intake. In these studies, the protein intake of plant-based groups was compared with non-vegetarian groups. The earliest study conducted by Reddy et al. in 1980 did not show a significant difference in the protein intake between Adventist vegetarians, Adventist non-vegetarians and the Finnish non-vegetarians. Chronologically, the next study was published by Calkins et al. in 1984, which showed that both vegetarians and non-vegetarians consumed adequate or even excess amounts of protein, although the non-vegetarians consumed 20 g and 30 g more protein than the vegans and vegetarians respectively.

A year earlier in 1983, Rouse et al. reported on the protein intake of Adventist vegetarians and non-vegetarians as well as Mormon non-vegetarians and showed no significant difference between any of the groups. The nutrient intake of premenopausal Adventist vegetarians was compared with non-Adventist omnivores by Shultz and Leklem in 1982. The study focused on examining the relationship between hormonal status and dietary nutrient intake, and protein intake was assessed as part of the nutrients investigated. No differences in protein intake were shown between the two groups.

A few years later in 1987, Shultz and Leklem investigated the vitamin B6 intake among 13 vegetarian Adventists and 16 non-Adventist omnivores, however the researchers also assessed other essential nutrients, such as protein. The average daily protein intake of Adventist vegetarians was 59 g, whilst the average protein intake among non-Adventists was 64 g, however this difference was not statistically significant. Of the other nutrients investigated, Adventists consumed significantly less calcium, niacin, cholesterol, fat and saturated fats, and significantly more fibre and carbohydrates.

Harman et al. (1998) compared the nutrient intake of vegetarian and non-vegetarian Adventists and showed that whilst there was no difference in protein intake between male vegetarians and non-vegetarians, vegetarian females consumed significantly less protein at 12.2% of daily energy. Similarly, vegans in the AHS-2 cohort consumed slightly less protein (13.6%) than non-vegetarians (14.7%) as reported by Orlich and Fraser (2014). This study analysed the relationship between the various dietary patterns and health outcomes. At baseline, vegan consumed the most fibre and the least amount of saturated fat and protein. The results also showed that those who consumed the least animal protein but consumed protein rich plant foods at least once a day, had a 68% lower risk of wrist fracture. In another publication, median intakes of protein in all five diet groups in the AHS-2 cohort were also reported to be around 14% of daily energy consumption, with no significant differences between the groups, however vegans consumed the most plant-protein, while omnivores consumed the most amount of animal protein (Rizzo et al. 2013).

5.3.4.3 Essential minerals

Anderson et al. (1981) investigated the iron and zinc status of vegetarian Adventist women living in Canada. Participant's daily mean zinc and iron intake were 9.2 mg and 12.5 mg respectively. According to the researchers, participants' available iron for absorption was only 81% of the amount recommended by the WHO and the Canadian Dietary Standard (CDS). Based on the Nutrition Canada Interpretive Standard, 71% of participants were at low risk of iron deficiency, and 22% were at moderate risk, however none of the participants were in the high-risk category based on blood iron status. Calkins et al. (1984) also assessed iron intake in their sample of vegetarian Adventists and non-Adventist omnivores and showed that all females in the sample consumed less iron than recommended with no significant differences between the Adventists and non-Adventists.

The study also found that non-supplementing participants who consumed meat, which is a source of haem iron, did not have higher intake of iron than the Adventist vegetarians. In addition, the study reported on the intake of other essential minerals such as calcium and phosphorus. The mean calcium intake of pure vegetarians was 652 mg per day, which was well below the recommended intake for females, and it was significantly lower than that of the lacto-ovo-vegetarian and non-vegetarian groups. Phosphorous intake was also significantly lower among pure vegetarians, and their intake level was slightly below the recommended amount. On the other hand, the 3-day dietary records collected from participants showed that the use of calcium and iron supplements greatly improved the intake of these nutrients, and it helped pure vegetarians and lacto-ovo-vegetarians meet their recommended iron and calcium intakes respectively. Another study that reported on dietary iron intake was that of Shultz and Leklem (1987), who did not find a difference in the iron intake of Adventist vegetarian females and non-Adventist omnivore females, however the calcium intake of non-Adventist omnivores was significantly higher than that of vegetarian Adventist females.

This was later confirmed by an analysis of the AHS-2 by Thorpe et al. (2021), which showed that vegans had the lowest intake of dietary calcium (788 mg/day), with pesco-vegetarians consuming the most calcium at 937 mg/day). Vegans' calcium intake was significantly lower than any of the other 4 groups' reported intake. This study also reported on calcium supplementation, which showed that the mean intake of calcium from supplements was lowest among vegans at 287 mg/day, and highest among pescatarians at 431 mg/day. Phosphorus intake was lowest among vegans as well; however they consumed the most magnesium and potassium out of the 5 diet groups.

Furthermore, in the study conducted by Harman et al. in 1998, the iron intake of vegetarian Adventists and non-Adventists did not differ significantly, although the mean iron intake of vegetarian females was higher than that of non-vegetarian females. This study also showed that male non-vegetarians (943 mg/day) consumed significantly more calcium than vegetarian males (721 mg/day), however there were no differences in females. Moreover, there were no significant differences in the intake of zinc between vegetarians and non-vegetarians.

In addition, essential mineral intake was assessed in the study by Hunt et al. (1988). The study investigated the food and nutrient intake of Adventist females who were vegetarians. Calcium intake in both groups were slightly below the Recommended Dietary Allowance (RDA). Zinc intake was also below the RDA in both groups, however there were no significant differences between the Adventist and non-Adventist groups. Furthermore, Rizzo et al. (2013) showed that the omnivore group had the lowest daily iron intake at 20 mg, whilst vegans and vegetarians consumed 22.2 mg and 22.1 mg respectively. In addition, vegans were reported to have the highest intake of magnesium (591 mg) and phosphorous (1370 mg), but they also consumed the least amount of calcium (933 mg/day). On the other hand, omnivores in this sample consumed the most amount of zinc on average (11.9 mg). Adventist vegetarian males and females were shown to have significantly higher average intakes of potassium and magnesium than Mormon omnivores in the study conducted by Rouse et al. (1983).

Selenium status was only reported by a single study, which showed no differences in blood selenium concentrations between vegetarians and non-vegetarians (Shultz and Leklem, 1983). Dietary intake of this essential mineral could not be investigated in this study, due to the limited data.

5.3.4.4 Omega fatty acids

In the analysis of the AHS-2 cohort by Rizzo et al. in 2013, over 50% of vegans and vegetarians did not consume any amount of the preformed omega 3 fatty acid docosahexaenoic acid (DHA). On the other hand, vegans and vegetarians consumed significantly more of the omega 6 fat linoleic acid. This was further confirmed by Miles et al. (2019) who showed that although the blood levels of linoleic acid and alpha-linolenic acid increased as the amount of animal foods decreased in the diet, the levels of the omega 3 fat docosahexaenoic acid was lowest in vegans and vegetarians.

Beezhold et al. (2010) investigated the effect of vegetarian diets on mood states and as part of their study, they assessed the intake of various polyunsaturated fatty acids. The results of the study showed that vegetarian participants ate lower amounts of EPA and DHA fats but consumed higher amounts of α-linolenic acid. Overall, the authors concluded that the lack of intake of EPA and DHA did not have a negative impact on participants' mood states since vegetarians were reported to have experienced significantly fewer negative emotions than omnivore Adventists. Of the earlier studies, Shultz and Leklem in two of their studies conducted in 1982 and 1987 assessed the intake of the omega 6 fatty acid linoleic acid and found no differences between Adventist vegetarians and non-Adventist omnivores.

On the other hand, Rouse et al. (1983) showed that the intake of polyunsaturated fats was significantly lower among Mormon and Adventist omnivores than among Adventist vegetarians, although the study did not report results for specific polyunsaturated fatty acids. In contrast, Harman et al. (1988) did not find a difference in the intake of polyunsaturated fats between vegetarian and non-vegetarian Adventists, however this study did not differentiate between the various PUFAs either.

5.4 DISCUSSION

5.4.1 Vitamin B12

This is the first systematic review and meta-analysis that investigated the serum levels and dietary intake of vitamin B12 of vegan and vegetarian Adventists. The results of the meta-analyses suggest that there were no significant differences in the intake or serum concentration of vitamin B12 between plant-based Adventists and omnivore controls.
This data is not in agreement with the results of a previous meta-analysis that investigated studies with non-Adventist vegan populations (Obersby et al., 2013). This previous meta-analysis showed that vegans had a significantly lower vitamin B12 level than omnivores, however the present meta-analysis included studies with supplement users, whereas the study published by Obersby et al. (2013) excluded studies with participants who took

methylcobalamin supplements. In addition, another meta-analysis was published in December of 2024 by Niklewicz et al., which also showed that vegans had significantly lower vitamin B12 status as indicated by serum vitamin B12 and holotranscobalamin levels, compared to omnivores.
Another meta-analysis investigated the serum vitamin B12 levels of non-Adventist children and adolescents following a plant-based diet. The study showed that children following a vegan diet, had significantly lower serum vitamin B12 levels (Koller et al., 2023), whilst vegetarian children did not have lower levels. We were unable to carry out a subgroup analysis on vegetarian Adventists only because of the limited number of studies included. Furthermore, educational status and female gender have been associated with higher dietary supplement use among vegans (Fuschlberger and Putz, 2023), but these could not be investigated in subgroup analyses in this study due to the lack of available data for vegans based on gender and education levels in regard to supplement use. To enhance the validity of the meta-analysis, further studies are needed with more robust study designs and statistical analysis methods that adjust for important confounders.

It seems that the vegan and vegetarian Adventist participants in the included studies did not have a higher risk of vitamin B12 deficiency than omnivores, likely due to the high prevalence of fortified foods and supplements in their diet. In fact, the average serum vitamin B12 levels of vegans in the two studies that presented separate data for vegans (Damayanti et al., 2018 and Haddad et al., 2020) was around 300 pmol/L which is over twice the amount of the deficiency threshold of 133 pmol/L. Nevertheless, Damayanti et al. (2018) also showed that the incidence of low vitamin B12 consumption (<2.0 μg/d) was most common among vegans, which further highlights the importance of supplementation and the consumption of fortified foods. By incorporating fortified foods in the diet, examples of which are plant-based milks, cereals, and nutritional yeast, along with B12 supplements, Adventists following a plant-based diet can ensure they meet their daily requirements and support optimal health based on the findings of this meta-analysis. It seems that the church's health promotion strategies concerning the promotion of plant-based diets effectively inform members about the appropriate intake of vitamin B12, however it is unknown whether Adventists in other parts of the world are as equally well informed.

5.4.2 Other essential nutrients

None of the included studies reported inadequate protein intakes for plant-based Adventists. In some studies plant-based Adventists consumed less protein as a percentage of daily energy than omnivore comparators (Orlich and Fraser (2014) and Shultz and Leklem (1987), Harman et al (1998)), however their intakes were still above 10% of daily energies consumed, which is the lower limit of the current recommended daily allowance for protein of 10-15% total energy intake (Wallace and Frankenfeld, 2017), therefore plant-based Adventists seem to consume adequate amounts of protein based on the results reported in the included studies. On the other hand, iron intake was found to be below the recommended daily allowance set by international guidelines such as the recommendation of the Institute of Medicine (2001) in the United States. This was also the case for all females in the study published by Calkins et al. (1984), although it was not dependent on vegetarian status in this study. This is somewhat of a surprise since meat consumption has been shown to contribute to the maintenance of adequate iron status as compared to plant-based diets due to the higher iron availability of meat (Tetens et al., 2007).

Another essential mineral of potential concern identified in the systematic review is calcium, which was identified in a number of the included studies to be particularly low (Rizzo et al.

(2013), Harman et al., 1998, Hunt et al. (1988)). In all these studies, the average calcium intake of both omnivores and plant-based participants were below the recommended daily allowance value set as 1,000 mg/day for adults (National Institutes of Health, 2022), although this requirement may increase with age to 1200 mg/day for females.
On the other hand, even vegans consumed above 700 mg/day of calcium in the included studies, which may actually be sufficient to meet nutritional needs according to Garg and Mahalle (2019) since fractional calcium absorption in the intestines increases to up to 80% as a compensatory response when calcium intake is lower. The measurement of blood calcium levels could have aided assessment, however none of the included studies measured blood calcium levels to validate the self-reported intake of calcium for participants, which could have identified individuals with hypocalcaemia (Bove-Fenderson and Mannstadt, 2018).

It is worth mentioning that calcium intake may significantly be impacted by dairy intake, which may inflate the average intake levels if results are reported together for vegans and vegetarians and may not reflect true levels for vegans. This is confirmed by Calkins et al. (1984), where subgroup analysis showed that the calcium intake was only lower for vegans, which highlights the need for future research to present separate results for vegans and vegetarians.

Plant-based Adventist in some of the included studies (Beezhold et al., 2010; Rizzo et al., 2013) consumed little or no DHA or EPA. This is somewhat expected since the most common direct source of these long chain polyunsaturated fatty acids are marine animals such as fish and seafood, however vegetarians and vegans do not consume these foods. This may be a cause for concern since the intake of these long chain fatty acids have been associated with a number of health benefits such as a reduction in the risk of hypertension and in inflammatory markers (Guo et al., 2019), a reduced risk of depression and anxiety (Kelaiditis, 2023), and even a reduced risk of cardiovascular disease specific mortality, events caused by coronary heart disease, and major adverse cardiovascular events (Khan et al., 2021). Although, data from the AHS-2 cohort showed a reduced risk of all-cause mortality among vegans and vegetarians compared to omnivores, which shows that these plant-based participants had a lower mortality despite their low intakes of EPA and DHA, which are long chain omega 3 fats. A potential explanation is the intake of the short chain omega 3 fatty acid alpha linoleic acid (ALA), which can be converted to the longer chain omega 3 fats in the body. Alpha linolenic acid intake in the previously mentioned studies was higher amongst vegans and vegetarians as it can be found in plant-based sources such as seeds, nuts and soy foods (Rajaram, 2014). It has also been shown to be associated with a lower risk of all-cause mortality and cardiovascular disease (Naghshi et al., 2021). Furthermore, vegans and vegetarians can obtain DHA through the consumption of algae oil, which has been shown to significantly increase the blood and erythrocyte levels of DHA (Lane et al., 2013), however the included studies have not assessed the supplemental intake of algae oil among participants.

5.4.3 The influence of nutrient deficiencies and supplementation on COVID-19 risk

None of the included studies in this systematic review investigated nutrient intake or status in relation to infectious disease risk, however, there are numerous studies involving non-Adventist cohorts that have investigated nutrient intake and supplement use and their impact on the risk of infections. This systematic review identified evidence of lower intakes of calcium, iron and longer chain omega-3 fatty acids among plant-based Adventists. Lower intakes of these essential nutrients may influence infectious disease risk, however, to-date there is no evidence that plant-based Adventists have a higher risk of COVID-19 or other infections. In fact, the observational study in Chapter 4 of this thesis showed that plant-based Adventists actually had a lower COVID-19 disease risk.

Low iron status as reflected by low haemoglobin concentration has been shown to increase COVID-19 risk (Taneri et al., 2020), however excessive iron intake has also been shown to increase COVID-19 infection, which highlights the importance of balanced iron intake (Chaubey et al., 2023). Although iron intake in the study published by Anderson et al. (1981) was below the recommended intake, none of the included studies showed evidence for iron deficiency among plant-based Adventists as measured by blood iron levels, which suggests that self-reported iron intake may have been underestimated during data collection. Also, nutrients such as vitamin C and curcumin can greatly enhance the absorption of non-haeme iron, which is the form of iron found in plant-based foods (Milman, 2020). This is important as Rizzo et al. (2013) showed that vegan Adventists consumed significantly more vitamin C than non-vegan participants, which can contribute to higher iron absorption. In addition, Adventists generally consume less coffee as shown by Kent and Worsley (2008) as well as the study described in Chapter 4 of this thesis, which is relevant since caffeine is an important inhibitor of iron absorption. Hanna et al. (2023) showed that coffee can inhibit fractional iron absorption by over 50%, therefore consuming less coffee can indirectly lead to better iron status. The potentially higher dietary intake of vitamin C and lower consumption of inhibitory foods such as coffee or tea may explain the lack of evidence for iron deficiency among plant-based Adventists despite their potentially lower dietary intake. This also is maybe the reason plant-based Adventists were shown to be protected against COVID-19 infection. Although, plant-based Adventists may consume less iron, they do not seem to have low serum iron concentration, and their higher intake of other essential nutrients such as vitamin C can contribute to the lower the risk of COVID-19 infection observed in Chapter 4 (Hafez et al., 2022).

In addition to the higher intake of vitamin C by plant-based Adventists, the study included in this systematic review by Miles et al. (2019) showed that vegans had higher blood levels of carotenoids and urinary isoflavones. These nutrients have also been shown to influence COVID-19 risk. According to Lu et al. (2022), carotenoids have important antioxidant activity and can help regulate the inflammatory response to COVID-19 infection, thereby lowering infection risk and severity. Isoflavones, which are found in soy foods, flaxseeds and other plant-based foods (Mulligan et al., 2012), have also been shown to have antiviral activity and may potentially contribute to a lower COVID-19 infection (Marmitt et al., 2021). Furthermore, Rizzo et al. (2013) showed that vegan Adventists consumed significantly more folate and vitamin E, additional nutrients which have been shown to impact COVID-19 infection. Ulloque-Badaracco et al. (2024) showed that low folate levels were associated with higher COVID-19 severity, whereas vitamin E supplementation has been shown to decrease the length of COVID-19 related hospitalization (Iman Mandour et al., 2023).

Regarding calcium intake, Alemzadeh et al. (2021) showed that low calcium levels didn't only increase the risk of COVID-19 infection risk, but it was also associated with increased disease severity, COVID-19 mortality as well as longer hospitalization due to the infection. These findings were based on the pooled results of 25 observational studies, which represent the best available evidence on the topic. In addition, viral infections have also been shown to reduce calcium levels because of host defence mechanisms (Crespi and Alcock, 2021) as well as due to deficiency in vitamin D intake, which is the result of chronic malnutrition (Alemzadeh et al., 2021). However, none of the Adventist studies included in this systematic review measured blood calcium levels, therefore the lower dietary intake could not be validated through serum levels. In connection to the findings from Chapter 4, calcium levels and intake were not measured, but being a plant-based Adventist was associated with lower COVID-19 incidence; therefore, it would be expected that calcium intake was adequate.

Regarding vitamin D, the included studies did not indicate a higher risk of vitamin D deficiency among plant-based Adventists. Data derived from Chen et al. (2009) showed no significant differences in the serum vitamin D levels of vegan and non-vegan Adventists. Although, vitamin D status can be influenced by sunlight (Saraff and Shaw, 2015), which limits the generalizability of these findings to Adventists living at higher latitudes such as the UK (Leary et al., 2017), where UVB radiation is less abundant.

Vitamin D deficiency could not be assessed in the study included in Chapter 4, but the lower incidence of COVID-19 among plant-based Adventists suggests that participants had adequate vitamin D levels, although this cannot be confirmed.

Vitamin D has an important role in supporting the immune system. A meta-analysis of four randomised clinical trials conducted by Yakoob et al. (2016) did not show a lower risk of pneumonia following vitamin D supplementation in children, however a later meta-analysis published in 2017 including 25 studies showed a lower risk of respiratory tract infections as a result of supplementation with vitamin D, although these studies did not specifically include plant-based participants, however the effect is likely to be even stronger among vegans and vegetarians (Martineau et al., 2017). This is because the meta-analysis showed stronger protective effects among those with a vitamin D deficiency at baseline, a condition which is more common among plant-based individuals (Baig et al., 2013), which suggests that vegans or vegetarians could especially benefit from vitamin D supplementation.

The effectiveness of vitamin A supplementation against measles infection was investigated in a 2017 Cochrane Review which included six clinical trials involving vitamin A supplementation at doses ranging from 15,000 mcg RAE (50,000 IU) to 60,000 mcg RAE (200,000 IU), which was dependent on age. The study, which included a total of 19,566 children between the ages of 6 months and 5 years, showed that supplementation reduced the risk of new measles cases by 50% (Imdad et al., 2010). Moreover, the effect of vitamin E supplementation on pneumonia risk was investigated by Neupane et al. (2010) in a prospective study of hospitalized elderly patients from Canada and found that vitamin E supplementation reduced the risk of rehospitalization for pneumonia by 63%. On the other hand, other research on the effects of vitamin E supplementation in reducing the risk or severity of respiratory tract infections, has been mixed (Graat et al.,2002), likely due to the variability in study designs concerning participants' baseline vitamin E status and the supplementation doses used (Nih.gov, 2025).

Furthermore, zinc supplementation has been shown to reduce the severity of symptoms caused by viral infections (Iddir et al., 2020). Finally, Sinopoli et al. (2024) investigated the effect of various vitamin supplements on the risk of COVID-19 infection using data from randomised controlled studies. Based on the pooled results of 3 studies, multivitamin use showed differing results, therefore no definitive conclusions could be drawn regarding its effects on COVID-19 related outcomes. The only supplements with significant effects from the meta-analyses were vitamins C and D. Vitamin C supplementation significantly lowered mortality in the included trials, with vitamin D also showing similar results.

These studies suggest that ensuring adequate nutrient intake among plant-based Adventists in the context of infectious diseases like COVID-19 should be further investigated as they may be at an increased risk of nutrient deficiencies, which can influence the risk of infections. The findings of this systematic review concerning potential nutrient deficiencies among plant-based Adventists could inform the Adventist church’s health promotion activities.

5.4.4 Strengths and Limitations

This is the first systematic review investigating a niche but important area of health research concerning the risk of nutritional deficiencies among plant-based Adventists, which might increase the susceptibility to COVID-19 disease. In addition, the pooling of the results concerning intake and status of vitamin B12 in the form of a meta-analysis enhanced the statistical power and the validity of the findings.

The results of this study provide important insights with practical implications, which are valuable for health promotion messaging for the Adventist community since the study highlights the potential nutrients of concern plant-based Adventists should pay attention to. Additionally, a comprehensive search strategy was used, which utilised a combination of keywords across multiple databases with no date limitations, which likely captured a comprehensive set of relevant studies.

Furthermore, the use of the Newcastle-Ottawa Scale offered a systematic approach for the assessment of the quality of the included studies, which adds credibility to the findings. Registering this systematic review on PROSPERO promoted transparency and reduced the potential for reporting bias.

One of the main limitations of the meta-analysis is the limited number of studies available, which increases the likelihood of publication bias and prevented any type of subgroup analysis to be carried out. Subgroup analyses based on supplement intake, duration of plant-based diet and educational level could have provided important insights into the vitamin and mineral status of plant-based Adventists, however supplement data were not reported in any of the vitamin B12 studies, and only in a few of the studies that reported on other essential nutrients. Another important limitation is that in all studies vegans and vegetarians were grouped together, which could potentially overlook important differences in vitamin B12 intake and status between these groups.

The low number of studies resulted in high heterogeneity, especially in the meta-analysis investigating vitamin B12 intake. Furthermore, all of the included studies were cross-sectional, which is considered a weaker source of evidence than longitudinal studies, which have a follow-up period as opposed to cross-sectional studies which only provide a snapshot of the dietary habits and nutritional status of participants. This is of special importance as vitamin B12 deficiency can take years to develop due to the high body stores of the vitamin (National Institutes of Health, 2022), therefore longer-term observational studies are warranted to investigate whether vegan Adventists are able to maintain normal serum vitamin B12 levels over long periods of time.

The reliance of self-reported dietary assessment methods such as food frequency questionnaires and dietary recalls within the included studies is another important limitation concerning the meta-analysis findings concerning vitamin B12 intake, however all of the included studies measured serum levels of vitamin B12 which corroborate the validity of the dietary intake assessment methods. However, the studies reporting on other nutrients did not measure blood levels of the nutrients in most cases and only reported on dietary intake, which may not be as accurate in determining nutrient deficiencies.

Furthermore, none of the included studies provided a justification for their sample size, which raises questions about their statistical robustness and power. A final notable limitation of this meta-analysis is the lack of geographic diversity since two studies were conducted in the United States of America, one in New Zealand and one in Australia. This means that the meta-analysis findings cannot be generalised to the broader Adventist plant-based communities spanning the regions in Europe, Africa, Asia and other parts of the Americas.

5.5 CONCLUSION

This systematic review and meta-analysis of cross-sectional studies investigated the serum levels and dietary intake of several essential nutrients among vegan and vegetarian members of the Seventh-day Adventist church. The results of this study suggest that Adventists following a vegan or vegetarian diet, which is naturally low in vitamin B12, were not at an increased risk of vitamin B12 deficiency when compared to omnivores, which in most part is attributed to the common use of fortified foods and vitamin B12 supplements in these samples of Adventists. Therefore, the results of this study suggest that the widespread adherence to plant-based diets among Adventist populations, which is motivated by religious reasons, is not detrimentally impacting their vitamin B12 status, which is often a common concern among healthcare professionals.

A meta-analysis could not be carried out for any of the other essential nutrients reported in the studies due to the lack of data and non-uniform reporting of results, however the narrative review **suggests** that plant-based Adventists consume adequate or even higher amounts of most essential nutrients such as vitamin D, protein and vitamin C, however the generally low intakes of iron, calcium and zinc as well as EPA and DHA warrants further investigation, however the synthesized data do not currently suggest a higher risk of nutritional deficiencies among plant-based Adventists, which would be expected to negatively impact their COVID-19 risk. This is further validated by the systematic review conducted in Chapter 3 of this thesis, which didn’t identify any published studies, where the risk of COVID-19 or other infectious diseases were higher among plant-based Adventists. This provides key answers to the underlying research question of this thesis. Plant-based Adventists seem to consume higher amounts of several nutrients such as vitamins C and E, and folate, which may protect against COVID-19 infection, and do not seem to be at risk for serious nutritional deficiencies which could negatively impact infection risk.

The results of this study contribute to the growing body of literature by confirming that the plant-based diet followed by many Adventists seems to meet nutritional needs in relation to vitamin B12 due to the use of fortified foods and supplements. Future research should utilise more robust study designs with follow-up periods and objective dietary intake assessment methods, involving geographically diverse Adventist populations to aid with the generalisability of future meta-analyses on this topic. It would also be useful if future studies on plant-based Adventists reported the risk of COVID-19 disease or other infectious diseases and their associations with nutrient intake or status. The findings of this systematic review should inform church-based health promotion strategies within the Adventist community to continue to emphasize appropriate nutritional planning among those following a plant-based diet.

Finally, building upon the findings of this present study concerning the lack of available literature reporting on nutrient intake and COVID-19 risk, and the longitudinal study described in Chapter 4, the study in the next chapter aimed to assess the knowledge of plant-based Adventists regarding key nutrients that are also related to immunity and infection susceptibility to COVID-19, and tested the efficacy of an educational intervention designed specifically for Adventists for the purpose of improving nutritional knowledge and nutrient intake behaviour by aiming influencing their perceptions of plant-based diets and supplements.

6 Chapter 6. The effect of a lecture based educational intervention to improve the nutrition knowledge and behaviour of plant-based Seventh-day Adventists.

6.1 Research Context

The literature review in Chapter 2 identified a significant gap in studies assessing the nutrition knowledge of Adventists, especially those following a vegan and vegetarian diet. The study in Chapter 4 showed that Adventist participants, especially those following plant-based diets, were significantly less likely to take multivitamin supplements compared to omnivores. Moreover, only 28% of Adventist respondents reported taking vitamin D supplements, and 32% used vitamin B12 supplements. This seemingly low use of supplements may be of concern as both of these nutrients are critical in plant-based diets. Although, the lower use of dietary supplements among plant-based dieters, did not translate to higher COVID-19 risk, however, nutrient deficiencies may take a long time to develop, sometimes even years. (Carmel, 2008).

Furthermore, the systematic review presented in Chapter 5 of the thesis provided further important insights into the nutrient intake and status of plant-based Adventists, who were shown to have lower intakes of some key nutrients, such as calcium, iron, zinc, and omega-3 fatty acids, all of which are less abundant in plant-based diets

This raises concerns about whether Adventists who eat a plant-based diet are fully aware of their risk of nutritional deficiencies, and about their knowledge of the role of supplements in mitigating these potential deficiencies.

Additionally, deficiency states of several nutrients can influence COVID-19 risk as well, therefore, improving the essential nutrient intake of plant-based Adventists wouldn't just improve their general health but it could also affect their risk of COVID-19 infection.

Therefore, understanding the extent of vegan and vegetarian Adventist’s nutritional knowledge and practices is essential for identifying any gaps in knowledge that could make them susceptible to nutrient deficiencies and which could be addressed through targeted educational interventions.

6.2 METHODS

6.2.1 Ethical approval

This study received ethical approval from the Health, Education and Life Sciences Faculty Academic Ethics Committee of Birmingham City University ensuring the research complied with university’s ethical standards. The ethical approval was granted in December 2023. Participants were provided with a Participant Information Sheet, which contained detailed information about the study's objectives, methodologies, and the data privacy measures that would be used to handle the collected information, including their personal data. In addition, participants were required to provide informed consent by agreeing to the provided Consent Form thereby acknowledging their understanding of the study's nature and their rights as participants.

6.2.2 Data collection

Adult Seventh-day Adventists living in the UK were recruited if they followed a vegan, vegetarian or pescatarian diet using convenience sampling. Participants were eligible for inclusion if they were UK-based and followed a plant-based diet. Anyone under 18 years of age was excluded from participation. In addition, Adventists living outside of the UK were excluded. Data collection took place between December 2023 and February, 2024.

The minimum number of participants required for this study was 34, which was established using the Statulator online statistical calculator for paired means (Dhand & Khatkar, 2014). This sample size estimate was based on detecting a medium effect size (Cohen's d) change of 0.5 with 80% power and with an alpha level of 0.05 (two-sided test). Based on this, a minimum of 34 paired observations was required to achieve the predetermined statistical power and significance level.

Online platforms and social media channels were used to advertise the study and connect with Seventh-day Adventists who followed a plant-based diet. In addition, individuals who had previously taken part in Study 1 were contacted via email and invited to participate in this study.

6.2.3 Study design

This study employed a quasi-experimental design and collected cross-sectional data before and after an educational intervention in the form of an online lecture. The primary outcome for this study was the change in test scores before and after a lecture based educational intervention.

The lecture, which formed the basis of the educational intervention, was delivered in February of 2024 by RKJ, who holds a master's degree in clinical nutrition. The lecture presentation lasted approximately 30 minutes, and the lecture slides are shown in Appendix 14.

Participants were provided with an email invite to a Zoom meeting, which they could access at the time of the event. The lecture presented an overview of the essential nutrients that are important in the context of a vegan or vegetarian diet as well as discussed information about the best available evidence for the use of dietary supplements in the context of COVID-19 prevention or treatment, both of which were based on data derived from systematic reviews and meta-analyses to reflect the best available evidence available in the scientific literature. Furthermore, the lecture explored the potential benefits of dietary supplements in relation to overall health and their appropriate use in supporting nutritional needs. It discussed the importance of consulting with a healthcare professional or registered dietitian to ensure proper and appropriate supplementation, which takes into account individual requirements and potential interactions with medications or underlying medical conditions. Before the lecture, participants were asked to fill in an online questionnaire using Microsoft Forms, which was designed to assess their baseline knowledge and beliefs about diet and nutrition in general as well as in relation to the treatment or prevention of COVID-19. Subsequently, participants were required to listen to the online lecture and were then asked to fill in the questionnaire again, in order to determine if the educational intervention has had any impact on their nutritional knowledge.

6.2.3.1 Theoretical framework

This educational intervention utilised the principles of the Health Belief Model as a theoretical framework. This health promotion model aims to change the views and beliefs participants hold on health-related topics, including dietary exposures, thereby leading to behaviour change (Conner and Norman, 2017). A key foundation of this health promotion model is that strategies to change human behaviour are more successful when they target an individual's unique perceptions regarding susceptibility and potential barriers. As discussed in Chapter 1, this behaviour change model has important limitations, however most of its limitations are mostly relevant for more complex behaviour changes such as starting a new diet or exercise routine, whereas the behaviour change targeted at in this study was to encourage the use of supplements or fortified foods, which are considered simple behaviour changes (Phillips and More, 2022). Complex behaviour changes involve greater number of barriers and require more self-efficacy, motivation and involvement than simple behaviour changes. Also, the recruited participants all consumed a plant-based diet, which is evidence of higher levels of self-efficacy, which has been shown to be a key determining factor in behaviour change (Noar et al., 2007). Based on this, it was assumed that plant-based Adventists exhibiting higher self-efficacy would be likely to start using certain dietary supplements or fortified foods if their perception of the seriousness of nutrient inadequacy of plant-based diets was changed as suggested by the HBM.

Therefore, the lecture covered various key areas, providing participants with an overview of the advantages and any potential serious drawbacks of vegan diet such as specific nutritional concerns like the risk of deficiencies in vitamins B12 and D, omega-3 fatty acids and iron among vegans. Strategies for mitigating these risks through dietary planning and the use of supplementation were emphasized and the lecture presented essential information about the role of specific supplements, such as zinc, vitamin C, curcumin, and probiotics, in the context of COVID-19 disease prevention and treatment. The potential benefits of these supplements were highlighted based on the best available research evidence. Data from clinical trials and systematic reviews was used to present which dietary supplements have been shown to lower the risk of COVID-19 infection or lower the risk of experiencing more severe symptoms caused by the infection, including hospitalisation. The exact information presented to participants during the lecture can be viewed in the slides included in Appendix 14.

The lecture also delved into the Seventh-day Adventist Church's stance on plant-based diets and on critical nutrients and supplementation strategies for individuals following vegan diets.

As part of the lecture, the hierarchy of evidence in medical and nutritional sciences was emphasized and the importance of high-quality evidence from systematic reviews and meta-analyses was highlighted with the aim to address and tackle common misconceptions and barriers held by some Adventists regarding the adequacy of plant-based diets and the use of supplements and highlighted the potential dangers of inappropriately planned plant-based diets. By tackling these misconceptions using the best available scientific evidence as well as the official position of the church regarding the use of supplements on a plant-based diet, the lecture aimed to break down common barriers to supplementation thereby changing participants' perceptions and thus leading to better scores on the post-intervention test. Furthermore, the educational intervention also aimed to equip participants with the knowledge necessary to make informed dietary decisions within the context of a vegan or vegetarian lifestyle.

6.2.4 The questionnaire

The pre- and post-intervention questionnaires were developed for this study as no validated instrument was available that precisely fit the scope and context of this study. The questionnaire is included in Appendix 9, and it contained multiple choice questions as well as open-ended questions with free to type responses. The first questionnaire contained 40 questions in total, 25 of which were the test questions used to evaluate nutritional knowledge, and the rest of the questions gathered general participant characteristics as well as information about the views and beliefs of participants concerning diet, supplements, and COVID-19. Some of these additional questions were developed to assess participants' perceptions about the nutritional adequacy of exclusively plant-based diets or whether religious text or scientific data are more important for them in diet related decisions.

The post lecture questionnaire only contained the 25 test questions. The follow-up questionnaire that was sent to participants 4 weeks after the lecture contained 21 questions, which mainly asked questions about any potential changes in diet or supplement use as well as in belief and views about the topics discussed. It is included in Appendix 10. The reliability of the questionnaire used for this study has been validated through a small pilot. During the pilot, the test-retest reliability approach was used, in which six individuals who were Seventh-day Adventist and followed a plant-based diet but were not sampled for the study. They filled in the questionnaire on two separate occasions, one week apart. The internal consistency of the questionnaire was analysed using Cronbach's alpha. The questionnaire showed high internal consistency (Cronbach's alpha = 0.873). Furthermore, the consistency and reliability of the questionnaire was further evaluated through the test-retest reliability method (Aithal and Aithal, 2020). The test-retest reliability of the questionnaire was confirmed by the high Pearson's r coefficient of 0.85 ($p = 0.03$).

The highest score attainable in the nutrition knowledge test was 25. The questionnaire was composed of two main sections; one focused on general nutritional information with 11 questions with a total possible score of 11, and the second section of the questionnaire contained 14 questions that focused on the efficacy of nutritional supplements such as vitamin D, zinc, or curcumin in the treatment of COVID-19 totalling a maximum score of 14.

6.2.4.1 Conventional treatments

Concerning the use of pharmaceutical drugs, the Adventist church operates a great number of hospitals around the world such as the renowned Loma Linda University Medical Centre in California, where doctors utilise the most modern pharmaceutical treatments, however the church has always placed a large emphasis on the use of natural remedies based on the views of Ellen G. White who clearly expressed her position about diet and medications in the book titled “The Ministry of Healing”. This book forms the basis of the Adventist Health Message and in addition to its support for a healthy lifestyle, it contains sentences such as the below: “Drug medication, as it is generally practiced, is a curse. Educate away from drugs. Use them less and less and depend more upon hygienic agencies; then nature will respond to God's physicians—pure air, pure water, proper exercise, a clear conscience” (White, 1865)

Such statements, without proper context, may have contributed to a higher degree of scepticism towards medication use than among the general population.

There is only limited data available with regard to COVID-19 vaccination among Seventh-day Adventists, however an article published by Jones (2022) reports that COVID-19 vaccination is common among Christian Churches, including the Seventh-day Adventist Church. The article further states that the denomination's leading body, the General Conference, is not opposed to public health initiatives, but stresses that members should have the freedom to follow their personal convictions regarding medical procedures. The study in Chapter 4 of this thesis showed a lower vaccination rate amongst Adventists, but the study did not assess potential reasons behind vaccine hesitancy, and there aren’t any published studies on this topic specific for UK Adventists. In addition, the perceptions of Adventists living in the UK about COVID-19 vaccines is unknown, which may often be considered natural alternatives to vaccines.

Currently, there are no peer-reviewed publications assessing the views and beliefs of vegan and vegetarian Adventists concerning natural and conventional treatments used in the treatment or prevention of COVID-19, and how knowledgeable Adventists are concerning the efficacy of dietary supplements and how these views may change when challenged with scientific evidence. In addition, the study in chapter 4 showed that Adventists were significantly less likely to have been vaccinated at baseline compared to non-Adventists. Since vaccination is a major factor in COVID-19 risk, this study aimed to assess Adventists’ views and perceptions of vaccines and other conventional treatments for COVID-19 in order to understand how it fits within the context of their lifestyle.

This study has been reported in line with the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) as published by Galvin et al. (2024). The completed checklist can be found in appendix 15.

6.2.5 Statistical analysis

All statistical analysis was completed in SPSS. The paired samples t-test was used to compare the pre- and post-intervention scores attained on the questionnaires. Statistical significance was confirmed when the p value was less than 0.05. Cohen's d was calculated as an effect size by dividing the mean difference between the groups by the standard deviation of the mean difference. As the sample size was below 50, Hedges' g was also calculated from Cohen's d by adjusting for small sample size bias using the below formula:

$1-(3/4n-9)$, where d denotes Cohen's d, and n denotes the sample size.

Effect sizes for both Cohen's d and Hedges' g were considered as follows (Brydges, 2019):

0.2 = small effect

0.5 = medium effect

0.8 or above = large effect

Corresponding 95% confidence intervals (CI) were calculated for the effect size and the differences in means and were considered statistically significant if the 95% CI did not cross 0.

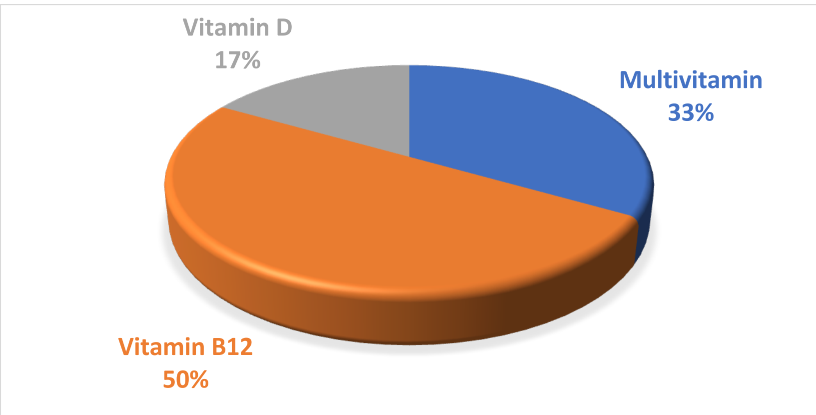
Correlation coefficients were also computed and are denoted by ‘r’. This was to assess the relationship between the pre- and post-intervention scores. A correlation of 0.7 or greater were considered as evidence of a strong relationship between the pre- and post-intervention scores. A strong correlation would indicate that participants scoring high on the first test would score high on the second test, and participants scoring low on the first test would also score low on the second test.

Repeated measures ANOVA was used to evaluate whether the change in scores were different between subjects following different dietary patterns (vegan, vegetarian, pescatarian). The Games-Howell Test was used as a post-hoc test due to the difference in sample size between the three groups. With regard to the improvement in test scores, potential covariates such as sex and education status were adjusted for using ANCOVA. Changes in dichotomous variables before and after the lecture were evaluated using the McNemar test. Potential associations between dichotomous variables were evaluated using the Chi-square test of independence or the Fisher’s exact test if the expected frequencies in any of the cells were less than 5.

6.3 RESULTS

In total, 37 participants were recruited in this study, 20 of whom identified as vegan, 13 as vegetarian and 4 as pescatarian. Participants’ mean age was 45 (SD 12.9) and baseline assessment showed that four participants used vitamin B12 supplementation, 11 supplemented vitamin D and 10 supplemented both nutrients. After the educational intervention, 18 participants confirmed having begun to use a new supplement at follow-up, which is 49% of all participants. Figure 16 presents the supplements participants started to take after the lecture. The follow-up questionnaire also revealed that most participants (n=34) made some type of a dietary change after the lecture such that 59% (n=22) reported using more fortified foods, whilst 2 individuals reported starting to consume more fish or dairy after the intervention, and this change in dietary behaviours after the lecture was not associated with gender (p=0.72). Furthermore, only 3 individuals reported being sceptical of using dietary supplements on the follow-up questionnaire, while 31 individuals reported paying more attention to what nutrients their diet may be lacking and supplementing accordingly.

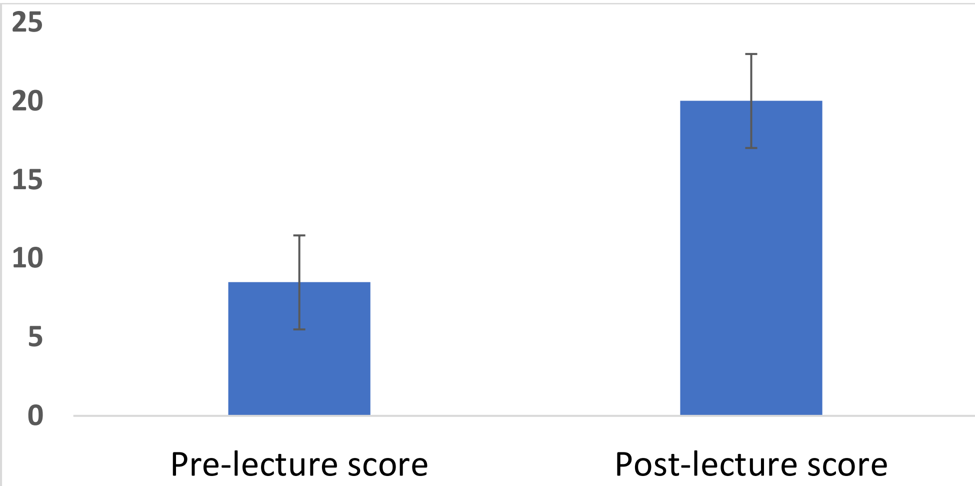
Figure 16. Percentage of participants (%) starting to use supplements after the educational intervention.



The mean test scores of participants before and after the lecture is presented in Figure 17. Participants had a total mean score of 8.49 (SD 3.75) out of 25 on the baseline questionnaire, and a mean score of 20.03 (SD 2.99) after the lecture. This was a significant increase in scores, suggesting a significant improvement in nutrition knowledge after the lecture such that the mean difference between the pre-lecture and post-lecture scores was 11.54, with a standard deviation of 4.21, indicating that on average, scores increased by a statistically significant 11.54 points after the lecture (t(df. 36) = -16.66, $p < 0.001$).

The effect size measure using the Cohen's d value was -2.739 (95% CI -3.44, -2.03), whilst the Hedges' g effect size was -2.681 (95% CI -3.37, -1.98). Repeated measures ANOVA further confirmed the significant change in scores for all participants (Wilk's Lambda for TestScore, $p < .001$), however it showed that there were no differences in the test scores between the three diet groups (Wilk's lambda Testscore*dietFollowed, p = 0.09).

Figure 17. Pre- and post-lecture test scores (mean, SD)



The correlation between the scores before and after the lecture is 0.232 (p=0.167), indicating a non-significant relationship, which suggests that the relationship between pre-lecture and post-lecture scores is not linear or predictable based on pre-lecture performance. This indicates that improvements in post-lecture scores were not dependent on participants' initial pre-lecture scores.

Furthermore, separate analyses have been conducted to compare the mean pre- and post-intervention scores for the general nutrition knowledge and COVID-19 specific questions. For general nutrition knowledge, the mean pre-lecture score was 4.22 (SD 2.28), which increased to 9.97 post-lecture (SD 1.34) indicating a mean difference of 5.76 (SD 2.60). For COVID-19 related nutrition knowledge, the average pre-lecture score was 4.27 (SD 2.31), which also increased post-lecture to 10.05 (2.07) indicating a mean difference of 5.78 (SD 2.59). The increases in scores on the post-intervention questionnaire were statistically significant for both with p-values less than 0.001.

The effect size indicated by Cohen's d for general nutrition knowledge was 2.22 (95% CI -2.82, - 1.61), and Hedges' g was 2.17 (95% CI -2.76, -1.58), both of which are large effect sizes. The effect size for COVID-19 related nutrition knowledge was similar (Cohen's d = 2.23 (95% CI -2.83, -1.62), Hedges' g = 2.18 (95% CI -2.77, -1.59)), and both of these are considered very large effects.

Regarding the analysis concerning the general nutrition questions, there was a very minimal positive correlation between the before and after scores ($r = 0.038$). Similar correlation was observed for the COVID-19 related questions suggesting only a **weak** positive relationship between the before and after lecture scores ($r = 0.300$). Both results imply that there were no strong associations between the pre- and post-scores for these domains.

Further analysis was carried out using ANCOVA to test whether the improvement in scores was associated with either sex or educational status defined as having at least an undergraduate degree or not. Of all participants, 13 individuals had at least an undergraduate degree and 15 were female. The results showed no association between sex and having a degree with the improvement in test scores (p=0.334, Effect size (Partial Eta Squared): 0.97)). In addition, the follow-up questionnaire also evaluated participants' comprehension of the lecture information by assessing how much of the information presented during the lecture was understood by participants. The response options included "all information", "most information", and "few information" indicating the amount of information comprehended from the lecture. All participants reported high comprehension levels as the selected responses were either the "all information" or "most information" options and none of the participants indicated that they had only grasped a few of the information presented.

At baseline, participants views' about how much processed foods a healthy diet should contain varied greatly such that 14 participants believed that their diet should consist of no processed foods, while 19 participants believed that it may contain small amounts of processed foods, whilst the rest of participants selected "I am unsure" as a third option. On the follow-up questionnaire the number of participants selecting "I am unsure" decreased to only 2 individuals, whilst the number of respondents selecting the option "It may contain small amounts of processed foods" increased to 28.

Concerning the question regarding whether eating meat is unethical or immoral, 14 agreed with the statement, but the rest of participants (n=23) did not believe eating meat was unethical or immoral. The view that meat consumption is unethical was not associated significantly with any of the three dietary patterns (p=0.254).
Before the lecture, 18 of the 37 participants believed that a plant-based diet is nutritionally adequate without the use of supplements, however there was a significant decrease in the number of participants who held this view after the lecture (p=0.03). The follow-up

questionnaire sent out at 4-weeks showed that only 2 participants believed that a vegan diet contained all essential nutrients without supplementation ($p<0.01$).

Furthermore, it was tested whether the lecture-based educational intervention had an influence on what participants considered as important as a basis for dietary practice. Participants were asked before and after the lecture about what they thought was more important in influencing their dietary decisions with options “The Bible or religious writings” or “Science” or “Both”. According to the pre-lecture questionnaire, 18 of the 37 respondents selected the option “Both”, whereas this has increased to 30 out of 37 on the post-lecture questionnaire, which was a significant change compared to baseline ($p=0.04$).

With regard to the impact of the presenter type on participants’ trust in the presented information during the lecture, 27 participants expressed on the follow-up questionnaire that they trusted the information more because the presenter was a nutrition professional. On the follow-up questionnaire, 28 out of the 37 participants indicated that they would consult a dietician or nutrition professional in the future, and this was independent of gender ($p=0.25$) or educational status ($p=0.45$), although both of these factors have previously been shown to be associated with increased willingness to use dietetic support (Tol et al., 2012).

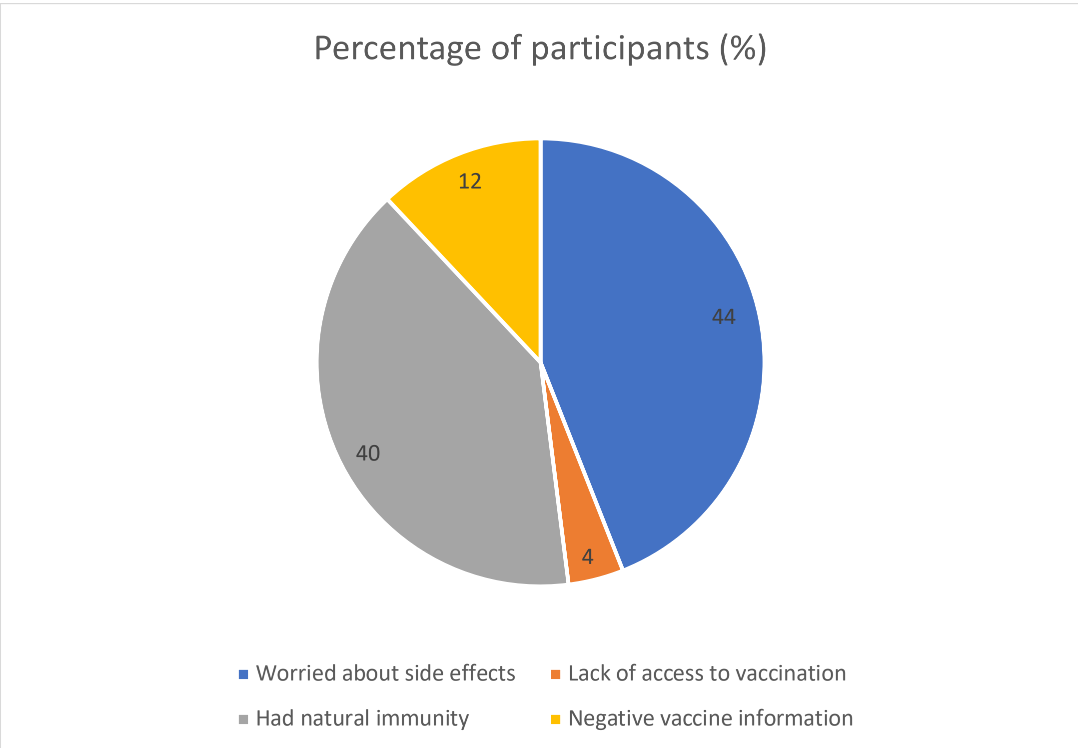
Participants were asked at follow-up if the educational intervention enabled them to make changes to their diet or lifestyle, and 35 of the 37 participants stated that the lecture enabled them to put into practise the presented information because it provided specific dosages of supplements as well as exact information about nutritional content of certain food items. This shows that the improvement in test scores was follow by improvements in diet related behaviour for a large proportion of the participants. Furthermore, all participants stated on the follow-up questionnaire that the educational intervention was useful and informative as it addressed concerns specific for Adventist populations.

6.3.1.1

6.3.1.2 COVID-19

Out of the 37 participants, 12 reported having been vaccinated against COVID-19, whilst 25 had not received a vaccine against COVID-19. The reasons selected by respondents for not taking a vaccine are summarised in Figure 18. On the follow-up questionnaire only 8 participants indicated that they had taken or would be willing to take a vaccine against COVID-19, however this decrease in the number of participants was not statistically significant (p=0.42).

Figure 18. Reasons for rejecting COVID-19 vaccination expressed as a percentage (%) of the total number of respondents.



Four weeks after the initial survey, a small subset of the study group, consisting of 3 individuals, reported that they had been infected with COVID-19 during the follow-up period. Additionally, 22% (n=8) participants were motivated after the lecture to start using dietary supplements specifically for the purposes of preventing or treating COVID-19, which is a considerable proportion of the total sample. The supplements adopted included vitamin D by five participants, zinc by two, and curcumin by three to assist in preventing or treating the infection. Notably, the follow-up responses revealed that 29 out of the 37 participants had experienced a shift in their perspective and views regarding the effectiveness of dietary supplements for COVID-19 prevention and treatment after the lecture. This change in attitude was not significantly different between male and female participants ($p=0.26$), which seems to suggest that the educational intervention had a uniform impact across genders in boosting confidence in the preventive and therapeutic potential of certain supplements against COVID-19.

At baseline, out of 37 participants, nearly 60% (n=22) held the belief that herbal or dietary supplements were safer than vaccines. However, this viewpoint was not statistically linked to a specific dietary pattern (i.e., vegan or vegetarian) ($p=0.93$). Similarly, there were no significant gender-based ($p=0.28$) or education level-based ($p=0.41$) differences that determined this belief, suggesting that these factors did not influence participants' trust in supplements over vaccines.

6.4 DISCUSSION

This was the first study, which has assessed the nutritional knowledge of plant-based Adventists living in the UK. The baseline knowledge of participants was deemed to be low as their average pre-lecture score was only 8 out of 25. However, this study showed that an expert-led lecture-based educational intervention tailored for Adventists was effective in improving participants' nutrition knowledge and resulted in behaviour change towards a more nutrient conscious approach as revealed in the follow-up questionnaire at 1-month post-intervention. Beyond increasing participants' understanding of the role of essential nutrients and how to obtain them on vegan and vegetarian diets, the intervention led to a notable shift in beliefs about supplements and fortified foods, particularly in relation to correcting the misconception that a vegan diet does not require supplementation and that supplements are not healthy because they are synthetic. The 4-week follow-up survey showed that 49% of participants began taking supplements they had not used previously, and 59% reported increasing their use of fortified foods. These results indicate that the intervention not only improved knowledge but also effectively influenced attitudes and beliefs and initiated behaviour change among a large proportion of participants, thereby successfully achieving the intervention's primary aim. This further supports the usefulness of the Health Belief Model (HBM) in the Adventist context, since the study showed that changing the perception of participants about their risk of nutritional deficiencies motivated them to adopt their behaviour towards supplementation and fortified food consumption.

This is the first educational intervention study which recruited Adventists living in the United Kingdom, however there aren't many such studies specifically investigating Adventists outside of the UK either. Kent et al. (2015) recruited Adventists in North America and used the Complete Health Improvement Program (CHIP) to influence participants' attitudes toward a healthy lifestyle and their nutritional literacy. In that study, 21.8% of participants were Adventists, whilst the rest were non-Adventists, which differs from the design of this study as it did not have a control group.

6.4.1 Educational interventions

The educational intervention utilised in this study aligns with the principles and fits the definition of a brief intervention as set out in the NICE guidelines (PH49) (National Institute for Health and Care Excellence, 2014), which are brief and structured discussions used to motivate people who may follow unhealthful behaviours to make changes. In the context of this study, it can be argued that a diet which is deficient in some essential nutrients may be considered damaging to health. Brief interventions are designed for health providers in the context of the NICE guidelines; however the Adventist church places a large emphasis on health promotion, which is usually carried out by church members and leaders who are healthcare professionals. In fact, Adventist church conferences have hired nurses since the beginning of the 20th century to serve as health missionaries for church members and local communities (David, 2024).

Therefore, church-based health promotion strategies within the Adventist church could incorporate a similar educational intervention to the one described and tested in this study with more regular follow up to ensure that members who follow a plant-based diet are well informed of the dangerous of nutrient deficiencies and receive sufficient support and encouragement to implement dietary changes into their lifestyles. In order to be more compliant with the NICE guidelines regarding interventions that encourage behaviour change, the church promotion strategies should incorporate interventions, which last for at least twelve months in order to allow sufficient time and maintenance of support for sustained behaviour change. The importance of the provision of continued support to participants is further confirmed by Baird et al. (2009). The authors highlighted that health interventions with an educational component, which also integrate continued support, and a social support structure are more likely to achieve behaviour change. This present study did utilise an educational component, however it lacked the components of social support and provision of continued support, which are important criticisms of the study.

The follow-up questionnaire to assess potential behavioural changes following the intervention was sent to participants 4 weeks after the lecture. The optimal timeframe to follow-up with participants following educational interventions depends on the type of the intervention. This study utilised a 4-week follow-up similar to the study conducted by Amoore et al. (2023), which assessed the influence of a nutrition education intervention on medical students' nutrition habits and nutrition care knowledge. The relatively short follow-up time can be justified in these instances as neither study assessed changes in disease incidence rates, biomarkers, or bodyweight all of which may require a longer follow-up. In this regard, the 4-week follow-up period provided sufficient time for participants in this present study to implement some of the information presented to them concerning dietary supplements in the lecture if they felt motivated to do so. Moreover, the follow-up questionnaire revealed that the educational intervention successfully impacted participants' self-efficacy regarding supplement use. However, church-based health promotion strategies utilising a similar intervention should implement longer follow up with more frequent contact with participants to help sustain behaviour change.

A number of systematic reviews have shown that interventions that have aimed to change participants' dietary, lifestyle or health behaviours can be effective (Van Teijlingen et al., 1998, Knai et al., 2006, Baird et al., 2009), however there are important limitations to these, which must be mentioned. Similarly to this present study, many of the dietary behaviour change interventions are non-randomised studies without the presence of a control group (Reed, 2005). Since the gold standard of evidence in nutrition and medical sciences are randomised, controlled trials, studies which lack any or all of these components may have an increased risk of bias. However, it has also been argued that it is unethical to recruit a control group who would be withheld educational information, which is one of the reasons educational interventions only have a single arm (Torgerson, 2002). Additionally, interventions often have very different designs, study durations, data collection methods and sample sizes, which can increase heterogeneity and limit the validity of the systematic review findings (Reed, 2005). However, it is not always feasible to conduct an adequately powered double-blind, randomised, controlled trial of an educational intervention, especially in the field of nutrition, therefore it is suggested that systematic reviewers set carefully planned inclusion and exclusion criteria to include only interventions that are similar in their design (Reed, 2005). On the other hand, it is important that researchers who conduct educational interventions use appropriate reporting methods, such as the CHERRIES checklist, to aid and improve the quality of future systematic reviews (Reed, 2005).

The best quality evidence regarding health interventions comes from a Cochrane review, which showed that community interventions have a small effect in reducing smoking prevalence (Secker-Walker et al., 2002). This review only included controlled studies, although only 4 out of 37 of them used random allocation of communities. However, changing people's behaviour to help them stop smoking requires a much more complex intervention than influencing people to take a dietary supplement or consume fortified foods, like in this present study. Therefore, although the non-randomised design of this study may be a limitation, this educational intervention is still useful in raising awareness about the low knowledge of vegan Adventists living in the UK about essential nutrients, and showed that the tailored educational content was able to motivate them to put into practice the presented information.

The educational intervention was delivered in the form of an online lecture by a nutrition professional, which may have contributed to the success of the intervention based on the findings of a systematic review and meta-analysis by McGavock et al. (2020) which showed that expert-led interventions targeting weight loss were associated with greater reductions in weight than interventions delivered by non-professionals. The follow-up questionnaire revealed that most participants trusted the presentation due to the qualification of the presenter. This is further confirmed by the meta-analysis published by Treciokiene et al. (2021) in the context of healthcare professional led lifestyle interventions which led to significant improvements in blood pressure measurements. Furthermore, the lecture aimed to address potential barriers Adventists may hold concerning supplements such as their perception as being not natural and thus unhealthy.

This educational intervention showed that an evidence-based health education, tailored for a religious population, in this case Adventists, can successfully address nutritional risks without undermining core beliefs, when the presented information is contextualised within their worldview. Appealing to sources in the lecture material, which was perceived as authoritative by the Adventist participants such as the General Conference position stand on topics relating to diet and nutrition contributed to the acceptance of the intervention, which can be a useful strategy for health promotion campaigns targeting other types of religious groups.

6.4.2 Theoretical framework

The lecture presentation emphasized the potential risks of nutritional deficiencies associated with vegan diets and the perceived benefits of supplementation; therefore, the lecture was theoretically guided by the Health Belief Model framework. A systematic review and meta-analysis published by Jones et al. (2013) showed that this health promotion model can be an effective tool to promote adherence in intervention studies and is based upon the observation that perceived barriers and benefits are the strongest predictors of behaviour change. The findings of our study are in agreement with the findings of the meta-analysis as most participants had a change of view concerning the adequacy of plant-based diets and the need for supplementation which may be perceived as potential barriers. By addressing these barriers in the lecture, many participants were motivated to adopt dietary supplements or fortified foods.

During the lecture, information from reputable official dietary guidelines such as the Position of the American Academy of Nutrition were presented to participants, which confirmed that plant-based diets may reduce the risk of several chronic diseases, however, it was also highlighted in the lecture that the guidelines emphasized that vitamin B12 must be obtained from supplements or fortified foods (Melina, Craig and Levin, 2016). The post-lecture and follow up questionnaires confirmed that participants' beliefs and views concerning the nutritional adequacy of plant-based diets significantly changed as there was a large increase in the number of participants who seemed to have changed their minds about the need for supplementation or at least vitamin B12 on a plant-based diet.

Although the Adventists recruited for this study followed a plant-based diet, the majority of them did not consider the consumption of meat as unethical or immoral. This differentiates plant-based Adventists from regular vegans as a literature review by Hargreaves et al. (2021) suggested that most people become vegan for ethical reasons, which is most often related to animal rights concerns. Although this conflicts with the findings of Anderson and Milyavskaya (2021) who showed that only 20% of the vegans participating in their study were motivated by animal welfare reasons and 42% started following the diet for health reasons. Plant-based Adventists are also different from the typical vegan or vegetarian as previous studies have shown an association between following plant-based diets and having liberal values (Hopwood et al., 2020), whereas Adventists are a conservative Protestant group (Phillips et al., 1978).

The views of participants in this study concerning processed food intake mostly reflected minimal or no intake suggesting that the Adventists in this cohort consumed little to no processed foods which confirms that the sample of Adventists in this study were representative of the wider Adventist community since this view of minimising processed foods is a commonly held view held by Adventists that the optimal diet should be based on wholefoods. Orlich et al. (2022) also showed in their cohort of 77,437 Adventists that the average consumption of ultra-processed foods was 27.4% of daily energy intake which is in great contrast with the consumption of ultra-processed foods typical in western populations. For instance, the National Health and Nutrition Examination Survey (NHANES) evaluated ultra-processed food intake among 9317 Americans (Martínez Steele et al., 2016).

Ultra-processed foods made up a considerable portion of individuals' energy intake, accounting for 57.9% of their total daily energy intake, which also meant that ultra-processed foods were found to be a major contributor to the consumption of added sugars, providing 89.7% of the energy derived from these sugars. Additionally, Vang et al. (2008) showed that 90% of Adventists never consumed processed meats whilst 10% consumed them on a weekly basis. Therefore, it is evident that Adventists not only believe that the consumption of ultra-processed foods should be minimised, but they have actually been shown to be low consumers of these foods.

6.4.3 COVID-19

It may be somewhat surprising or unexpected that the most common reason selected for refusal of COVID-19 vaccination was the concern about potential side effects, since ethical reasons such as the use of aborted human foetal cells or porcine components are usually the most popular among fundamentalist religious groups for refusing vaccines (Wombwell et al., 2015). This may be somewhat unexpected, and it highlights a shift in vaccine hesitancy drivers from purely religious or ethical to health-related anxieties. Although, the findings of this study are in agreement with the results of Lernout et al. (2009) who investigated the reasons behind measles vaccine hesitancy among the orthodox Jewish community and showed that the most common reason for refusing to take a vaccine against measles was due to fears of side effects. This suggests that concerns over potential adverse effects may transcend specific religious beliefs, therefore, approaches that are based on prioritizing societal health over traditional ethical concerns should contain clear communication regarding vaccine safety and efficacy if they aim to target religious groups such as Seventh-day Adventists.

Similarly to this study, Botabara-Yap et al. (2023) utilised the HBM as a theoretical framework to investigate the views of Asian Adventists of the COVID-19 pandemic, including vaccination. Although, the authors reported that over 67% of participants showed an intention to be vaccinated, perceptions on vaccine benefits were generally low, whereas perceptions of low susceptibility to the infection were high. These results agree with the findings of this study regarding low belief in COVID-19 vaccines, since 60% of the participants in this study stated that herbal supplements were safer than vaccines. These findings suggest that there is a need for appropriately educating Adventists regarding vaccine side-effects and addressing other potential barriers, which should be incorporated into the health promotion campaigns of the church in and outside of the UK.

There are numerous examples of public health agencies working in cooperation with religious communities and leaders during the COVID-19 pandemic, which can be an effective strategy to encourage adherence to public health guidelines (Ayub et al., 2023). Adventist health leaders should aim to seek advice and collaboration with public health to inform their church-based health promotion strategies in future infectious disease pandemics.

6.4.4 Supplement use for COVID-19

Regarding the use of dietary supplements for the specific purpose of treating or preventing COVID-19, 25% of participants in this study began their use following the educational intervention. These supplements included zinc, vitamin D and curcumin, all of which have been shown to have a significant effect on immunity against COVID-19 or help in the treatment of the infection. The use of dietary supplements for the treatment and prevention of COVID-19 have been extensively studied. For instance, Khasawneh et al. (2022) showed in a cross-sectional analysis that 35%, 39 and 49% of their participants, who were living in the country of Jordan, used vitamin D, zinc and ascorbic acid respectively for the purpose of improving their immunity against COVID-19. Mukattash et al. (2022) surveyed 2100 individuals in the Middle East and showed that 44% of participants experienced changes to their eating habits during the COVID-19 pandemic, with 21% held the belief that dietary supplements offered protection against COVID-19, while 45% thought they could be useful in the treatment of the infection. These results further corroborate that other religious groups such as Muslims may hold similar beliefs about the usefulness and safety of natural supplements as Adventists.

In addition to the data derived from observational research, interventional studies in the form of randomised controlled trials (RCTs) have been conducted to test the effect of nutritional supplements on COVID-19 related outcomes. Varikasuvu et al. (2022) showed, based on the pooled result of RCTs that vitamin D supplementation significantly reduced COVID-19 positivity and severity by 54%, which is thought to be attributed to its anti-viral, immuno-modulatory and anti-inflammatory effects. Similarly, evidence regarding zinc supplementation suggests that it significantly reduces COVID-19 mortality due to its antiviral properties through the activation of immune cells such as macrophages and natural killer cells (Tabatabaeizadeh, 2022). Furthermore, a meta-analysis of clinical trials involving patients hospitalised with COVID-19 showed that supplementation with curcumin significantly reduced the symptoms and hospital stay of patients as well as their risk of death (Vahedian-Azimi et al., 2022). The authors found evidence that curcumin can ameliorate the cytokine storm associated with COVID-19 infection by significantly reducing pro-inflammatory cytokines. On the other hand, vitamin C supplementation demonstrated no significant effect on the length of hospitalisation in a meta-analysis of 6 RCTs (Rawat et al., 2021).

In addition to dietary supplements, plant-based diets have been shown to lower the risk of COVID-19 infection (Papadaki et al., 2024). Some of the biological mechanisms involve the presence of polyphenols in plant foods, which are abundant in plant-based diets, and have been shown to exert anti-microbial properties. Furthermore, plant-based diets may also contain high amounts of antioxidants such as vitamins E and C that can improve immune function and are associated with a lower risk of obesity, which is an important risk factor for COVID-19 infection (Morais et al., 2020). On the other hand, plant-based diets may contain low amounts of vitamin B12, therefore the European Food Safety Authority (EFSA) advises the use of biomarkers such as serum cobalamin or holotranscobalamin to assess nutrient status (Fernandes et al., 2024). The use of vitamin B12 supplements have been shown to increase serum cobalamin levels (Gallego-Narbón et al., 2018) and is therefore an effective way of improving vitamin B12 status. Furthermore, supplementation with vitamin D has also been shown to increase vitamin D concentrations in serum as indicated by the levels of 25-hydroxy and 1,25-dihydroxy vitamin D (Khodadadiyan et al., 2023).

At baseline, 59% of Adventists in this study believed that dietary supplements were safer than vaccines in the context of COVID-19. This hesitancy towards vaccine safety could have been the result of a scepticism towards the new vaccines developed against COVID-19 using a new technology in a relatively short time as have been reported in previous surveys (Wong et al., 2022), however another potential source of hesitancy could be the writings of the church's founder Ellen G. White, who living in the 1800s expressed concerns about the use of medications. In the book "Healthful Living" she is quoted as stating "We are not excusable if, through ignorance, we destroy God's building by taking into the stomach poisonous drugs under a variety of names we do not understand." (Ellen White, 1896) and in another book she wrote "The inclination to use poisonous drugs, which kill if they do not cure, needs to be guarded against." (White, 1936). As Adventists believe that her writings were the result of divine inspiration, they are held in high esteem and such statements as quoted above may have led some to misinterpret them. Historical context is important in regard to her comments regarding drugs since drug development was certainly not as safe or well-regulated as it is today and she seems to have been most concerned about the potential side effects people experienced which is evident in her following statement "Paralysis of the brain and tongue is often the result, and the victims die an unnatural death" (White, 1936).

In summary, Adventists are exposed to health messages through various church interactions such as sermons, bible studies and regular health workshops, which are a great way to reinforce the Adventist health principles among its members. These provide a great opportunity to emphasise the importance of dietary supplements in the context of a plant-based diet. Therefore, health promotion activities carried out by the church should aim to address the previously mentioned barriers about supplementation and medicine use to enable members to correctly understand and interpret these topics. By addressing misconceptions and informational barriers during church activities, the Church can ensure that its members fully understand the connection between health practices and their faith-based texts and teachings.

6.4.5 Strengths and Limitations

The results of this study have been reported using the CHERRIES checklist, which is a tool developed to improve the quality of studies utilising online surveys (Eysenbach, 2004). Adherence to this guideline ensures the transparency of reporting study methods and results, thereby improving the quality of this study.

Another important strength of this study is the 100% response rate on the post-lecture and the follow-up questionnaires. The assessments at three different timepoints add further to the strengths of this study as it allows for the investigation of the intervention's immediate and longer-term impacts. Furthermore, the study didn't just assess the impact of the educational intervention on participants' knowledge and beliefs, but it also assessed behavioural change at follow-up. In addition, basing the educational intervention on the Health Belief Model provided a strong theoretical framework, which may have enhanced the intervention's design and effectiveness. The use of the Health Belief Model as a guiding framework likely facilitated a more targeted and relevant educational experience, addressing specific perceptions and behaviours related to nutritional supplements. On the other hand, the Health Belief Model of behaviour change has important limitations.

Moreover, the lecture presented information about nutritional supplements using high quality studies such as systematic reviews and meta-analyses. This means that the information provided to participants was evidence-based, current, and reflected the results of the entirety of the literature available at the time. This emphasis on high-quality evidence likely contributed to the credibility of the information in the eyes of the participants. To ensure that participants were informed about the various forms of scientific evidence, the lecture incorporated the levels of evidence hierarchy pyramid (Tannenbaum and Sebastian, 2021), which provided a visual representation of the concept.

The online nature of this study may be perceived as a potential limitation, however anonymity in online surveys has been shown to reduce response bias resulting from social desirability and may reduce anxiety experienced by the participants (Joinson, 1999).

Finally, the questionnaire showed a high internal consistency during the validation study, which likely improved its reliability. However, it is important to acknowledge that even with high internal consistency, the external validity of the findings might be limited by the study's sample size and composition of participants since those who volunteer for dietary or lifestyle interventions might be more motivated or health-conscious than the general population, potentially influencing the generalizability of the results. On the other hand, the sample size of the study was determined a priori, ensuring that the sample size was adequate to detect a statistically significant change in the pre- and post-lecture scores. This enhances the statistical power of the study and reduces the likelihood of Type II errors, although the pilot study for the validation of the questionnaire was conducted using only 6 individuals.

A potential limitation of the test-retest reliability of the questionnaire is that participants could potentially remember the correct answers after taking the test the first time, therefore the correct answers were not provided to participants after questionnaire completion in the pilot. The time period of one week between the two questionnaires during the pilot further prevented recall bias (Aithal and Aithal, 2020).

Another potential limitation of this study is the generalizability of the results to non-Adventist plant-based populations due to the fact that the Adventists are a particularly health-conscious group, which is evident by their abstinence from smoking and alcohol. Furthermore, the generalizability of this educational intervention may also be limited by the availability of fortified foods and vitamin supplements across the globe as they are widely available and affordable in the UK but may not be as accessible in other parts of the world.

A further limitation of the study is the lack of socioeconomic data collected, however a previous study found that nutritional knowledge was not significantly associated with socioeconomic status (Yu et al., 2020), whereas educational status has been positively associated with better nutritional knowledge (Lane et al., 2013). Data concerning educational status, however, was collected in this study, but having a higher educational background (i.e. undergraduate degree or above) showed no association with the improvement in test scores. This also shows that despite the complexity of the presented information, it was understandable by all participants and not just by the more educated ones, thereby addressing another potential limitation of the study, namely that the lecture material could have been too complicated or difficult to comprehend for some participants.

This is further confirmed by the fact that all participants indicated having understood all or most of the information presented during the follow-up survey, and there was not a single participant who expressed that they only understand some parts of the lecture.

It may also be a limitation that the participants were only exposed to the intervention once because repeated exposures may be more effective. A study published by Serret-Montoya et al. (2023) reported that repeating the educational intervention at 6 months improved the attitude of participants towards to intervention, although it didn’t further impact their knowledge.

The follow-up questionnaire at week 4 collected information about whether the educational intervention motivated participants to make changes to their diet or lifestyle or not, and as such it may be subject to self-reporting bias as participants could under- or overreport behaviours based on whether they are perceived as socially desirable or not (Latkin et al., 2017). Additionally, the reliance on self-reported data may not only reflect potential biases in reporting but also in memory, however the four-week follow-up period can be considered a relatively short period, making it easier to recall information concerning whether a person has started taking a new supplement or not.

Willingness to participate in research may also be a source of various biases. For instance, a previous survey by Farha et al. (2020) showed willingness to volunteer in a research study was positively associated with having a degree, thus indicating that a higher lever education is associated with willingness to participate in research, however this was not the case in this sample as only 13 participants had a degree and 24 did not.

Furthermore, it has been shown that participants who are willing to engage in health promoting behaviours are more health conscious and have more healthy lifestyle practices, which is called healthy user bias (Espinosa and Kadić-Maglajlić, 2018). Healthy user bias may limit the generalisability of the findings of this educational intervention, however since Adventists are considered a health-conscious group, it is likely that those who took part in this study are representative of the general plant-based Adventist community in the United Kingdom.

6.5 CONCLUSION

This lecture-based educational intervention study conducted in the United Kingdom has proven to be effective in enhancing the nutritional knowledge of Seventh-day Adventists following a vegan or vegetarian diet. The findings of this study contribute to the growing body of evidence that highlights the efficacy of educational interventions in encouraging individuals to make healthier lifestyle choices, including the appropriate use of dietary supplements and fortified foods, particularly among those Adventists who consume a plant-based diet. Notably, the educational intervention didn't only increased participants' knowledge but also motivated a significant proportion of them to proactively start the use of vitamin B12 supplements in their daily routines and pay more attention to consuming fortified foods. These findings suggest that tailored educational interventions can play a significant role in motivating Adventists to make health-related behaviour changes by influencing perceptions about the risk of nutrient deficiencies on vegan and vegetarian diets. Given the findings of this study, it is suggested that similar brief interventions utilising expert led educational interventions with more frequent follow-ups be implemented by Adventist health leaders.

However, it is important to note that further extensive and longer-term studies are necessary to corroborate these findings and to evaluate the long-term impact and sustainability of such educational interventions, especially in different geographic areas where dietary supplements and fortified foods may not be as readily available as they are in the UK. Finally, the results may not be generalisable to non-Adventist plant-based populations.

7 Chapter 7. General Discussions

7.1 MAIN FINDINGS

This is the first in-depth investigation of the diet and lifestyle of UK Adventists in the context of COVID-19 disease risk. The aim of this thesis was to investigate how the dietary practices and lifestyle of Seventh-day Adventists influenced COVID-19 outcomes. Based on the findings of this thesis, the Adventist dietary practices, especially the consumption of plant-based diets and abstinence from alcohol and red meat, seem to be protective against COVID-19 disease. In addition, Adventists were shown to experience fewer long-COVID symptoms, which is another important finding of this research.

Evidence from the literature shows that plant-based Adventists are generally not at an increased risk of nutrient deficiencies due to their diet, which also meant that there was no evidence to suggest that they had a higher COVID-19 risk. In fact, they were shown to have a lower COVID-19 risk than the non-Adventists recruited in Study 1. Regardless, this thesis highlights the importance of addressing the nutrient adequacy of plant-based diets among church members due to the low nutrient knowledge scores observed in the educational intervention study presented in Chapter 6.

A second potentially contributing lifestyle factor to the lower infection risk associated with the Adventist lifestyle is the widespread use of stress management techniques such as prayer or Bible reading, which was shown in the prospective cohort study. With regard to the potential mechanism underlying this observation, it's been suggested that unhealthy lifestyle habits such as alcohol consumptions and poor sleep hygiene can lead to increased anxiety, which may result in increased COVID-19 susceptibility. Another potential biological mechanism is the higher serum cortisol level observed in COVID-19 patients, which negatively influences immune function and has been shown to be associated with increased mortality from COVID-19 (Tan et al., 2020). Therefore, appropriate stress management resulting in lower anxiety levels is directly associated with a lower risk of infection.

Chapters 1 and 2 presented essential background information on the role of religion on health, which served as the basis for subsequent chapters, where the focus narrowed down to Adventists specifically and how their religiously motivated dietary habits may influence COVID-19 risk.

The systematic review described in Chapter 3 synthesized the available evidence on the risk of COVID-19 and other infectious diseases among Adventists. The review found limited but suggestive evidence that the Adventist lifestyle, characterized by a plant-based diet and abstention from alcohol and smoking, might contribute to a reduced prevalence of certain infectious diseases. However, the overall quality of the included studies was low, and more robust research is needed to confirm these findings. An important gap was identified in the literature regarding the risk of COVID-19 among Adventists as none of the three included studies investigated the risk of COVID-19 among Adventists. The findings of this literature review, therefore, informed the design of the study described in Chapter 4 such that a control group of non-Adventists were recruited, and a 2-year follow up period was incorporated into the study design, which allowed for the calculation of COVID-19 incidence among both groups. These are considerable improvements in study design compared to previous research on this topic and the use of a food frequency questionnaire allowed for the investigation of the impact of dietary factors on COVID-19 risk.

The novel finding from Study 1 is the significantly lower COVID-19 incidence over the 2 years of follow up among Adventists compared to non-Adventists as well as a significantly lower risk of experiencing symptoms of long-COVID. The only significant predicter of a lower COVID-19 risk was plant-based dietary status as shown by the logistic regression analysis. This suggests that the adherence to a plant-based diet among Adventists may be a significant contributor to their lower COVID-19 infection incidence, which is further confirmed by the finding related to a higher COVID-19 risk at baseline among the highest red-meat consumers.

Interestingly, a lower incidence rate of COVID-19 among Adventists was observed despite their higher age and lower vaccination rate as compared with non-Adventists. Furthermore, Adventists were shown to use less dietary supplements such as vitamin D and B12, which would be expected to increase the risk of COVID-19 infection, however Adventists may obtain these essential nutrients via other means such as fortified foods or supplementation with a multivitamin, which may explain the observed results concerning the lower infection risk. The topic of potential nutritional deficiencies among plant-based Adventists was further explored in Chapter 5, in the form of a systematic review, which focused on the intake and serum levels of essential nutrients among plant-based Adventists, which could have an impact on the risk of infectious diseases such as COVID-19. The review found no significant differences in serum vitamin B12 levels or daily intake between plant-based Adventists and omnivore controls. Despite the adequate intake of most nutrients, some studies reported lower intakes of iron, calcium, and zinc among Adventists, suggesting potential areas for further investigation, a finding with important health promotion implications for Adventists. However, this thesis showed that Adventists who consume a vegan or vegetarian diet are not at an increased susceptibility of COVID-19 due to nutritional deficiencies.

Study 2 demonstrated a significant increase in nutritional knowledge following a lecture-based educational intervention, although the baseline scores showed evidence of poor knowledge. The post-lecture test scores showed an 11-point improvement compared to pre-lecture scores, indicating that the intervention effectively enhanced participants' understanding of essential nutrients and dietary practices. This study also revealed that the intervention influenced participants' dietary behaviours, leading to increased use of supplements and fortified foods.

7.2 GENERAL LIMITATIONS

The self-reported data concerning COVID-19 infections, dietary habits and other lifestyle factors may be subject to recall bias and misreporting. This is a known limitation of observational studies that collect self-reported data. As Study 1 was launched during the COVID-19 lockdowns, participants could not be recruited in-person as the churches were closed, however the use of validated questionnaires and the 2-year follow-up period greatly improved the quality of the study.

The studies described in Chapters 4 and 6, which involved original data collection may be perceived as having a relatively small sample size; however, both were adequately powered with the aid of sample size calculations.

Although Study 1 had a longer, 2-year follow-up period, it was only a month in Study 2, which may be perceived as a limitation, however similar studies have also used similar time periods to assess behaviour change, although diet related behaviour change maintenance may require interventions longer than 24 months (Fjeldsoe et al., 2011), although participants in this study did not have to adopt a new diet, but were only encouraged to make a simple behaviour change of either using dietary supplements or fortified foods. This relates to another potential limitation of the study and the whole thesis, which is the use of the health belief model as a theoretical framework. The major limitations of this model have been described in great detail elsewhere in this thesis. Despite its limitations, it has been one of the most influential theories of behaviour change, which is evident in its growing use over the past years (Alamer, 2024).

With regard to the systematic reviews, both of them highlighted the scarcity of high-quality studies, which underscores the need for more rigorous research in the area of the Adventist lifestyle and its association with COVID-19 and other infectious disease risk.

It is important to highlight that the evidence derived from this thesis cannot infer causality with regards to the protective nature of the Adventist lifestyle against COVID-19 disease. Randomised controlled trial data would be required for causal inferences.

Additionally, a variable, which may have had an influence on a number of outcomes investigated in this thesis is religiosity, which has not been considered in detail in this work. Religiosity can be defined as the extent to which religious practices such as prayer or church attendance are expressed (Jacksaint Saintila et al., 2022). A study conducted by Tan et al. (2016) involving a cohort of Malaysian Adventists, highlights the potential influence of religiosity as it showed that following a vegan or vegetarian diet was associated with being more dedicated to the faith of Adventism, therefore the adherence to a plant-based diet may be indicative of an individual's commitment to and belief in the writings of Ellen G. White, which may also suggests a potential association between vegetarianism and religious beliefs and views on other topics such as medication use, vaccines and dietary supplements, which should be further investigated in future research.

7.2.1 The challenges of researching the association between religion and health

This thesis hypothesized that religion and religious practices, especially in the context of Adventism, have an influence on health. However, studying health in the context of religion presents a number of challenges, which may be ethical, methodological or even cultural (Koenig et al., 2012). Oman and Thoresen (2002) also highlight the numerous challenges that are present in researching the association between religion and health, while also emphasizing the difficulty of deciphering the diverse pathways through which religion impacts health. The authors suggest that at least 4 mechanisms are responsible for the positive effects of religion on health which are (1) religion's promotion of healthy lifestyle behaviours, (2) its positive effects on psychological well-being, (3) the social support structures it offers and (4) potential 'super empirical' influences such as intercessory prayer.

In addition to self-reporting bias, which is the inaccurate reporting of participants' religious practices or health behaviours, social desirability bias is often present in research focusing on the topic of religion and health (de Oliveira Maraldi, 2018). For instance, Stavrova et al. (2013) investigated subjective well-being of religious individuals and found that their responses were influenced by the extent to which following their specific religion was socially desirable within the country. de Oliveira Maraldi (2018) suggests that this may be due to the fact that religious individuals may have a heightened sensitivity to moral values and social norms, therefore, they are naturally seeking socially desirable behaviours. Furthermore, there are numerous other potential confounding variables not mentioned previously such as socioeconomic status, educational status, levels of religiosity and lifestyle, all of which can influence the results of studies that focus on the topic of religion and health and make it difficult to isolate religion's impact on health as these variables may be difficult to adjust for, which may lead to over- or underestimation of effects (Koenig, King & Carson, 2012 and Jokela, 2021). For instance, it can be difficult to measure religiosity or spirituality because of the subjective nature of these constructs as well as their multidimensionality (Baumsteiger and Chenneville, 2015). Religiosity encompasses easily quantifiable and measurable aspects such as church attendance, regularity of prayer or adherence to religious doctrines, however it also includes faith and religious identity, which are difficult to measure. Baumsteiger and Chenneville (2015) further highlight the challenge of attempting to translate deeply personal and qualitative experiences such as faith and spirituality into quantitative data, which lead to oversimplification of these complex constructs, potentially overlooking essential aspects of their richness and significance.

Considering all of these factors as potential confounders can lead to overadjustment as confirmed by the earlier meta-analysis of McCullough et al. (2000), who found that the more rigorous statistical adjustment was used in a study, the weaker the association became between religious involvement and mortality. This indicated that other factors, such as demographic, psychosocial, or health-related variables had a significant influence on the results. One of the important confounders was shown to be bodyweight as studies that did not account for obesity or body mass in their statistical analysis had greater effect size estimates than studies that adjusted for this variable, although it could also be argued that religion contributed to the lower bodyweight, thereby influencing mortality (Yeary et al., 2017).

Furthermore, there are differences and variations in religious beliefs and practices, which are influenced by cultural and regional factors. This means that there can be differences among followers of the same religious tradition based on their geographical location such that Christians in Europe may practice their faith differently from those in Africa, Asia or the United States, and this helps explain the globally observed variations in how religion and health are connected (Zimmer et al., 2019). It is acknowledged by Zimmer et al. (2019) that most of the research on the relationship between health and religion has been conducted in the United States, and there aren't a great deal of studies investigating the same topic on individuals living in Europe or the United Kingdom. The authors showed that the country where religious participation is the most strongly associated with better health is Cyprus and the country where religious people have the worst health is China. This highlights the fact that there are variations in how religion influences health across the world. The authors believe that countries with greater economic development and greater religious diversity tend to show positive associations between health and religion, whereas individuals living in countries with restrictions on religious practice, such as China, experience greater stress, which results in poorer health.

7.2.2 The role of Adventist health leaders

Religious believers usually have high levels of trust in their religious leaders and organisations, which makes religious communities and leaders effective instruments for health communication, even in the context of infectious disease outbreaks. Within Adventism, this applies not only to Adventist pastors but to health leaders also, who engage in church-based health promotion. During public health crises, it may be an appropriate strategy for Adventist health leaders to leverage the existing networks in their religious communities in order to aid the dissemination of public health messages and guidance. This approach may result in a more rapid response within the Adventist community and avoids the need for public health professionals to establish new communication networks (Santibañez et al., 2017).

An example of the important role of religious leaders is the Ebola outbreak in West Africa, during which time public health officials worked together with religious leaders who proved to be instrumental in advocating for behavioural changes such as avoiding traditional burial practices which involved direct contact with the deceased bodies, thereby reducing the possibility of viral transmission (Kowalczyk et al., 2020). Another important example is Senegal, which through collaboration between religious organisations and public health

officials became a success story in the fight against the human immunodeficiency virus (HIV) infection (Olowu, 2015). This HIV rate decline was achieved with the involvement of religious leaders of all faiths, who played an important role in educating their members of the important risk factors of HIV infection. This led to reductions in the number of sexual partners and an increase in the age at first sexual experience, both of which contributed to the decline in HIV rates. This shows that in certain scenarios a mutual compromise from both government bodies and religious organisations can yield a successful outcome.
However, the original studies within this thesis did not investigate the influence of Adventist leaders on church members' attitudes and behaviours during the COVID-19 pandemic, therefore this is an area, which could be further explored in research as it may provide useful insights for future pandemics.

Conducting this research as an Adventist nutrition professional and a health leader allowed me to draw on my insider knowledge about the common misconceptions vegan Adventists have about the nutritional adequacy of vegan diets and the use of certain supplements and vaccine. This insider knowledge enabled me to focus on commonly held misconceptions in the educational intervention and use respected Adventist sources such as the writings of Ellen White or the General Conference statements to address these misconceptions. On the other hand, my scientific background provided the critical and analytical rigour required to design and conduct this research in a way that minimized bias and was objective. This meant that validated data collection tools and reporting guidelines were used in the studies described within this thesis, which improved the transparency, reliability and validity. My insider and outsider status also played a key role in the development of the research question since I had been very familiar with the Adventist Health Studies and their focus on chronic diseases, which helped me identify a gap in research relating to the influence of the Adventist lifestyle and diet on COVID-19 risk.

7.3 IMPLICATIONS FOR HEALTH PROMOTION

The findings from this research have a number of important implications for church-based health promotion in the context of Adventism. The implications of this thesis are mostly relevant to those Adventists who engage in health promotion. Most Adventist churches in the UK and elsewhere have appointed health ministry's leaders, who are responsible for educating members and the public about the health principles of Adventism (SDA Church, 2016). Their roles include the promotion of a healthy lifestyle in various forms such as writing articles for the church newsletter, websites and social media sites, but they regularly hold health related presentations and plan church promotion events such as CHIP for the wider community. The studies conducted as part of this thesis may inform the activities of health ministry's leaders within the church regarding the role of nutrition and lifestyle in the prevention of COVID-19. Furthermore, Adventists were shown to be more protected against mental health issues during the lockdowns compared to the non-Adventists, which may be due to the strong sense of community and supportive structure that was maintained among members online with regular bible studies, workshops and prayer meetings. The church should continue to emphasize the need for a supportive community as it could help in future global crises and the Adventist approach to community support could even serve as a model for non-Adventist groups. The practice of prayer, singing, reading of religious books were also linked to the observed protective effect concerning mental health, and they could directly affect susceptibility to COVID-19 infection, however, these practices may not be generalizable to other groups, although it highlights the importance of emphasizing effective stress management techniques, which may be included in health promotion strategies.

In addition, Adventists were less likely to gain weight during the pandemic, which shows that diet and exercise should continue to be at the forefront of church-based health promotion strategies. On the other hand, there may be a need among Adventists for more education concerning the nutritional adequacy of vegan and vegetarian diets to ensure that nutrient requirements are met by all.

There is a need for more studies with better methodologies to further investigate the potential relationship between the Adventist nutritional practices and lifestyle and COVID-19 risk as well as the risk of other infectious diseases. Randomized controlled trials (RCTs) and longitudinal studies with larger sample sizes could help establish whether the Adventist lifestyle can play a significant role in lowering the infectious disease risk, and studies should aim to measure blood levels of nutrients in addition to assessing self-reported dietary intake. The beliefs and knowledge of Adventists regarding diet supplements and pharmaceutical drugs should be further explored as the observed lower intake of essential dietary supplements warrants further investigation. The church should utilise and develop targeted health education campaigns for church members to make members aware about the importance of obtaining adequate amounts of all the essential nutrients that may be of concern on a plant-based diet via the use of supplements and fortified foods.

In addition, future research should also consider vaccination status in their analyses on infectious disease risk and nutrient intake or status, since vaccination is a key confounding variable that should always be controlled for in statistical analyses. In relation to this, vaccine hesitancy among Adventists could be further explored due to the lack of research in this area.

In the context of health promotion activities within the church to prevent infectious diseases such as COVID-19 disease, understanding perceptions of vaccines that contribute to vaccine hesitancy could inform church leadership who are involved with health promotion strategies that aim to improve vaccine acceptance rates.

Finally, there is need for a broader geographic representation of Adventists in scientific studies since most studies have focused on Adventists in North America. Future research should recruit Adventist populations from diverse geographic regions which would certainly enhance the findings' generalizability.

While the Adventist lifestyle is religiously motivated, many of its key components, such as a plant-based diet, abstinence from alcohol and smoking, regular physical activity, and fasting are lifestyle factors that can be generalized to non-Adventist populations, however the Adventist lifestyle also includes practices such as Sabbath rest, prayer, religious service attendance and faith and belief in the divine. These factors can be clearly distinguished, although within the context of Adventism both are rooted in religious practice. For instance, a plant-based diet, lower BMI, regular physical activity, and abstinence from alcohol and smoking were all significantly associated with reduced COVID-19 incidence, symptom severity, and long-COVID risk. These variables may be religiously encouraged within Adventism; however, they are lifestyle practices that can be adopted in non-religious populations.

On the other hand, it was identified that Adventists who engaged in faith-based stress management techniques, such as prayer, Bible reading, and singing, reported lower anxiety during the pandemic compared with non-Adventists, which may have indirectly impacted COVID-19 outcomes. While these stress-management practices are considered as inherently religious, their underlying principle, which is intentional emotional regulation, social support and community-based coping, may be adopted to the secular context through mindfulness techniques, music therapy, or other structured interventions. As this thesis mostly focused on lifestyle factors that directly have an influence on health, further research is needed to assess the impact of Adventist lifestyle practices such as resting on the Sabbath and bible reading on COVID-19 risk directly.

7.4 CONCLUSIONS

This research provides valuable insights into the lifestyle and diet of Seventh-day Adventists in the UK, especially in the context of the COVID-19 pandemic, and showed that the Adventist lifestyle may be associated with a lower COVID-19 risk. The findings of this thesis highlight the potential protective effects of the Adventist dietary practices against COVID-19 and shed light on the importance of dietary interventions in the field of church-based health promotion targeting Adventists, especially those following a plant-based diet.

In summary, the results of this thesis support the hypothesis that the Adventist lifestyle is associated with a reduced incidence and severity of COVID-19 disease and likely contributes to a lower long-COVID risk. Causality cannot be established due to the observational nature of the primary studies, the consistency of evidence across studies of this thesis and their agreement with the published literature provides confirmation to this conclusion.

References

About Epic-Norfolk (no date) The EPICNorfolk Study. Available at: https://www.epic-norfolk.org.uk/about-epic-norfolk/nutritional-methods/ffq/ (Accessed: January 16, 2023).

Abood, D.A., Black, D.R. and Feral, D. (2003). Nutrition Education Worksite Intervention for University Staff: Application of the Health Belief Model. Journal of Nutrition Education and Behavior, 35(5), pp.260–267. doi:https://doi.org/10.1016/s1499-4046(06)60057-2.

Abris, G.P., Shavlik, D.J., Mathew, R.O., Butler, F.M., Oh, J., Rawiwan Sirirat, Sveen, L.E. and Fraser, G.E. (2024). Cause-specific and all-cause mortalities in vegetarian compared to non-vegetarian participants from the Adventist Health Study-2 cohort. American Journal of Clinical Nutrition. [online] doi:https://doi.org/10.1016/j.ajcnut.2024.07.028.

Acheanpong, K., Pan, X., Kaminga, A.C. and Liu, A. (2022). Prevalence and risk factors of prenatal depression among pregnant women attending antenatal clinic at Adventist Hospital, Bekwai Municipality, Ghana. Medicine, [online] 101(10), p.e28862. doi:https://doi.org/10.1097/MD.0000000000028862.

Acosta-Navarro, J.C., Dias, L.F., Gouveia, L.A.G. de, Ferreira, E.P., Oliveira, M.V.P.F. de, Marin, F.A., Oliveira, J.V.C., Silva, A.C. da, Silva, I.L., Freitas, F. de O. and Soares, P.R. (2024). Vegetarian and plant-based diets associated with lower incidence of COVID-19. BMJ Nutrition, Prevention & Health, [online] p.e000629. doi:https://doi.org/10.1136/bmjnph-2023-000629.

Adventist.uk. (2024). Statistics: Adventist Church in UK and Ireland | National Site. [online] Available at: https://adventist.uk/who-we-are/statistics/ [Accessed 23 Aug. 2024].

Ahrenfeldt, L.J., Möller, S., Hvidt, N.C., VanderWeele, T.J. and Stripp, T.A. (2023). Effect of religious service attendance on mortality and hospitalisations among Danish men and women: longitudinal findings from REGLINK-SHAREDK. European Journal of Epidemiology. doi:https://doi.org/10.1007/s10654-023-00964-y.

Aggarwal, S.K., Wright, J.C., Morgan, A.J., Patton, G.C. and Reavley, N. (2023). Religiosity and spirituality in the prevention and management of depression and anxiety in young people: a systematic review and meta-analysis. BMC Psychiatry, 23(1). doi:https://doi.org/10.1186/s12888-023-05091-2.

Aithal, A. and Aithal, S. (2020). Development and Validation of Survey Questionnaire and Experimental Data – A Systematical Review-based Statistical Approach. [online] mpra.ub.uni-muenchen.de. Available at: https://mpra.ub.uni-muenchen.de/104830/.

Alamer, A.S. (2024) Behavior Change Theories and Models Within Health Belief Model Research: A Five-Decade Holistic Bibliometric Analysis. Cureus, 16(6), e63143. Available at: https://doi.org/10.7759/cureus.63143

Albashir, A.A.D. (2020). The potential impacts of obesity on COVID-19. Clinical Medicine, 20(4), pp.e109–e113. doi:https://doi.org/10.7861/clinmed.2020-0239.

Alemzadeh, E., Alemzadeh, E., Ziaee, M., Abedi, A. and Salehiniya, H. (2021). The effect of low serum calcium level on the severity and mortality of Covid patients: A systematic review and meta-analysis. Immunity, inflammation and disease, [online] 9(4), pp.1219–1228. doi:https://doi.org/10.1002/iid3.528.

Alwine, J.C., Casadevall, A., Enquist, L.W., Goodrum, F.D. and Imperiale, M.J. (2023). A critical analysis of the evidence for the SARS-CoV-2 origin hypotheses. mBio. doi:https://doi.org/10.1128/mbio.00583-23.

Alyafei, A. and Easton-Carr, R. (2024). The Health Belief Model of Behavior Change. [online] Nih.gov. Available at: https://www.ncbi.nlm.nih.gov/books/NBK606120/.

Amy Tikkanen. (2018). Ebers papyrus | Egyptian texts. In: Encyclopædia Britannica. [online] Available at: https://www.britannica.com/topic/Ebers-papyrus.

Anderson, B.M., Gibson, R.S. & Sabry, J.H. (1981) 'The iron and zinc status of long-term vegetarian women', The American Journal of Clinical Nutrition, 34(6), pp. 1042-1048.

Anderson, J. and Milyavskaya, M. (2021). Going Vegan Or Vegetarian: Motivations & Influences. Diet. [online] https://www.wellbeingintlstudiesrepository.org/hw_diet/10/
Ankar, A. and Kumar, A. (2022). Vitamin B12 Deficiency. [online] PubMed. Available at: https://pubmed.ncbi.nlm.nih.gov/28722952/#:~:text=As%20a%20result%2C%20B12%20deficiency.

Askari, M., Daneshzad, E., Darooghegi Mofrad, M., Bellissimo, N., Suitor, K. and Azadbakht, L. (2020). Vegetarian diet and the risk of depression, anxiety, and stress symptoms: a systematic review and meta-analysis of observational studies. Critical Reviews in Food Science and Nutrition, pp.1–11. doi:10.1080/10408398.2020.1814991.

Ayling, K., Jia, R., Coupland, C., Chalder, T., Massey, A., Broadbent, E. and Vedhara, K. (2022). Psychological Predictors of Self-reported COVID-19 Outcomes: Results From a Prospective Cohort Study. Annals of Behavioral Medicine, 56(5). doi:https://doi.org/10.1093/abm/kaab106.

Ayub, S., Anugwom, G.O., Tajudeen Basiru, Sachdeva, V., Muhammad, N., Bachu, A., Trudeau, M., Gulati, G., Sullivan, A., Ahmed, S. and Jain, L. (2023). Bridging science and spirituality: the intersection of religion and public health in the COVID-19 pandemic. 14. doi:https://doi.org/10.3389/fpsyt.2023.1183234.

Bai, Y. and Tao, X. (2021). Comparison of COVID-19 and influenza characteristics. Journal of Zhejiang University-SCIENCE B, 22(2), pp.87–98. doi:https://doi.org/10.1631/jzus.b2000479.

Baig, J.A., Sheikh, S.A., Islam, I. and Kumar, M. (2013). Vitamin D status among vegetarians and non-vegetarians. Journal of Ayub Medical College, Abbottabad: JAMC, [online] 25(1-2), pp.152–155. Available at: https://pubmed.ncbi.nlm.nih.gov/25098082/.

Baird, J., Cooper, C., Margetts, B.M., Barker, M. and Inskip, H.M. (2009). Changing health behaviour of young women from disadvantaged backgrounds: evidence from systematic

reviews. Proceedings of the Nutrition Society, 68(2), pp.195–204.
doi:https://doi.org/10.1017/s0029665109001050.

Bakaloudi, D.R., Halloran, A., Rippin, H.L., Oikonomidou, A.C., Dardavesis, T.I., Williams, J., Wickramasinghe, K., Breda, J. and Chourdakis, M. (2020). Intake and adequacy of the vegan diet. A systematic review of the evidence. Clinical Nutrition, [online] 40(5). doi:https://doi.org/10.1016/j.clnu.2020.11.035.

Barmania, S. and Reiss, M.J., (2018). Islam and health policies related to HIV prevention in Malaysia. Dordrecht: Springer.
Barrero, M.J., Cejas, P., Long, H.W. and Ramirez de Molina, A. (2022). Nutritional Epigenetics in Cancer. Advances in Nutrition. doi:https://doi.org/10.1093/advances/nmac039.

Batista, K.S., Cintra, V.M., Lucena, P.A.F., Manhães-de-Castro, R., Toscano, A.E., Costa, L.P., Queiroz, M.E.B.S., de Andrade, S.M., Guzman-Quevedo, O. and Aquino, J. de S. (2021). The role of vitamin B12 in viral infections: a comprehensive review of its relationship with the muscle–gut–brain axis and implications for SARS-CoV-2 infection. Nutrition Reviews. doi:https://doi.org/10.1093/nutrit/nuab092.

Bauhoff, S. (2014). Self-Report Bias in Estimating Cross-Sectional and Treatment Effects. Encyclopedia of Quality of Life and Well-Being Research, [online] pp.5798–5800. doi:10.1007/978-94-007-0753-5_4046.

Baum, J., Kim, I.-Y. and Wolfe, R. (2016). Protein Consumption and the Elderly: What Is the Optimal Level of Intake? Nutrients, [online] 8(6), p.359.
doi:https://doi.org/10.3390/nu8060359.

Baumsteiger, R. and Chenneville, T. (2015). Challenges to the Conceptualization and Measurement of Religiosity and Spirituality in Mental Health Research. Journal of Religion and Health, 54(6), pp.2344–2354. doi:https://doi.org/10.1007/s10943-015-0008-7.

Beeson, W.L., Mills, P.K., Phillips, R.L., Andress, M. and Fraser, G.E. (1989). Chronic disease among seventh-day adventists, a low-risk group. Rationale, methodology, and description of the population. Cancer, 64(3), pp.570–581. doi:https://doi.org/10.1002/1097-0142(19890801)64:3%3C570::aid-cncr2820640303%3E3.0.co;2-4.

Beezhold, B.L., Johnston, C.S. and Daigle, D.R. (2010). Vegetarian diets are associated with healthy mood states: a cross-sectional study in Seventh Day Adventist adults. Nutrition Journal, [online] 9(1). doi:10.1186/1475-2891-9-26.

Beezhold, B. L., Radnitz, C., Rinne, A. & DiMatteo, J. (2010) 'Vegetarian diets are associated with healthy mood states: a cross-sectional study in Seventh Day Adventist adults', Nutrition Journal, 9, Article number: 26.

Belluco, S., Simonato, G., Mancin, M., Pietrobelli, M. and Ricci, A. (2017). Toxoplasma gondii infection and food consumption: A systematic review and meta-analysis of case-controlled studies. Critical Reviews in Food Science and Nutrition, 58(18), pp.3085–3096. doi:https://doi.org/10.1080/10408398.2017.1352563.

Berg, J., Seyedsadjadi, N. and Grant, R. (2020). Increased Consumption of Plant Foods is Associated with Increased Bone Mineral Density. The journal of nutrition, health & aging, 24(4), pp.388–397. doi:https://doi.org/10.1007/s12603-020-1339-y.

Berg, S. (2021). What doctors wish patients knew about the Johnson & Johnson vaccine. [online] American Medical Association. Available at: https://www.ama-assn.org/delivering-care/public-health/what-doctors-wish-patients-knew-about-johnson-johnson-vaccine.

Berkel, J. and de Waard, F. (1983). Mortality Pattern and Life Expectancy of Seventh-Day Adventists in the Netherlands. International Journal of Epidemiology, 12(4), pp.455–459. doi:https://doi.org/10.1093/ije/12.4.455.

Bliss, J.W., Lavery, J.A., Underwood, W.P., Chun, S.S., Fickera, G.A., Lee, C.P., Corcoran, S., Maloy, M.A., Polubriaginof, F.C., Kelly, D.W., Scott, J.M., Boutros, P.C., Moskowitz, C.S. and Jones, L.W. (2022). Impact of Exercise on Susceptibility and Severity of COVID-19 in Patients with Cancer: A Retrospective Study. Cancer epidemiology, biomarkers &

prevention, [online] 31(5), pp.1036–1042. doi:https://doi.org/10.1158/1055-9965.epi-21-1186.

Bokek-Cohen, Y. and Tarabeih, M. (2022). The Use of Porcine-Derived Materials for Medical Purposes: What do Muslim and Jewish Individuals Know and Opine About It? Journal of Bioethical Inquiry, 19(4), pp.599–612. doi:https://doi.org/10.1007/s11673-022-10203-w.

Booranasuksakul, U., Singhato, A., Rueangsri, N. and Prasertsri, P. (2019). Association between alcohol consumption and body mass index in university students. Asian/Pacific Island Nursing Journal, 4(1), pp.57–65. doi:10.31372/20190401.1035.

Bostanghadiri,N., Ziaeefar P.,, Mofrad G., M., Yousefzadeh, P., Hashemi, A. and Darban-Sarokhalil D., (2023). COVID-19: An Overview of SARS-CoV-2 Variants—The Current Vaccines and Drug Development. BioMed Research International, 2023, pp.1–29. doi:https://doi.org/10.1155/2023/1879554.

Botabara-Yap, M. J., Torres, M. C. B., Macayan, Y. Y. C., Alpuerto, M. L. L., Romero, C. L., Oliverio, L. W. V. and Sinaga, Y. L. D. Y. (2023) “Knowledge, Beliefs, and Intention to Vaccinate against COVID-19 among the Seventh Day Adventists in Southeast Asia Region”, Acta Medica Philippina, 57(6). doi: 10.47895/amp.vi0.4549.

Bove-Fenderson, E. and Mannstadt, M. (2018). Hypocalcemic disorders. Best Practice & Research. Clinical Endocrinology & Metabolism, [online] 32(5), pp.639–656. doi:https://doi.org/10.1016/j.beem.2018.05.006.

Brathwaite, N., Fraser, H.S., Modeste, N., Broome, H. and King, R. (2003). Obesity, diabetes, hypertension, and vegetarian status among Seventh-Day Adventists in Barbados: preliminary results. Ethnicity & Disease, [online] 13(1), pp.34–39. Available at: https://pubmed.ncbi.nlm.nih.gov/12723010/ [Accessed 9 Apr. 2024].

Bright Yammaha Amoore, Patience Kanyiri Gaa, Amalba, A. and Mogre, V. (2023). Nutrition education intervention improves medical students’ dietary habits and their competency and self-efficacy in providing nutrition care: A pre, post and follow-up quasi-experimental study. Frontiers in Nutrition, 10. doi:https://doi.org/10.3389/fnut.2023.1063316.

Brown, A.E., Heinsbroek, E., Kall, M.M., Allen, H., Beebeejaun, K., Blomquist, P., Campos-Matos, I., Campbell, C.N.J., Mohammed, H., Sinka, K., Lamagni, T., Phin, N. and Dabrera, G. (2021). Epidemiology of Confirmed COVID-19 Deaths in Adults, England, March–December 2020. Emerging Infectious Diseases, 27(5), pp.1468–1471. doi:https://doi.org/10.3201/eid2705.203524.

Brown, L. and Durrheim, K. (2009). Different Kinds of Knowing. Qualitative Inquiry, 15(5), pp.911–930. doi:https://doi.org/10.1177/1077800409333440.

Brydges, C.R. (2019). Effect Size Guidelines, Sample Size Calculations, and Statistical Power in Gerontology. Innovation in Aging, 3(4). doi:https://doi.org/10.1093/geroni/igz036.

Buettner, D. and Skemp, S. (2016) Blue zones: Lessons from the world's longest lived, American journal of lifestyle medicine. U.S. National Library of Medicine. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6125071/ (Accessed: January 15, 2023).

Büssing, A., Recchia, D.R., Starck, L. and van Treeck, K. (2022). Perceived Changes of Attitudes and Behaviors of Seventh-Day Adventists During the COVID-19 Pandemic: Findings from a Cross-Sectional Survey in Germany. Journal of Religion and Health, 61(3), pp.2253–2278. doi:https://doi.org/10.1007/s10943-022-01580-y.

Cahill, L. et al. (2013) Prospective study of breakfast eating and incident ... - circulation, www.ahajournals.org. Circulation. Available at: https://www.ahajournals.org/doi/10.1161/CIRCULATIONAHA.113.001474 (Accessed: January 16, 2023).

Calkins, B.M., Whittaker, D.J., Nair, P.P., Rider, A.A. & Turjman, N. (1984) 'Diet, nutrition intake, and metabolism in populations at high and low risk for colon cancer. Nutrient intake', The American Journal of Clinical Nutrition, 40(4 Suppl), pp. 896-905.

Campbell, M., McKenzie, J.E., Sowden, A., Katikireddi, S.V., Brennan, S.E., Ellis, S., et al., 2020. Synthesis without meta-analysis (SWiM) in systematic reviews: reporting guideline. BMJ, 368, p.l6890. doi:10.1136/bmj.l6890.

Candio, P., Violato, M., Clarke, P., Duch, R.M. and Roope, L. (2023). Prevalence, predictors and reasons for COVID-19 vaccine hesitancy: Results of a global online survey. Health Policy, 137, pp.104895–104895. doi:https://doi.org/10.1016/j.healthpol.2023.104895.

Canales, E. (2021). A Market Basket Assessment: Prices and Availability of Healthy Foods Across SNAP-Authorized Food Outlets in Counties With High Obesity Rates in Mississippi. Preventing Chronic Disease, [online] 18. doi:https://doi.org/10.5888/pcd18.210173.

Cardoso, F.J., Victor, D.R., Silva, J.R. da, Guimarães, A.C., Leal, C.A., Taveira, M.R. and Alves, J.G. (2023). Physical fitness level and the risk of severe COVID-19: A systematic review. Sports Medicine and Health Science, [online] 5(3), pp.174–180. doi:https://doi.org/10.1016/j.smhs.2023.07.010.

Carmel, R. (2008). How I treat cobalamin (vitamin B12) deficiency. Blood, 112(6), pp.2214–2221. doi:https://doi.org/10.1182/blood-2008-03-040253.

Carpenter, C.J. (2010). A meta-analysis of the effectiveness of health belief model variables in predicting behavior. Health communication, 25(8), pp.661–669. doi:https://doi.org/10.1080/10410236.2010.521906.

Carroll, W.D., Strenger, V., Eber, E., Porcaro, F., Cutrera, R., Fitzgerald, D.A. and Balfour-Lynn, I.M. (2020). European and United Kingdom COVID-19 pandemic experience: The same but different. Paediatric Respiratory Reviews, 35(35), pp.50–56. doi:https://doi.org/10.1016/j.prrv.2020.06.012.

Castro, J. (2004) The Time of Day of Food Intake Influences Overall Intake in Humans , Academic.oup.com. The Journal of Nutrition. Available at: https://academic.oup.com/jn/article/134/1/104/4688191?login=false (Accessed: January 16, 2023).

CDC (2024). Similarities and Differences between Flu and COVID-19. [online] Influenza (Flu). Available at: https://www.cdc.gov/flu/about/flu-vs-covid19.html [Accessed 19 Feb. 2025].

Cedric A., et al., Vitamin D and survival in COVID-19 patients: A quasi-experimental study. (2020). The Journal of Steroid Biochemistry and Molecular Biology, [online] 204, p.105771. doi:10.1016/j.jsbmb.2020.105771.

Channa, A., Popescu, N., Skibinska, J. and Burget, R. (2021). The Rise of Wearable Devices during the COVID-19 Pandemic: A Systematic Review. Sensors, [online] 21(17), p.5787. doi:https://doi.org/10.3390/s21175787.

Chandra, R.K. (1979) 'Nutritional deficiency and susceptibility to infection', Bulletin of the World Health Organization, 57(2), pp. 167–177.

Chapple, C. K., 1993. Nonviolence to Animals, Earth, and Self in Asian Traditions. Albany: State University of New York Press. Available at: https://archive.org/details/nonviolencetoani0000chap/page/n163/mode/2up [Accessed 24 December 2024].

Chaubey, G.K., Dilawari, R., Modanwal, R., Talukdar, S., Dhiman, A., Raje, C.I. and Raje, M. (2023). Excess iron aggravates the severity of COVID-19 infection. Free radical biology & medicine, [online] 208, pp.186–193. doi:https://doi.org/10.1016/j.freeradbiomed.2023.08.011.

Chen, H., Ward, M. H., Graubard, B. I., Heineman, E. F., Markin, R. M., Potischman, N. A., Russell, R. M., Weisenburger, D. D., & Tucker, K. L. (2009). 'Dietary patterns and adenocarcinoma of the esophagus and distal stomach', The American Journal of Clinical Nutrition, 89(1), 1-10.

Chen, Y. and VanderWeele, T.J. (2018). Associations of Religious Upbringing With Subsequent Health and Well-Being From Adolescence to Young Adulthood: An Outcome-

Wide Analysis. American Journal of Epidemiology, 187(11), pp.2355–2364. doi:https://doi.org/10.1093/aje/kwy142.

Chiba, T., Kobayashi, E., Okura, T., Sekimoto, M., Mizuno, H., Saito, M. and Umegaki, K. (2020). An educational intervention improved knowledge of dietary supplements in college students. BMC Public Health, 20(1). doi:https://doi.org/10.1186/s12889-020-08786-3.

Chouraqui, J.-P., Turck, D., Briend, A., Darmaun, D., Bocquet, A., Feillet, F., Frelut, M.-L., Girardet, J.-P., Guimber, D., Hankard, R., Lapillonne, A., Peretti, N., Roze, J.-C., Siméoni, U., Dupont, C. and Committee on Nutrition of the French Society of Pediatrics (2021). Religious dietary rules and their potential nutritional and health consequences. International Journal of Epidemiology, [online] 50(1), pp.12–26. doi:https://doi.org/10.1093/ije/dyaa182.

Chow, S.K., Francis, B., Ng, Y.H., Naim, N., Beh, H.C., Ariffin, M.A.A., Yusuf, M.H.M., Lee, J.W. and Sulaiman, A.H. (2021). Religious Coping, Depression and Anxiety among Healthcare Workers during the COVID-19 Pandemic: A Malaysian Perspective. Healthcare, 9(1), p.79. doi:https://doi.org/10.3390/healthcare9010079.

Conner, M. and Norman, P. (2017). Health Belief Model - An overview. [online] Sciencedirect.com. Available at: https://www.sciencedirect.com/topics/medicine-and-dentistry/health-belief-model.

Cook, E.A.J., Gitahi, N., de Glanville, W.A., Thomas, L.F., Kariuki, S., Kang'ethe, E. and Fèvre, E.M. (2021). Prevalence and risk factors for exposure to Toxoplasma gondii in slaughterhouse workers in western Kenya. BMC Infectious Diseases, [online] 21, p.944. doi:https://doi.org/10.1186/s12879-021-06658-8.

Craig, B.A., Morton, D.P., Kent, L.M., Gane, A.B., Butler, T.L., Rankin, P.M. and Price, K.R. (2017). Religious Affiliation Influences on the Health Status and Behaviours of Students Attending Seventh-Day Adventist Schools in Australia. Journal of Religion and Health, 57(3), pp.994–1009. doi:https://doi.org/10.1007/s10943-017-0495-9.

Crespi, B. and Alcock, J. (2021) ‘Conflicts over calcium and the treatment of COVID-19’, Evolution, Medicine, and Public Health, 9(1), pp. 149–156. Available at: https://doi.org/10.1093/emph/eoa046

Cruwys, T. et al. (2020) "an important part of who I am": The predictors of dietary adherence among weight-loss, vegetarian, vegan, Paleo, and gluten-free dietary groups, Nutrients. MDPI. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7231009/ (Accessed: January 16, 2023).

Cusack, L., Del Mar, C.B., Chalmers, I., Gibson, E. and Hoffmann, T.C. (2018). Educational interventions to improve people’s understanding of key concepts in assessing the effects of health interventions: a systematic review. Systematic Reviews, 7(1). doi:https://doi.org/10.1186/s13643-018-0719-4.

Dai, X., Tan, L., Ren, L., Shao, Y., Tao, W. and Wang, Y. (2022). COVID-19 Risk Appears to Vary Across Different Alcoholic Beverages. Frontiers in Nutrition, 8. doi:https://doi.org/10.3389/fnut.2021.772700.

da Luz Scheffer, D. and Latini, A. (2020). Exercise-induced immune system response: Anti-inflammatory status on peripheral and central organs. Biochimica et Biophysica Acta. Molecular Basis of Disease, [online] 1866(10). doi:https://doi.org/10.1016/j.bbadis.2020.165823.

Damayanti, D., Jaceldo-Siegl, K., Beeson, W., Fraser, G., Oda, K. and Haddad, E. (2018). Foods and Supplements Associated with Vitamin B12 Biomarkers among Vegetarian and Non-Vegetarian Participants of the Adventist Health Study-2 (AHS-2) Calibration Study. Nutrients, 10(6), p.722. doi:10.3390/nu10060722.

David, A., (2024). For Pastors & Church Leaders. [online] Health Ministries. Available at: https://nadhealth.org/aafcn/leaders/ [Accessed 12 Feb. 2025].

Demicheli, V., Jefferson, T., Ferroni, E., Rivetti, A. and Di Pietrantonj, C. (2018). Vaccines for preventing influenza in healthy adults. Cochrane Database of Systematic Reviews. doi:https://doi.org/10.1002/14651858.cd001269.pub6.

Demicheli, V., Jefferson, T., Di Pietrantonj, C., Ferroni, E., Thorning, S., Thomas, R.E. and Rivetti, A. (2018). Vaccines for preventing influenza in the elderly. Cochrane Database of Systematic Reviews, (2). doi:https://doi.org/10.1002/14651858.cd004876.pub4.

de Frel, D.L., Atsma, D.E., Pijl, H., Seidell, J.C., Leenen, P.J.M., Dik, W.A. and van Rossum, E.F.C. (2020). The Impact of Obesity and Lifestyle on the Immune System and Susceptibility to Infections Such as COVID-19. Frontiers in Nutrition, 7. doi:https://doi.org/10.3389/fnut.2020.597600.

de Oliveira Maraldi, E. (2018). Response Bias in Research on Religion, Spirituality and Mental Health: A Critical Review of the Literature and Methodological Recommendations. Journal of Religion and Health, 59(2), pp.772–783. doi:https://doi.org/10.1007/s10943-018-0639-6.

Dhand, N. K., & Khatkar, M. S. (2014). Statulator: An online statistical calculator. Sample size calculator for comparing two paired means. Retrieved from http://statulator.com/SampleSize/ss2PM.html

Di Pietrantonj, C., Rivetti, A., Marchione, P., Debalini, M.G. and Demicheli, V. (2020). Vaccines for measles, mumps, rubella, and varicella in children. Cochrane Database of Systematic Reviews, (4). doi:https://doi.org/10.1002/14651858.cd004407.pub4.

Doctrow, B. (2022). Calorie restriction, immune function, and health span. [online] National Institutes of Health (NIH). Available at: https://www.nih.gov/news-events/nih-research-matters/calorie-restriction-immune-function-health-span.

Dobesek, U., Wy, G., Adkins, J., Altmeyer, S., Krout, K., Lavie, C.J. and Archer, E., 2020. Meat and mental health: a systematic review of meat abstention and depression, anxiety, and related phenomena. Critical Reviews in Food Science and Nutrition, 61(4), pp.622-635. Available at: https://doi.org/10.1080/10408398.2020.1741505 [Accessed date].

Drewnowski, A. and Shultz, J. (2001). Impact of Aging on Eating Behaviors, Food Choices, Nutrition, and Health Status. [online] The journal of nutrition, health & aging. Available at: https://pubmed.ncbi.nlm.nih.gov/11426286/.

Dror, A.A., Morozov, N., Daoud, A., Namir, Y., Yakir, O., Shachar, Y., Lifshitz, M., Segal, E., Fisher, L., Mizrachi, M., Eisenbach, N., Rayan, D., Gruber, M., Bashkin, A., Kaykov, E., Barhoum, M., Edelstein, M. and Sela, E. (2022). Pre-infection 25-hydroxyvitamin D3 levels and association with severity of COVID-19 illness. PLOS ONE, 17(2), p.e0263069. doi:https://doi.org/10.1371/journal.pone.0263069.

Duchateau, J., Delepesse, G., Vrijens, R. and Collet, H. (1981). Beneficial effects of oral zinc supplementation on the immune response of old people. The American Journal of Medicine, 70(5), pp.1001–1004. doi:https://doi.org/10.1016/0002-9343(81)90849-4.

Dutta, D., Naiyer, S., Mansuri, S., Soni, N., Singh, V., Bhat, K.H., Singh, N., Arora, G. and Mansuri, M.S. (2022). COVID-19 Diagnosis: A Comprehensive Review of the RT-qPCR Method for Detection of SARS-CoV-2. Diagnostics, 12(6), p.1503. doi:https://doi.org/10.3390/diagnostics12061503.

Dwyer-Lindgren, L., Kendrick, P.J., Kelly, Y.O., Baumann, M.M., Compton, K., Blacker, B.F., Daoud, F., Li, Z., Mouhanna, F., Hasan Nassereldine, Schmidt, C., Sylte, D.O., Hay, S.I., Mensah, G.A., Anna María Nápoles, Pérez-Stable, E.J., Murray, C.J.L. and Mokdad, A.H. (2023). Cause-specific mortality by county, race, and ethnicity in the USA, 2000–19: a systematic analysis of health disparities. The Lancet, 402(10407). doi:https://doi.org/10.1016/s0140-6736(23)01088-7.

Ebrahim, S.H. and Memish, Z.A. (2020). COVID-19: preparing for superspreader potential among Umrah pilgrims to Saudi Arabia. The Lancet, 395(10227), p.e48. doi:https://doi.org/10.1016/s0140-6736(20)30466-9.

Edelman, A., Boniface, E.R., Male, V., Cameron, S.T., Benhar, E., Han, L., Matteson, K.A., Lamsweerde, A.V., Pearson, J.T. and Darney, B.G. (2022). Association between menstrual cycle length and covid-19 vaccination: global, retrospective cohort study of prospectively collected data. BMJ Medicine, [online] 1(1). doi:10.1136/bmjmed-2022-000297.

Ellen G. White (1905). The Ministry of Healing. [online] Available at: https://m.egwwritings.org/en/book/135.1493#1493 [Accessed 30 Mar. 2024].

Enstrom, J.E. (1979). Cancer Mortality Among Low-Risk Populations. CA: A Cancer Journal for Clinicians, 29(6), pp.352–361. doi:https://doi.org/10.3322/canjclin.29.6.352.

Erfani, Z., Alizadeh, N., Faraji, N. and Alireza Teymouri (2023). Vitamin B12 effectiveness in the management of hospitalized COVID-19 and its clinical outcomes and complications: A randomized clinical trial. Health science reports, 6(9). doi:https://doi.org/10.1002/hsr2.1509.

Esolen, A., 2022. The Church Has Always Built Hospitals. Linacre Quarterly, 89(1), pp. 116–118. doi: 10.1177/00243639221075671. Available at: https://doi.org/10.1177/00243639221075671 [Accessed 24 December 2024].

Espinosa, A. and Kadić-Maglajlić, S. (2018). The Mediating Role of Health Consciousness in the Relation Between Emotional Intelligence and Health Behaviors. Frontiers in Psychology, 9. doi:https://doi.org/10.3389/fpsyg.2018.02161.

Eysenbach, G. (2004). Improving the Quality of Web Surveys: The Checklist for Reporting Results of Internet E-Surveys (CHERRIES). Journal of Medical Internet Research, [online] 6(3), p.e34. doi:https://doi.org/10.2196/jmir.6.3.e34.

Famodu, A.A., Osilesi, O., Makinde, Y.O. and Osonuga, O.A. (1998). Blood pressure and blood lipid levels among vegetarian, semi-vegetarian, and non-vegetarian native Africans. Clinical Biochemistry, 31(7), pp.545–549. doi:https://doi.org/10.1016/s0009-9120(98)00067-8.

Farha, R.A., Alzoubi, K.H., Khabour, O.F. and Mukattash, T.L. (2020). Factors Influencing Public Knowledge and Willingness to Participate in Biomedical Research in Jordan: A National Survey. Patient Preference & Adherence, [online] 14, pp.1373–1379. doi:https://doi.org/10.2147/PPA.S261903.

Farshbafnadi, M., Kamali Zonouzi, S., Sabahi, M., Dolatshahi, M. and Aarabi, M.H. (2021). Aging & COVID-19 susceptibility, disease severity, and clinical outcomes: The role of entangled risk factors. Experimental Gerontology, 154, p.111507. doi:https://doi.org/10.1016/j.exger.2021.111507.

Fauziana, R. et al. (2016) Body mass index, waist-hip ratio and risk of chronic medical condition in the elderly population: Results from the well-being of the Singapore elderly (WISE) study, BMC geriatrics. BioMedCentral. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4912714/#:~:text=Waist%20to%20Hip%20Ratio%20(WHR)&text=WHO%20%5B24%5D%20recommends%20cut%2D,risk%20of%20various%20health%20complications (Accessed: January 16, 2023).

Ferguson, L.R., Alley, P.G. and Gribben, B.M. (1985). DNA-damaging activity in ethanol-soluble fractions of feces from New Zealand groups at varying risks of colorectal cancer. Nutrition and Cancer, 7(1-2), pp.93–103. doi:https://doi.org/10.1080/01635588509513844.

Fernandes, S., Oliveira, L., Pereira, A., Costa, M. do C., Raposo, A., Saraiva, A. and Magalhães, B. (2024). Exploring Vitamin B12 Supplementation in the Vegan Population: A Scoping Review of the Evidence. Nutrients, 16(10), p.1442. https://doi.org/10.3390/nu16101442

Ferngren, G. B., 2009. Medicine and Health Care in Early Christianity. Baltimore: Johns Hopkins University Press. Available at: http://ndl.ethernet.edu.et/bitstream/123456789/3826/3/Gary%20B.%20Ferngren.pdf [Accessed 24 December 2024].

Fjeldsoe, B., Neuhaus, M., Winkler, E. and Eakin, E. (2011). Systematic review of maintenance of behavior change following physical activity and dietary interventions. Health Psychology, 30(1), pp.99–109. doi:https://doi.org/10.1037/a0021974.

Følling, I.S., Oldervoll, L.M., Hilmarsen, C. and Ersfjord, E.M.I. (2021). Exploring use of activity monitors for patients with obesity during weight-loss treatment - a qualitative study. BMC Sports Science, Medicine and Rehabilitation, 13(1). doi:10.1186/s13102-021-00253-9.

Fønnebø, V. (1994). The healthy Seventh-day Adventist lifestyle: what is the Norwegian experience? The American Journal of Clinical Nutrition, 59(5), pp.1124S1129S. doi:https://doi.org/10.1093/ajcn/59.5.1124s.

Foster, C., Hillsdon, M. & Thorogood, M., 2005. *Interventions for promoting physical activity*. Cochrane Database of Systematic Reviews, Issue 1, CD003180. Available at: http://www.mrw.interscience.wiley.com/cochrane/clsysrev/articles/CD003180/frame.html

Fraser, G.E. (1999). Diet as Primordial Prevention in Seventh-Day Adventists. Preventive Medicine, 29(6), pp.S18–S23. doi:https://doi.org/10.1006/pmed.1998.0415.

Fraser, G.E. and Shavlik, D.J. (1997). Risk factors for all-cause and coronary heart disease mortality in the oldest-old. The Adventist Health Study. Archives of Internal Medicine, [online] 157(19), pp.2249–2258. Available at: https://pubmed.ncbi.nlm.nih.gov/9343002/.

Fraser, G.E., Cosgrove, C.M., Mashchak, A.D., Orlich, M.J. and Altekruse, S.F. (2019). Lower rates of cancer and all-cause mortality in an Adventist cohort compared with a US Census population. Cancer, 126(5), pp.1102–1111. doi:https://doi.org/10.1002/cncr.32571.

Freedman, D.S., Kompaniyets, L., Daymont, C., Zhao, L. and Blanck, H.M. (2022). Weight Gain Among U.S. Adults during the COVID-19 Pandemic through May 2021. Obesity. doi:https://doi.org/10.1002/oby.23511.

Furman, D., Campisi, J., Verdin, E., Carrera-Bastos, P., Targ, S., Franceschi, C., Ferrucci, L., Gilroy, D.W., Fasano, A., Miller, G.W., Miller, A.H., Mantovani, A., Weyand, C.M., Barzilai, N., Goronzy, J.J., Rando, T.A., Effros, R.B., Lucia, A., Kleinstreuer, N. and Slavich, G.M. (2019). Chronic inflammation in the etiology of disease across the life span. Nature Medicine, [online] 25(12), pp.1822–1832. doi:https://doi.org/10.1038/s41591-019-0675-0.

Fuschlberger, M. and Putz, P. (2023). Vitamin B12 supplementation and health behavior of Austrian vegans: a cross-sectional online survey. Scientific Reports, [online] 13(1). doi:https://doi.org/10.1038/s41598-023-30843-1.

Galanis, P., Vraka, I., Siskou, O., Konstantakopoulou, O., Katsiroumpa, A. and Kaitelidou, D. (2022). Willingness, refusal and influential factors of parents to vaccinate their children against the COVID-19: A systematic review and meta-analysis. Preventive Medicine, 157, p.106994. doi:https://doi.org/10.1016/j.ypmed.2022.106994.

Gallego-Narbón, A., Zapatera, B., Álvarez, I. and Vaquero, M.P. (2018). Methylmalonic Acid Levels and their Relation with Cobalamin Supplementation in Spanish Vegetarians. Plant Foods for Human Nutrition, 73(3), pp.166–171. https://doi.org/10.1007/s11130-018-0677-y

Galvez, C.A., Calbayan, C., Pondi, K. and Vallejos, M. (2020). Influence of Knowledge and Attitude on Lifestyle Practices Among Seventh-Day Adventists in Metro Manila, Philippines. Journal of Religion and Health. doi:https://doi.org/10.1007/s10943-020-01091-8.

Galvez, C.A. et al. (2021) Influence of knowledge and attitude on lifestyle practices among Seventh-day Adventists in Metro Manila, Philippines, Journal of religion and health. Springer. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7997818/ (Accessed: January 17, 2023).

Galvin, E., Gavin, B., Kilbride, K., Desselle, S., McNicholas, F., Cullinan, S. and Hayden, J. (2024). The use of telehealth in attention-deficit/hyperactivity disorder: a survey of parents and caregivers. European Child & Adolescent Psychiatry. [online] doi:https://doi.org/10.1007/s00787-024-02466-y.

Gao, M., Piernas, C., Astbury, N.M., Hippisley-Cox, J., O'Rahilly, S., Aveyard, P. and Jebb, S.A. (2021). Associations between body-mass index and COVID-19 severity in 6·9 million people in England: a prospective, community-based, cohort study. The Lancet Diabetes & Endocrinology, 9(6). doi:10.1016/s2213-8587(21)00089-9.

Garg, M. and Mahalle, N. (2019). Calcium supplementation: Why, which, and how? Indian Journal of Endocrinology and Metabolism, 23(4), p.387. doi:https://doi.org/10.4103/2230-8210.268505.

Garrido, R.A., Semeraro, M.B., Temesgen, S.M. and Simi, M.R. (2009). Metabolic syndrome and obesity among workers at Kanye Seventh-Day Adventist Hospital, Botswana. South African Medical Journal = Suid-Afrikaanse Tydskrif Vir Geneeskunde, [online] 99(5), pp.331–334. Available at: https://pubmed.ncbi.nlm.nih.gov/19588794/ [Accessed 3 Apr. 2024].

Gaskell, K.M., Johnson, M., Gould, V., Hunt, A., Stone, N.R., Waites, W., Kasstan, B., Chantler, T., Lal, S., Roberts, C.H., Goldblatt, D., Eggo, R.M. and Marks, M. (2021). SARS-CoV-2 seroprevalence in a strictly-Orthodox Jewish community in the UK: A retrospective cohort study. The Lancet Regional Health - Europe, 6, p.100127. doi:https://doi.org/10.1016/j.lanepe.2021.100127.

Gaughan, C.H., Ayoubkhani, D., Nafilyan, V., Goldblatt, P., White, C., TIngay, K. and Bannister, N. (2021). Religious affiliation and COVID-19-related mortality: a retrospective cohort study of prelockdown and postlockdown risks in England and Wales. J Epidemiol Community Health, [online] 75(6), pp.509–514. doi:https://doi.org/10.1136/jech-2020-215694.

Gaughan, C.H., Razieh, C., Khunti, K., Banerjee, A., Chudasama, Y.V., Davies, M.J., Dolby, T., Gillies, C.L., Lawson, C., Mirkes, E.M., Morgan, J., Tingay, K., Zaccardi, F., Yates, T. and Nafilyan, V. (2022). COVID-19 vaccination uptake amongst ethnic minority communities in England: a linked study exploring the drivers of differential vaccination rates. Journal of Public Health, 45(1). doi:https://doi.org/10.1093/pubmed/fdab400.

General Conference of Seventh-day Adventists. (2020). Fundamental beliefs. Available at: https://www.adventist.org/beliefs

Graat, J.M., Schouten, E.G. and Kok, F.J., 2002. Effect of daily vitamin E and multivitamin-mineral supplementation on acute respiratory tract infections in elderly persons: A randomized controlled trial. JAMA, 288, pp.715–721.

Grant, J.J., Wilmore, S.M.S., McCann, N.S., Donnelly, O., Lai, R.W.L., Kinsella, M.J., Rochford, H.L., Patel, T., Kelsey, M.C. and Andrews, J.A. (2020). Seroprevalence of SARS-CoV-2 antibodies in healthcare workers at a London NHS Trust. Infection Control & Hospital Epidemiology, pp.1–3. doi:https://doi.org/10.1017/ice.2020.402.

Grant, W.B., Lahore, H., McDonnell, S.L., Baggerly, C.A., French, C.B., Aliano, J.L. and Bhattoa, H.P. (2020). Evidence that Vitamin D Supplementation Could Reduce Risk of Influenza and COVID-19 Infections and Deaths. Nutrients, [online] 12(4). doi:10.3390/nu12040988.

Guo, X.-F., Li, K.-L., Li, J.-M. and Li, D. (2019). Effects of EPA and DHA on blood pressure and inflammatory factors: a meta-analysis of randomized controlled trials. Critical Reviews in Food Science and Nutrition, [online] 59(20), pp.3380–3393. doi:https://doi.org/10.1080/10408398.2018.1492901.

Ha, E.-J. and Caine-Bish, N. (2011). Interactive Introductory Nutrition Course Focusing on Disease Prevention Increased Whole-Grain Consumption by College Students. Journal of Nutrition Education and Behavior, 43(4), pp.263–267. doi:https://doi.org/10.1016/j.jneb.2010.02.008.

Haddad, E.H., Jaceldo-Siegl, K., Oda, K. and Fraser, G.E. (2020). Associations of Circulating Methylmalonic Acid and Vitamin B-12 Biomarkers Are Modified by Vegan Dietary Pattern in Adult and Elderly Participants of the Adventist Health Study 2 Calibration Study. Current Developments in Nutrition, 4(2). doi:https://doi.org/10.1093/cdn/nzaa008.

Hafez, W., Osman, S., Muneir Gador, Khair, D. and Aslam, M. (2022). Correlation Between Plasma Vitamin C Concentration and COVID-19 Outcomes among Patients Seen at a Major

Hospital in the United Arab Emirates. International Journal of MCH and AIDS, [online] 11(2). doi:https://doi.org/10.21106/ijma.608.

Hamer, M., Kivimäki, M., Gale, C.R. and Batty, G.D. (2020). Lifestyle risk factors, inflammatory mechanisms, and COVID-19 hospitalization: A community-based cohort study of 387,109 adults in UK. Brain, Behavior, and Immunity, 87, pp.184–187. doi:https://doi.org/10.1016/j.bbi.2020.05.059.

Hanna, Moretti, D., Zimmermann, M.B. and Stoffel, N.U. (2023). Effect of dietary factors and time of day on iron absorption from oral iron supplements in iron deficient women. American Journal of Hematology, 98(9). doi:https://doi.org/10.1002/ajh.26987.

Hansen, M.E. and Pickering, S.D., 2024. The role of religion and COVID-19 vaccine uptake in England. Vaccine, 42, pp.3215–3219. Available at: https://www.sciencedirect.com/science/article/pii/S0264410X24001471

Hargreaves, S.M., Raposo, A., Saraiva, A. and Zandonadi, R.P. (2021). Vegetarian Diet: An Overview through the Perspective of Quality of Life Domains. International Journal of Environmental Research and Public Health, [online] 18(8), p.4067. doi:https://doi.org/10.3390/ijerph18084067.

Harman, S.K. and Parnell, W.R. (1998). The nutritional health of New Zealand vegetarian and non-vegetarian Seventh-day Adventists: selected vitamin, mineral and lipid levels. The New Zealand Medical Journal, [online] 111(1062), pp.91–94. Available at: https://pubmed.ncbi.nlm.nih.gov/9577459/ [Accessed 12 Feb. 2024].

Harrison, J.A., Mullen, P.D. and Green, L.W. (1992). A meta-analysis of studies of the Health Belief Model with adults. Health Education Research, 7(1), pp.107–116. doi:https://doi.org/10.1093/her/7.1.107.

Head, J.R., Chanthavilay, P., Catton, H., Vongsitthi, A., Khamphouxay, K. and Simphaly, N. (2022). Changes in household food security, access to health services and income in northern Lao PDR during the COVID-19 pandemic: a cross-sectional survey. BMJ open, [online] 12(6), p.e055935. doi:10.1136/bmjopen-2021-055935.

Hemmati, R., Bidel, Z., Nazarzadeh, M., Valadi, M., Berenji, S., Erami, E., Al Zaben, F., Koenig, H.G., Sanjari Moghaddam, A., Teymoori, F., Sabour, S., Ghanbarizadeh, S.R. and Seghatoleslam, T. (2018). Religion, Spirituality and Risk of Coronary Heart Disease: A Matched Case–Control Study and Meta-Analysis. Journal of Religion and Health, 58(4), pp.1203–1216. doi:https://doi.org/10.1007/s10943-018-0722-z.

Herring, R.P., Butler, T., Hall, S., Montgomery, S.B. and Fraser, G.E. (2010). Recruiting black Americans in a large cohort study: the Adventist Health Study-2 (AHS-2) design, methods and participant characteristics. Ethnicity & disease, [online] 20(4), pp.437–43. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3172000/ [Accessed 1 Apr. 2024].

Higgins JPT, Green S. Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [updated March 2011]. The Cochrane Collaboration, Table7.7.a: Formulae for combining groups. Available from www.handbook.cochrane.org.

Higgins JPT, Green S. Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [updated March 2011]. The Cochrane Collaboration, 7.7.3.2 Obtaining standard deviations from standard errors and confidence intervals for group means. Available from www.handbook.cochrane.org.

Hodges, R.E. and Lamotte, A.V. (2022). Impact of Diet and Lifestyle on Vaccine Efficacy in Adults Aged 55 and Older: A Review. Integrative Medicine: A Clinician's Journal, [online] 21(4), p.32. Available at: https://pmc.ncbi.nlm.nih.gov/articles/PMC9542930/.

Hoff, A., Christine Tind Johannessen-Henry, Ross, L., Niels Christian Hvidt and Johansen, C. (2008). Religion and reduced cancer risk – What is the explanation? A review. European Journal of Cancer, 44(17), pp.2573–2579. doi:https://doi.org/10.1016/j.ejca.2008.08.001.

Hokin, B.D. and Butler, T. (1999). Cyanocobalamin (vitamin B-12) status in Seventh-day Adventist ministers in Australia. The American Journal of Clinical Nutrition, 70(3), pp.576s578s. doi:https://doi.org/10.1093/ajcn/70.3.576s.

Holmbäck, I. et al. (2010) A high eating frequency is associated with an overall healthy lifestyle in middle-aged men and women and reduced likelihood of general and Central Obesity in men: British Journal of Nutrition, Cambridge Core. Cambridge University Press. Available at: https://www.cambridge.org/core/journals/british-journal-of-nutrition/article/high-eating-frequency-is-associated-with-an-overall-healthy-lifestyle-in-middleaged-men-and-women-and-reduced-likelihood-of-general-and-central-obesity-in-men/A0A079076CF60DD0E918345DC33DD8AA (Accessed: January 17, 2023).

Hopkins, R.J., Russell, R.G., O'Donnoghue, J.M., Wasserman, S.S., Lefkowitz, A. and Morris, J.G. (1990). Seroprevalence of Helicobacter pylori in Seventh-Day Adventists and other groups in Maryland. Lack of association with diet. Archives of Internal Medicine, [online] 150(11), pp.2347–2348. Available at: https://pubmed.ncbi.nlm.nih.gov/2241444/ [Accessed 18 Jan. 2024].

Hopwood, C.J., Bleidorn, W., Schwaba, T. and Chen, S. (2020). Health, environmental, and animal rights motives for vegetarian eating. PLOS ONE, [online] 15(4), p.e0230609. doi:https://doi.org/10.1371/journal.pone.0230609.

Horden, P., 2006. How Medicalised Were Byzantine Hospitals? Medicina e Storia, 10, pp. 49–50. Available at: file:///Users/robertjanko/Downloads/17783-Artikeltext-42928-1-10-20141219.pdf [Accessed 24 December 2024].

Horne, B.D., May, H.T., Muhlestein, J.B., Le, V.T., Bair, T.L., Knowlton, K.U. and Anderson, J.L. (2022). Association of periodic fasting with lower severity of COVID-19 outcomes in the SARS-CoV-2 prevaccine era: an observational cohort from the INSPIRE registry. BMJ Nutrition, Prevention & Health, [online] p.e000462. doi:https://doi.org/10.1136/bmjnph-2022-000462.

Hsu, E. (2020). Plant-based diets and bone health: sorting through the evidence. Current Opinion in Endocrinology, Diabetes & Obesity, 27(4), pp.248–252. doi:https://doi.org/10.1097/med.0000000000000552.

Huang, B.-H., Inan-Eroglu, E., Shaban, R.Z., Hamer, M., Britton, A. and Stamatakis, E. (2022). Alcohol intake and mortality risk of COVID-19, pneumonia, and other infectious diseases: An analysis of 437191 UK biobank participants. Preventive Medicine Reports, [online] 26, p.101751. doi:https://doi.org/10.1016/j.pmedr.2022.101751.

Hunt, I.F., Murphy, N.J. and Henderson, C. (1988). Food and nutrient intake of Seventh-day Adventist women. The American Journal of Clinical Nutrition, 48(3), pp.850–851. doi:https://doi.org/10.1093/ajcn/48.3.850.

Iddir, M., Brito, A., Dingeo, G., Fernandez Del Campo, S.S., Samouda, H., La Frano, M.R. and Bohn, T. (2020). Strengthening the Immune System and Reducing Inflammation and Oxidative Stress through Diet and Nutrition: Considerations during the COVID-19 Crisis. Nutrients, 12(6), p.1562. doi:https://doi.org/10.3390/nu12061562.

Iman, M., Sabah, A. H., Hanna, W.Z., Abdel-Latif, S.A. and Balsam E. F., (2023). Evaluation of vitamin A and E deficiency with severity of SARS-COV-2 disease: a case–control study. Egyptian Journal of Bronchology, 17(1). doi:https://doi.org/10.1186/s43168-023-00210-9.

Imdad, A., Herzer, K., Mayo-Wilson, E., Yakoob, M.Y. and Bhutta, Z.A. (2010). Vitamin A supplementation for preventing morbidity and mortality in children from 6 months to 5 years of age. The Cochrane Database of Systematic Reviews, [online] (12), p.CD008524. doi:https://doi.org/10.1002/14651858.CD008524.pub2.

Institute of Medicine (US) Panel on Micronutrients. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. Washington (DC): National Academies Press (US); 2001. 9, Iron. Available from: https://www.ncbi.nlm.nih.gov/books/NBK222309/

Ironson, G., Stuetzle, R. and Fletcher, M.A. (2006). An increase in religiousness/spirituality occurs after HIV diagnosis and predicts slower disease progression over 4 years in people with HIV. Journal of General Internal Medicine, 21(S5), pp.S62–S68. doi:https://doi.org/10.1111/j.1525-1497.2006.00648.x.

Jaceldo-Siegl K., Estevez D;Fraser G.E., Hayes-Bautista D.E., Flores H., Jordan M., Singh P.N., (2019) Plant-based diets in Hispanic/Latino adult Adventists in the United States and their association with body mass index, American journal of health promotion : AJHP. Sage Journals. Available at: https://pubmed.ncbi.nlm.nih.gov/30773023/ (Accessed: January 16, 2023).

Jaceldo-Siegl, K., Knutsen, S.F., Sabaté, J., Beeson, W.L., Chan, J., Herring, R.P., Butler, T.L., Haddad, E., Bennett, H., Montgomery, S., Sharma, S.S., Oda, K. and Fraser, G.E. (2009). Validation of nutrient intake using an FFQ and repeated 24 h recalls in black and white subjects of the Adventist Health Study-2 (AHS-2). Public Health Nutrition, 13(06), pp.812–819. doi:10.1017/s1368980009992072.

Jacksaint Saintila, Calizaya-Milla, Y.E., Brañes-Ruiz, D.E., Nunura-Figueroa, P.R., Chávez-Hernández, T.C., Bautista-Mayuri, V.A., Santisteban-Murga, L.N.R., Calizaya-Milla, S.E. and Baquedano-Santana, L.E. (2022). Relationship Between Dietary Self-Efficacy and Religiosity Among Seventh-Day Adventists in Peru. Journal of multidisciplinary healthcare, [online] Volume 15, pp.259–269. doi:https://doi.org/10.2147/jmdh.s350990.

Jacobs, L. (1957). The Interrelation of Toxoplasmosis in Swine, Cattle, Dogs, and Man. Public Health Reports (1896-1970), 72(10), p.872. doi:https://doi.org/10.2307/4589927.

Jacobson, A., Sivan Spitzer-Shohat, Gorelik, Y. and Edelstein, M. (2023). Barriers and enablers to vaccination in the ultra-orthodox Jewish population: a systematic review. Frontiers in Public Health, 11. doi:https://doi.org/10.3389/fpubh.2023.1244368.

Jafar, A.J.N. (2018). What is positionality and should it be expressed in quantitative studies? Emergency Medicine Journal, [online] 35(5), pp.323–324. doi:https://doi.org/10.1136/emermed-2017-207158.

Jafri A., Mathe, N., Aglago, E.K., Konyole, S., Ouedraogo, M., Audain, K., Zongo, U., Laar, A.K., Johnson, J. and Sanou, D. (2021). Food availability, accessibility, and dietary practices during the COVID-19 pandemic: A multi-country survey. Public Health Nutrition, [online] pp.1–23. doi:https://doi.org/10.1017/S1368980021000987.

Jahrami, H.A., Alsibai, J., Clark, C.C.T. and Faris, M.A.-I.E. (2020). A systematic review, meta-analysis, and meta-regression of the impact of diurnal intermittent fasting during Ramadan on body weight in healthy subjects aged 16 years and above. European Journal of Nutrition. doi:https://doi.org/10.1007/s00394-020-02216-1.

Janz, N.K. and Becker, M.H. (1984). The Health Belief Model: A Decade Later. Health Education Quarterly, [online] 11(1), pp.1–47. doi:https://doi.org/10.1177/109019818401100101.

Jim, H.S.L., Pustejovsky, J.E., Park, C.L., Danhauer, S.C., Sherman, A.C., Fitchett, G., Merluzzi, T.V., Munoz, A.R., George, L., Snyder, M.A. and Salsman, J.M. (2015). Religion, spirituality, and physical health in cancer patients: A meta-analysis. Cancer, [online] 121(21), pp.3760–3768. doi:https://doi.org/10.1002/cncr.29353.

Joinson, A. (1999). Social desirability, anonymity, and internet-based Questionnaires. Behavior Research Methods, Instruments, & Computers, 31(3), pp.433–438. https://doi.org/10.3758/bf03200723

Jokela, M. (2021). Religiosity, psychological distress, and wellbeing: Evaluating familial confounding with multicohort sibling data. American Journal of Epidemiology. doi:https://doi.org/10.1093/aje/kwab276.

Jones, C.J., Smith, H. and Llewellyn, C. (2013). Evaluating the Effectiveness of Health Belief Model Interventions in Improving adherence: a Systematic Review. Health Psychology Review, 8(3), pp.253–269. doi:https://doi.org/10.1080/17437199.2013.802623.

Jones, D.G. (2022). Religious Concerns About COVID-19 Vaccines: From Abortion to Religious Freedom. Journal of Religion and Health. doi:https://doi.org/10.1007/s10943-022-01557-x.

Jussawalla, D.J., Yeole, B.B. and Natekar, M.V. (1985). Cancer incidence in Indian Christians. British journal of cancer, [online] 51(6), pp.883–91. doi:https://doi.org/10.1038/bjc.1985.134.

Kahleova, H. and Barnard, N.D. (2022). The Role of Nutrition in COVID-19: Taking a Lesson from the 1918 H1N1 Pandemic. American Journal of Lifestyle Medicine, p.155982762210976. doi:https://doi.org/10.1177/15598276221097621.

Kahleova, H. et al. (2017) Meal frequency and timing are associated with changes in body mass index in Adventist Health Study 2, The Journal of nutrition. American Society for Nutrition. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5572489/?report=reader (Accessed: January 16, 2023).

Kahn, H.A., Phillips, R.L., Snowdon, D.A., and Choi, W. (1984). Association between reported diet and all-cause mortality. American Journal of Epidemiology, 119(5), pp.775–787. DOI: 10.1093/oxfordjournals.aje.a113798.

Kaiser, D. (2019). Adventism, Eight Laws of Health. Springer eBooks, pp.39–42. doi:https://doi.org/10.1007/978-3-319-27078-4_479.

Kasstan, B. (2021). 'If a rabbi did say "you have to vaccinate," we wouldn't': Unveiling the secular logics of religious exemption and opposition to vaccination. Social Science & Medicine, 280, p.114052. doi:https://doi.org/10.1016/j.socscimed.2021.114052.

Katona, P. and Katona-Apte, J. (2008). The Interaction between Nutrition and Infection. Clinical Infectious Diseases, [online] 46(10), pp.1582–1588. doi:https://doi.org/10.1086/587658.

Kaya, M.O., Pamukçu, E. and Yakar, B. (2021). The role of vitamin D deficiency on the Covid-19: A systematic review and meta-analysis of observational studies. Epidemiology and Health, p.e2021074. doi:10.4178/epih.e2021074

Kawachi, I. (2019). Religion as a Social Determinant of Health. American Journal of Epidemiology, 189(12). doi:https://doi.org/10.1093/aje/kwz204.

Kawachi, I. (2019). Religion as a Social Determinant of Health. American Journal of Epidemiology, 189(12). doi:https://doi.org/10.1093/aje/kwz204.

Kelaiditis, C.F., Gibson, E.Leigh. and Dyall, S.C. (2023). Effects of long-chain omega-3 polyunsaturated fatty acids on reducing anxiety and/or depression in adults; A systematic review and meta-analysis of randomised controlled trials. Prostaglandins, Leukotrienes and Essential Fatty Acids, 192, p.102572. doi:https://doi.org/10.1016/j.plefa.2023.102572.

Keni, R., Alexander, A., Nayak, P.G., Mudgal, J. and Nandakumar, K. (2020). COVID-19: Emergence, Spread, Possible Treatments, and Global Burden. Frontiers in Public Health, [online] 8(216). doi:https://doi.org/10.3389/fpubh.2020.00216.

Kent, L.M. and Worsley, A. (2008). Does the prescriptive lifestyle of Seventh-day Adventists provide 'immunity' from the secular effects of changes in BMI?. Public Health Nutrition, 12(04), p.472. doi:https://doi.org/10.1017/s1368980008002334.

Kent, L.M., Morton, D.P., Ward, E.J., Rankin, P.M., Ferret, R.B., Gobble, J. and Diehl, H.A. (2015). The Influence of Religious Affiliation on Participant Responsiveness to the Complete Health Improvement Program (CHIP) Lifestyle Intervention. Journal of Religion and Health, 55(5), pp.1561–1573. doi:https://doi.org/10.1007/s10943-015-0141-3.

Khan, S.U., Lone, A.N., Khan, M.S., Virani, S.S., Blumenthal, R.S., Nasir, K., Miller, M., Michos, E.D., Ballantyne, C.M., Boden, W.E. and Bhatt, D.L. (2021). Effect of omega-3 fatty acids on cardiovascular outcomes: A systematic review and meta-analysis. EClinicalMedicine, [online] 38, p.100997. doi:https://doi.org/10.1016/j.eclinm.2021.100997.

Khasawneh, R.A., Al-Shatnawi, S.F., Alhamad, H. and Kheirallah, K.A. (2022). Perceptions toward the use of over-the-counter dietary supplements during the coronavirus disease 2019 pandemic: A cross sectional study of the general public in Jordan. Health Science Reports, 5(4). doi:https://doi.org/10.1002/hsr2.716.

Khodadadiyan, A., Rahmanian, M., Shekouh, D., Golmohammadi, M., Ghaedi, A., Bazrgar, A., Sayadi, M., Bazrafshan, M., Heydari, A. and Drissi, H.B., 2023. Evaluating the effect of vitamin D supplementation on serum levels of 25-hydroxy vitamin D, 1,25-dihydroxy vitamin D, parathyroid hormone and renin–angiotensin–aldosterone system: a systematic review and meta-analysis of clinical trials. BMC Nutrition, 9(1). [Online] Available at: https://doi.org/10.1186/s40795-023-00786-x

Kibongani Volet, A., Scavone, C., Catalán-Matamoros, D. and Capuano, A. (2022). Vaccine Hesitancy Among Religious Groups: Reasons Underlying This Phenomenon and Communication Strategies to Rebuild Trust. Frontiers in Public Health, [online] 10(10). doi:https://doi.org/10.3389/fpubh.2022.824560.

Kim, E.S. and VanderWeele, T.J. (2018). Mediators of the Association Between Religious Service Attendance and Mortality. American Journal of Epidemiology, 188(1), pp.96–101. doi:https://doi.org/10.1093/aje/kwy211.

Kim, H., Rebholz, C.M., Hegde, S., LaFiura, C., Raghavan, M., Lloyd, J.F., Cheng, S. and Seidelmann, S.B. (2021). Plant-based diets, pescatarian diets and COVID-19 severity: a population-based case–control study in six countries. BMJ Nutrition, Prevention & Health, [online] p.bmjnph. doi:https://doi.org/10.1136/bmjnph-2021-000272.

Kim, Y., Bae, S., Chang, H.-H. and Kim, S.-W. (2023). Long COVID prevalence and impact on quality of life 2 years after acute COVID-19. Scientific Reports, [online] 13(1), p.11207. doi:https://doi.org/10.1038/s41598-023-36995-4.

Knai, C., Pomerleau, J., Lock, K., et al., 2006. Getting children to eat more fruit and vegetables: a systematic review. Preventive Medicine, 42, pp.85–95.

Koenig, H.G. (2000). Religion and Medicine I: Historical Background and Reasons for Separation. The International Journal of Psychiatry in Medicine, 30(4), pp.385–398. doi:https://doi.org/10.2190/2rwb-3ae1-m1e5-tvhk.

Koenig, H.G. (2012). Religion, Spirituality, and Health: The Research and Clinical Implications. ISRN Psychiatry, [online] 2012(278730), pp.1–33. doi:https://doi.org/10.5402/2012/278730.

Koenig, H. G., King, D. E., & Carson, V. B. (2012). Handbook of Religion and Health (2nd ed.). Oxford University Press. ISBN: 978-0-19-533595-8.

Koller, A., Rohrmann, S., Wakolbinger, M., Gojda, J., Selinger, E., Cahova, M., Světnička, M., Haider, S., Schlesinger, S., Kühn, T. and Keller, J.W. (2023). Health aspects of vegan diets among children and adolescents: a systematic review and meta-analyses. Critical Reviews in Food Science and Nutrition, [online] pp.1–12. doi:https://doi.org/10.1080/10408398.2023.2263574.

Kołodziejska, M. (2021). What can the COVID-19 pandemic tell us about the connection between media and religion? The case of the Seventh-Day Adventist Church in Poland. Zeitschrift für Religion, Gesellschaft und Politik, 6(1), pp.27–41. doi:https://doi.org/10.1007/s41682-021-00091-z.

Konstantine Chakhunashvili, Eka Kvirkvelia and Chakhunashvili, D.G. (2024). Religious belongings and Covid-19 vaccination. BMC Public Health, [online] 24(1). doi:https://doi.org/10.1186/s12889-024-20133-4.

Kørup, A.K., Thygesen, L.C., Christensen, R. dePont, Johansen, C., Søndergaard, J. and Hvidt, N.C. (2016). Association between sexually transmitted disease and church membership. A retrospective cohort study of two Danish religious minorities. BMJ Open, [online] 6(3). doi:https://doi.org/10.1136/bmjopen-2015-010128.

Kowalczyk, O., Roszkowski, K., Montane, X., Pawliszak, W., Tylkowski, B. and Bajek, A. (2020). Religion and Faith Perception in a Pandemic of COVID-19. Journal of Religion and Health, 59(6), pp.2671–2677. doi:https://doi.org/10.1007/s10943-020-01088-3.

Kreft, B., Fischer, A., Krüger, S., Sack, K., Kirchner, H. and Rink, L. (2000). Biogerontology, 1(1), pp.61–66. doi:https://doi.org/10.1023/a:1010077622172.

Kwok, C.S., Umar, S., Myint, P.K., Mamas, M.A. and Loke, Y.K. (2014). Vegetarian diet, Seventh Day Adventists and risk of cardiovascular mortality: A systematic review and meta-analysis. International Journal of Cardiology, 176(3), pp.680–686. doi:10.1016/j.ijcard.2014.07.080.

Laestadius, L. I., & Wahl, M. (2018). Health behavior and religious conservatism: A study of attitudes toward vaccination among Seventh-day Adventists. Social Science & Medicine, 211, 135-142.

Lai, J., Ma, S., Wang, Y., Cai, Z., Hu, J., Wei, N., Wu, J., Du, H., Chen, T., Li, R., Tan, H., Kang, L., Yao, L., Huang, M., Wang, H., Wang, G., Liu, Z. and Hu, S. (2020). Factors Associated With Mental Health Outcomes Among Health Care Workers Exposed to Coronavirus Disease 2019. JAMA Network Open, [online] 3(3), pp.e203976–e203976. doi:https://doi.org/10.1001/jamanetworkopen.2020.3976.

Laliotis, I. and Minos, D. (2021). Religion, social interactions, and COVID-19 incidence in Western Germany. European Economic Review, p.103992. doi:https://doi.org/10.1016/j.euroecorev.2021.103992.

Lane, K., Derbyshire, E., Li, W. and Brennan, C. (2013). Bioavailability and Potential Uses of Vegetarian Sources of Omega-3 Fatty Acids: A Review of the Literature. Critical Reviews in Food Science and Nutrition, 54(5), pp.572–579. doi:https://doi.org/10.1080/10408398.2011.596292.

Lane, M., Barrett, E.M., O'Higgins, A., Mullaney, L., Turner, M.J. and McCartney, D. (2013). The relationship between socioeconomic status and nutritional knowledge in women during pregnancy. Proceedings of the Nutrition Society, 72(OCE3). doi:https://doi.org/10.1017/s0029665113001857.

Larsen, T., Bosworth, M.L., Ayoubkhani, D., Schofield, R., Ali, R., Khunti, K., Walker, A.S., Glickman, M., Harrison, C. and Nafilyan, V. (2023). Inequalities in SARS-CoV-2 case rates by ethnicity, religion, measures of socioeconomic position, English proficiency, and self-reported disability: cohort study of 39 million people in England during the alpha and delta waves. BMJ Medicine, 2(1), p.e000187. doi:https://doi.org/10.1136/bmjmed-2022-000187.

Latkin, C.A., Edwards, C., Davey-Rothwell, M.A. and Tobin, K.E. (2017). The relationship between social desirability bias and self-reports of health, substance use, and social network factors among urban substance users in Baltimore, Maryland. Addictive Behaviors, [online] 73, pp.133–136. doi:https://doi.org/10.1016/j.addbeh.2017.05.005.

Leary, P.F., Zamfirova, I., Au, J. and McCracken, W.H. (2017). Effect of Latitude on Vitamin D Levels. The Journal of the American Osteopathic Association, 117(7), p.433. doi:https://doi.org/10.7556/jaoa.2017.089.

Lee, M., Lim, H., Xavier, M.S. and Lee, E.-Y. (2021). 'A Divine Infection': A Systematic Review on the Roles of Religious Communities During the Early Stage of COVID-19. Journal of Religion and Health. doi:https://doi.org/10.1007/s10943-021-01364-w.

Lee, S. and Kim, U.B. (2019). A report of association among faith, lifestyle, and health in the Korean Seventh-Day Adventists. Asia-Africa Journal of Mission and Ministry, 19, pp.15-42. DOI: 10.21806/aamm.2019.19.02.

Lefkowitz, A., Fout, G.S., Losonsky, G., Wasserman, S.S., Israel, E. and Morris Jr., J.G., 1992. A serosurvey of pathogens associated with shellfish: Prevalence of antibodies to Vibrio species and Norwalk virus in the Chesapeake Bay region. American Journal of Epidemiology, 135(4), pp.369-376.

Leibow, M.S., Lee, J.W. and Morton, K.R. (2020). Exercise, Flourishing, and the Positivity Ratio in Seventh-Day Adventists: A Prospective Study. American Journal of Health Promotion, 35(1), pp.48–56. doi:10.1177/0890117120930392.

Lernout, T., Kissling, E., Hutse, V., De Schrijver, K. and Top, G. (2009). An outbreak of measles in orthodox Jewish communities in Antwerp, Belgium, 2007-2008: different reasons for accumulation of susceptibles. Eurosurveillance, 14(2). doi:https://doi.org/10.2807/ese.14.02.19087-en.

Levene H., (1960). Contributions to Probability and Statistics: Essays in Honor of Harold Hotelling. [online] Google Books. Stanford University Press. Available at: https://books.google.hu/books/about/Contributions_to_Probability_and_Statist.html?id=ZUSsAAAAIAAJ&redir_esc=y [Accessed 11 Jun. 2024].

Li, L. and Werler, M.M. (2009). Fruit and vegetable intake and risk of upper respiratory tract infection in pregnant women. Public Health Nutrition, 13(2), pp.276–282. doi:https://doi.org/10.1017/s1368980009990590.

Li, T., Chen, Y., Li, J., Yang, X., Zhang, H., Qin, X., Hu, Y. and Mo, Z. (2015). Serum Homocysteine Concentration Is Significantly Associated with Inflammatory/Immune Factors. PLOS ONE, 10(9), p.e0138099. doi:https://doi.org/10.1371/journal.pone.0138099.

Liao, W.L., Knutsen, S.F. and Beeson, L., 2006. Is there an association between dietary habits and risk of upper respiratory infections? Results from the Adventist Health Study 2. 2006 Congress of Epidemiology Abstracts, S199.

Lindsted, K.D., Tonstad, S. and Kuzma, J.W. (1991) Self-report of physical activity and patterns of mortality in Seventh-day Adventist men, Journal of clinical epidemiology. Elsevier. Available at: https://pubmed.ncbi.nlm.nih.gov/2010779/ (Accessed: January 17, 2023).

Lippi, G., Sanchis-Gomar, F. and Henry, B.M. (2023). COVID-19 and its long-term sequelae: what do we know in 2023? Polish Archives of Internal Medicine. doi:https://doi.org/10.20452/pamw.16402.

Ljajić, A., Prodanović, N., Medvecki, D., Bašaragin, B. and Mitrović, J. (2022). Uncovering the Reasons behind COVID-19 Vaccine Hesitancy in Serbia: Sentiment-Based Topic Modeling (Preprint). Journal of Medical Internet Research. doi:https://doi.org/10.2196/42261.

Locks, L.M., Parekh, A., Newell, K., Dauphinais, M.R., Cintron, C., Maloomian, K., Yu, E.A., Finkelstein, J.L., Mehta, S. and Sinha, P. (2024) 'The ABCDs of nutritional assessment in infectious diseases research', Journal of Infectious Diseases. Advance online publication. doi: 10.1093/infdis/jiae540.

Lodrick, D. O., 1981. Sacred Cows, Sacred Places: Origins and Survivals of Animal Homes in India. Berkeley: University of California Press. Available at: https://archive.org/details/sacredcowssacred0000lodr/mode/2up [Accessed 24 December 2024].

Lőrinc, M., Kilkey, M. and Ryan, L. (2022). 'You Still Want to Go Lots of Places': Exploring Walking Interviews in Research With Older Migrants Get access Arrow. [online] Oup.com. Available at: https://academic.oup.com/gerontologist/article-abstract/62/6/832/6395256?redirectedFrom=fulltext&login=true [Accessed 10 May 2023].

Lu, L.W., Gao, Y., Quek, S.-Y., Foster, M., Eason, C.T., Liu, M., Wang, M., Chen, J.-H. and Chen, F. (2022). The landscape of potential health benefits of carotenoids as natural supportive therapeutics in protecting against Coronavirus infection. Biomedicine & Pharmacotherapy, 154, p.113625. doi:https://doi.org/10.1016/j.biopha.2022.113625.

Lucas, M., Mirzaei, F., O'Reilly, E.J., Pan, A., Willett, W.C., Kawachi, I., Koenen, K. and Ascherio, A. (2011). Dietary intake of n−3 and n−6 fatty acids and the risk of clinical depression in women: a 10-y prospective follow-up study. The American Journal of Clinical Nutrition, [online] 93(6), pp.1337–1343. doi:https://doi.org/10.3945/ajcn.111.011817.

Luo, D., Wan, X., Liu, J. and Tong, T. (2016). Optimally estimating the sample mean from the sample size, median, mid-range, and/or mid-quartile range. Statistical Methods in Medical Research, 27(6), pp.1785–1805. doi:https://doi.org/10.1177/0962280216669183.

Maghzi, H., Ataei, B., Khorvash, F., Yaran, M. and Maghzi, A.-H. (2016). Association Between Acute Infectious Mononucleosis and Vitamin D Deficiency. Viral Immunology, 29(7), pp.398–400. doi:https://doi.org/10.1089/vim.2016.0038.

Malik, V.S., Ravindra, K., Attri, S.V., Bhadada, S.K. and Singh, M. (2020). Higher body mass index is an important risk factor in COVID-19 patients: a systematic review and meta-analysis. Environmental Science and Pollution Research International, [online] pp.1–9. doi:10.1007/s11356-020-10132-4.

Mancuso, P. (2013). Obesity and respiratory infections: Does excess adiposity weigh down host defense? Pulmonary Pharmacology & Therapeutics, 26(4), pp.412–419. doi:https://doi.org/10.1016/j.pupt.2012.04.006.

Martineau, A.R., Wilkinson, R.J., Wilkinson, K.A., Newton, S.M., Kampmann, B., Hall, B.M., Packe, G.E., Davidson, R., Eldridge, S., Maunsell, Z., Rainbow, S., Berry, J.L. and Griffiths, C. (2007). A Single Dose of Vitamin D Enhances Immunity to Mycobacteria. American Journal of Respiratory and Critical Care Medicine, 176(2), pp.208–213. doi:https://doi.org/10.1164/rccm.200701-007oc.

Martineau, A.R., Jolliffe, D.A., Greenberg, L., Aloia, J.F., Bergman, P., Dubnov-Raz, G., Esposito, S., Ganmaa, D., Ginde, A.A., Goodall, E.C., Grant, C.C., Janssens, W., Jensen, M.E., Kerley, C.P., Laaksi, I., Manaseki-Holland, S., Mauger, D., Murdoch, D.R., Neale, R., Meydani, S.N. (1997). Vitamin E Supplementation and In Vivo Immune Response in Healthy Elderly Subjects. JAMA, 277(17), p.1380. doi:https://doi.org/10.1001/jama.1997.03540410058031.

Marmitt, D.J., Goettert, M.I. and Rempel, C. (n.d.). Compounds of plants with activity against SARS-CoV-2 targets. Expert Review of Clinical Pharmacology, [online] pp.1–11. doi:https://doi.org/10.1080/17512433.2021.1903317.

Martínez Steele, E., Baraldi, L.G., Louzada, M.L. da C., Moubarac, J.-C., Mozaffarian, D. and Monteiro, C.A. (2016). Ultra-processed foods and added sugars in the US diet: evidence from a nationally representative cross-sectional study. BMJ Open, [online] 6(3), p.e009892. doi:https://doi.org/10.1136/bmjopen-2015-009892.

Matos, L., Machado, J., Monteiro, F. and Greten, H. (2021). Understanding Traditional Chinese Medicine Therapeutics: an Overview of the Basics and Clinical Applications. Healthcare, [online] 9(3), p.257. doi:https://doi.org/10.3390/healthcare9030257.

McBride, D.C., Bailey, K.G.D., Landless, P.N., Baltazar, A.M., Trim, D.J.B. and Stele, G. (2021). Health Beliefs, Behavior, Spiritual Growth, and Salvation in a Global Population of Seventh-day Adventists. Review of Religious Research. doi:https://doi.org/10.1007/s13644-021-00451-4.

McCullough, M.E., Hoyt, W.T., Larson, D.B., Koenig, H.G. and Thoresen, C. (2000). Religious involvement and mortality: A meta-analytic review. Health Psychology, 19(3), pp.211–222. doi:https://doi.org/10.1037//0278-6133.19.3.211.

McDonough, D.J., Su, X. and Gao, Z. (2021). Health wearable devices for weight and BMI reduction in individuals with overweight/obesity and chronic comorbidities: systematic review and network meta-analysis. British Journal of Sports Medicine, 55(16), pp.917–925. doi:10.1136/bjsports-2020-103594.

McGavock, J., Chauhan, B.F., Rabbani, R., Dias, S., Klaprat, N., Boissoneault, S., Lys, J., Wierzbowski, A.K., Sakib, M.N., Zarychanski, R. and Abou-Setta, A.M. (2020). Layperson-Led vs Professional-Led Behavioral Interventions for Weight Loss in Pediatric Obesity. JAMA Network Open, 3(7), p.e2010364. doi:https://doi.org/10.1001/jamanetworkopen.2020.10364.

McKenna, K.C. (2018). Use of Aborted Fetal Tissue in Vaccines and Medical Research Obscures the Value of All Human Life. The Linacre Quarterly, [online] 85(1), pp.13–17. doi:https://doi.org/10.1177/0024363918761715.

McNair, P. and Lewis, G. (2012). Levels of evidence in medicine. International journal of sports physical therapy, [online] 7(5), pp.474–81. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3474306/.

Melina, V., Craig, W. and Levin, S. (2016). Position of the Academy of Nutrition and Dietetics: Vegetarian Diets. Journal of the Academy of Nutrition and Dietetics, [online] 116(12), pp.1970–1980. doi:https://doi.org/10.1016/j.jand.2016.09.025.

Melton, J. G., 2011. Religions of the World: A Comprehensive Encyclopedia of Beliefs and Practices. Santa Barbara: ABC-CLIO. Available at: https://www.bethanyipcmm.org/wp-content/uploads/2020/10/Religions-of-the-World.pdf [Accessed 24 December 2024].

Memish, Z.A., Ahmed, Y., Alqahtani, S.A. and Ebrahim, S.H. (2020). Pausing superspreader events for COVID-19 mitigation: International Hajj pilgrimage cancellation. Travel Medicine and Infectious Disease, 36, p.101817. doi:https://doi.org/10.1016/j.tmaid.2020.101817.

Merino, J., Joshi, A.D., Nguyen, L.H., Leeming, E.R., Mazidi, M., Drew, D.A., Gibson, R., Graham, M.S., Lo, C.-H., Capdevila, J., Murray, B., Hu, C., Selvachandran, S., Hammers, A., Bhupathiraju, S.N., Sharma, S.V., Sudre, C., Astley, C.M., Chavarro, J.E. and Kwon, S. (2021). Diet quality and risk and severity of COVID-19: a prospective cohort study. Gut, [online] 70(11), pp.2096–2104. doi:https://doi.org/10.1136/gutjnl-2021-325353.

Miao, Y., Zhang, W., Li, Y., Wu, J., Xu, D., Gu, J., Wang, M., Wei, W., Ye, B., Miao, C., Clifford Silver Tarimo and Dong, W. (2022). Association between lifestyle and COVID-19 vaccination: A national cross-sectional study. [online] 10. doi:https://doi.org/10.3389/fpubh.2022.918743.

Michalsen, A. and Li, C. (2013) Fasting therapy for treating and preventing disease - current state of evidence, Forschende Komplementarmedizin (2006). U.S. National Library of Medicine. Available at: https://pubmed.ncbi.nlm.nih.gov/24434759/ (Accessed: January 16, 2023).

Michie, S., van Stralen, M.M. and West, R. (2011). The Behaviour Change wheel: a New Method for Characterising and Designing Behaviour Change Interventions. Implementation Science, [online] 6(42). doi:https://doi.org/10.1186/1748-5908-6-42.

Miles, F.L., Lloren, J.I.C., Haddad, E., Jaceldo-Siegl, K., Knutsen, S., Sabate, J. and Fraser, G.E. (2019). Plasma, Urine, and Adipose Tissue Biomarkers of Dietary Intake Differ Between Vegetarian and Non-Vegetarian Diet Groups in the Adventist Health Study-2. The Journal of Nutrition, 149(4), pp.667–675. doi:https://doi.org/10.1093/jn/nxy292.

Milligan, R., Paul, M., Richardson, M. and Neuberger, A. (2018) 'Vaccines for preventing typhoid fever', Cochrane Infectious Diseases Group. Available at: https://pubmed.ncbi.nlm.nih.gov/29851031/

Milman, N.T. (2020). A Review of Nutrients and Compounds, Which Promote or Inhibit Intestinal Iron Absorption: Making a Platform for Dietary Measures That Can Reduce Iron Uptake in Patients with Genetic Haemochromatosis. Journal of Nutrition and Metabolism, 2020, pp.1–15. doi:https://doi.org/10.1155/2020/7373498.

Mishra, P., Pandey, C.M., Singh, U., Sahu, C., Keshri, A. and Gupta, A. (2019). Descriptive Statistics and Normality Tests for Statistical Data. Annals of Cardiac Anaesthesia, 22(1), pp.67–72. doi:https://doi.org/10.4103%2Faca.ACA_157_18.

Modesti, P.A., Reboldi, G., Cappuccio, F.P., Agyemang, C., Remuzzi, G., Rapi, S., Perruolo, E. and Parati, G. (2016). Panethnic Differences in Blood Pressure in Europe: A Systematic Review and Meta-Analysis. PLOS ONE, 11(1), p.e0147601. doi:https://doi.org/10.1371/journal.pone.0147601.

Montazersaheb, S., Hosseiniyan Khatibi, S.M., Hejazi, M.S., Tarhriz, V., Farjami, A., Ghasemian Sorbeni, F., Farahzadi, R. and Ghasemnejad, T. (2022). COVID-19 infection: an overview on cytokine storm and related interventions. Virology Journal, [online] 19(1). doi:https://doi.org/10.1186/s12985-022-01814-1.

Morais, A.H. de A., Aquino, J. de S., Silva-Maia, J.K. da, Vale, S.H. de L., Maciel, B.L.L. and Passos, T.S. (2020). Nutritional status, diet and viral respiratory infections: perspectives for severe acute respiratory syndrome coronavirus 2. British Journal of Nutrition, pp.1–12. https://doi.org/10.1017/S0007114520003311

Moskala, J. (2011) 'The Validity of the Levitical Food Laws of Clean and Unclean Animals: A Case Study of Biblical Hermeneutics', Journal of the Adventist Theological Society, 22(2), pp. 3–31.

Mukattash, T.L., Alkhalidy, H., Alzu'bi, B., Abu-Farha, R., Itani, R., Karout, S., Khojah, H.M.J., Khdour, M., El-Dahiyat, F. and Jarab, A. (2022). Dietary supplements intake during the second wave of COVID-19 pandemic: A multinational Middle Eastern study. European Journal of Integrative Medicine, [online] 49, p.102102. doi:https://doi.org/10.1016/j.eujim.2022.102102.

Mulligan, A.A., Kuhnle, G.G., Lentjes, M.A., van Scheltinga, V., Powell, N.A., McTaggart, A., Bhaniani, A. and Khaw, K.-T. (2012). Intakes and sources of isoflavones, lignans, enterolignans, coumestrol and soya-containing foods in the Norfolk arm of the European Prospective Investigation into Cancer and Nutrition (EPIC-Norfolk), from 7 d food diaries, using a newly updated database. Public Health Nutrition, 16(8), pp.1454–1462. doi:https://doi.org/10.1017/s1368980012003904.

Muravsky, N.L., Betesh, G.M. and McCoy, R.G. (2021). Religious Doctrine and Attitudes Toward Vaccination in Jewish Law. Journal of Religion and Health, [online] 62(1), pp.1–16. doi:https://doi.org/10.1007/s10943-021-01447-8.

Mytton O., Watson J., Whiting P., 2021. The ‘false positive paradox’ and risks of testing asymptomatics. www.bmj.com. [online] Available at: https://www.bmj.com/content/373/bmj.n1411/rr.

Naghshi, S., Aune, D., Beyene, J., Mobarak, S., Asadi, M. and Sadeghi, O. (2021). Dietary intake and biomarkers of alpha linolenic acid and risk of all cause, cardiovascular, and cancer mortality: systematic review and dose-response meta-analysis of cohort studies. BMJ, p.n2213. doi:https://doi.org/10.1136/bmj.n2213.

Nanna SC. et al. (2015) Risk for cardiovascular disease among Seventh-day Adventists and Baptists in Denmark, 1977-2009, International journal of cardiology. U.S. National Library of Medicine. Available at: https://pubmed.ncbi.nlm.nih.gov/25791113/ (Accessed: January 15, 2023).

National Institute for Health and Care Excellence. NICE 2. https://www.nice.org.uk/guidance/GID-NG10176/documents/draft-guideline. Accessed year 2023.

National Institutes of Health (2017). Office of Dietary Supplements - Vitamin B12. [online] Available at: https://ods.od.nih.gov/factsheets/VitaminB%E2%82%81%E2%82%82-HealthProfessional/#h7 [Accessed 3 Apr. 2024].

National Institutes of Health (2022). Office of Dietary Supplements - Vitamin B12. [online] Nih.gov. Available at: https://ods.od.nih.gov/factsheets/VitaminB12-HealthProfessional/.

National Institutes of Health (2022). Office of Dietary Supplements - Calcium. [online] Nih.gov. Available at: https://ods.od.nih.gov/factsheets/Calcium-HealthProfessional/.

National Institute for Health and Care Excellence (NICE), 2014. Behaviour change: individual approaches. [online] Available at: https://www.nice.org.uk/guidance/ph49

Neupane, B., Walter, S.D., Krueger, P., Marrie, T. and Loeb, M. (2010). Predictors of inhospital mortality and re-hospitalization in older adults with community-acquired pneumonia: a prospective cohort study. BMC Geriatrics, 10(1). doi:https://doi.org/10.1186/1471-2318-10-22.

NHS Choices (2020). B vitamins and folic acid - Vitamins and minerals. [online] Nhs. Available at: https://www.nhs.uk/conditions/vitamins-and-minerals/vitamin-b/.

NHS West Essex CCG Medicine's Optimisation Team (n.d.). Vitamin D supplementation during COVID-19. [online] https://westessexccg.nhs.uk/. Available at: https://westessexccg.nhs.uk/your-health/medicines-optimisation-and-pharmacy/clinical-guidelines-and-prescribing-formularies/00-covid-19/3425-vitamin-d-supplementation-during-covid-19/file [Accessed 17 Jan. 2023].

Negin Gholampoor, Amir Hossien Sharif and Mellor, D. (2024). The Effect of Observing Religious or Faith-based Fasting on Cardiovascular Disease Risk Factors: A Systematic Review and Meta-analysis. NMCD. Nutrition Metabolism and Cardiovascular Diseases, 34(5), pp.1097–1109. doi:https://doi.org/10.1016/j.numecd.2024.02.002.

Neufingerl, N. and Eilander, A. (2022). Nutrient Intake and Status in Adults Consuming Plant-Based Diets Compared to Meat-Eaters: A Systematic Review. Nutrients, [online] 14(1), p.29. doi:https://doi.org/10.3390/nu14010029.

Nimblett-Clarke, A. (2021). The role of vaccine exemptions in the resurgence of measles. Journal of the American Academy of Physician Assistants, 34(2), pp.36–40. doi:https://doi.org/10.1097/01.jaa.0000731512.09853.af.

Niklewicz, A., Hannibal, L., Warren, M. and Ahmadi, K.R. (2024). A systematic review and meta-analysis of functional vitamin B12 status among adult vegans. Nutrition Bulletin. doi:https://doi.org/10.1111/nbu.12712.

Niklewicz, A., Smith, A.D., Smith, A., Holzer, A., Klein, A., McCaddon, A., Molloy, A.M., Wolffenbuttel, B.H.R., Nexo, E., McNulty, H., Refsum, H., Gueant, J.-L., Dib, M.-J., Ward, M., Murphy, M., Green, R., Ahmadi, K.R., Hannibal, L., Warren, M.J. and Owen, P.J.

(2022). The importance of vitamin B12 for individuals choosing plant-based diets. European Journal of Nutrition, [online] 62(3). doi:https://doi.org/10.1007/s00394-022-03025-4.

Nieman, D.C., Underwood, B.C., Sherman, K.M., Arabatzis, K., Barbosa, J.C., Johnson, M. and Shultz, T.D. (1989). Dietary status of Seventh-Day Adventist vegetarian and non-vegetarian elderly women. Journal of the American Dietetic Association, [online] 89(12), pp.1763–1769. Available at: https://pubmed.ncbi.nlm.nih.gov/2592707/.

Nih.gov. (2025). Office of Dietary Supplements - Dietary Supplements for Immune Function and Infectious Diseases. [online] Available at: https://ods.od.nih.gov/factsheets/ImmuneFunction-HealthProfessional/#en128 [Accessed 19 Jan. 2025].

Nikniaz, L., Akbarzadeh, M.A., Hosseinifard, H. and Hosseini, M.-S. (2021). The impact of vitamin D supplementation on mortality rate and clinical outcomes of COVID-19 patients: A systematic review and meta-analysis. Pharmaceutical Sciences. doi:10.34172/ps.2021.13.

Noar, S.M., Benac, C.N. and Harris, M.S. (2007). Does tailoring matter? Meta-analytic review of tailored print health behavior change interventions. Psychological Bulletin, 133(4), pp.673–693. doi:https://doi.org/10.1037/0033-2909.133.4.673.

Noor H., Ang Y., Yap L.C., F., Nurul, W., Cheah, W.L., Ruzita, A.T., Jumuddin, F.A., Koh, D., Lee, J.A.C., Essau, C.A., Reeves, S., Summerbell, C., Leigh Gibson, E. and Poh, B.K. (2019). Validity and Reliability of a Food Frequency Questionnaire (FFQ) to Assess Dietary Intake of Preschool Children. International Journal of Environmental Research and Public Health, [online] 16(23), p.4722. doi:10.3390/ijerph16234722.

Nucci, D., Fatigoni, C., Amerio, A., Odone, A. and Gianfredi, V. (2020). Red and Processed Meat Consumption and Risk of Depression: A Systematic Review and Meta-Analysis. International Journal of Environmental Research and Public Health, 17(18), p.6686. doi:10.3390/ijerph17186686.

Nuffield Council on Bioethics (2007) Public health: ethical issues. London: Nuffield Council on Bioethics. Available at: https://cdn.nuffieldbioethics.org/wp-content/uploads/Public-health-ethical-issues.pdf

Odoms-Young, A., Brown, A., Agurs-Collins, T. and Karen Glanz RDN (2023). Food Insecurity, Neighborhood Food Environment, and Health Disparities: State of the Science, Research Gaps and Opportunities. The American Journal of Clinical Nutrition, [online] 119(3). doi:https://doi.org/10.1016/j.ajcnut.2023.12.019.

Obersby, D., Chappell, D.C., Dunnett, A. and Tsiami, A.A. (2013). Plasma total homocysteine status of vegetarians compared with omnivores: a systematic review and meta-analysis. British Journal of Nutrition, 109(5), pp.785–794. doi:https://doi.org/10.1017/s000711451200520x.

Oduwole, E.O., Esterhuizen, T.M., Mahomed, H. and Wiysonge, C.S. (2021). Estimating Vaccine Confidence Levels among Healthcare Staff and Students of a Tertiary Institution in South Africa. Vaccines, 9(11), p.1246. doi:https://doi.org/10.3390/vaccines9111246.

Oliveira, E.R.A., Cade, N.V., Velten, A.P.C., Silva, G.A. e and Faerstein, E. (2016). Estudo comparativo da mortalidade cardiovascular e por neoplasia de Adventistas e Não Adventistas do Estado do Espírito Santo, no período de 2003 a 2009. Revista Brasileira de Epidemiologia, 19(1), pp.112–121. doi:https://doi.org/10.1590/1980-5497201600010010.

Olowu, D. (2015). Responses to the global HIV and AIDS pandemic: a study of the role of faith-based organisations in Lesotho. SAHARA-J: Journal of Social Aspects of HIV/AIDS, 12(1), pp.76–86. doi:https://doi.org/10.1080/17290376.2015.1124802.

Oman, D. and Thoresen, C.E., 2002. Does religion cause health? Differing interpretations and diverse meanings. Journal of Health Psychology, 7(4), pp.365-380. https://doi.org/10.1177/1359105302007004326.

Orlich, M. J., & Fraser, G. E. (2014). 'Vegetarian diets in the Adventist Health Study 2: a review of initial published findings', The American Journal of Clinical Nutrition, 100(suppl), 353S–8S.

Orlich, M.J., Singh, P.N., Sabaté, J., Jaceldo-Siegl, K., Fan, J., Knutsen, S., Beeson, W.L. and Fraser, G.E. (2013). Vegetarian Dietary Patterns and Mortality in Adventist Health Study 2. JAMA Internal Medicine, [online] 173(13), p.1230. doi:https://doi.org/10.1001/jamainternmed.2013.6473.

Paleiron, N., Mayet, A., Marbac, V., Perisse, A., Barazzutti, H., Brocq, F.-X., Janvier, F., Dautzenberg, B. and Bylicki, O. (2021). Impact of Tobacco Smoking on the Risk of COVID-19: A Large Scale Retrospective Cohort Study. Nicotine & Tobacco Research, [online] p.ntab004. doi:https://doi.org/10.1093/ntr/ntab004.

Pan, S.-Y., Litscher, G., Gao, S.-H., Zhou, S.-F., Yu, Z.-L., Chen, H.-Q., Zhang, S.-F., Tang, M.-K., Sun, J.-N. and Ko, K.-M. (2014). Historical Perspective of Traditional Indigenous Medical Practices: The Current Renaissance and Conservation of Herbal Resources. Evidence-Based Complementary and Alternative Medicine, [online] 2014(525340), pp.1–20. doi:https://doi.org/10.1155/2014/525340.

Paoli, A., Tinsley, G. and Bianco, A. (2019) The influence of meal frequency and timing on health in humans: The role of fasting, Nutrients. MDPI. Available at: https://pubmed.ncbi.nlm.nih.gov/30925707/ (Accessed: January 16, 2023).

Papadaki, A., Coy, E.M., Anastasilakis, D.A., Peradze, N. and Mantzoros, C.S. (2024). The role of plant-based dietary patterns in reducing COVID-19 risk and/or severity in adults: A systematic review and meta-analysis of observational studies. Clinical Nutrition, 43(7), pp.1657–1666. https://doi.org/10.1016/j.clnu.2024.05.033

Pargament, K., Feuille, M. and Burdzy, D. (2011). The Brief RCOPE: Current Psychometric Status of a Short Measure of Religious Coping. Religions, 2(1), pp.51–76. doi:https://doi.org/10.3390/rel2010051.

Parwati, N.M., Bakta, I.M., Januraga, P.P. and Wirawan, I.M.A. (2021). A Health Belief Model-Based Motivational Interviewing for Medication Adherence and Treatment Success in Pulmonary Tuberculosis Patients. International Journal of Environmental Research and Public Health, [online] 18(24), p.13238. doi:https://doi.org/10.3390/ijerph182413238.

Pawlak R., Parrot Sj., Raj S., Cullum-Dugan D., and Lucus D., (2013). How prevalent is vitamin B(12) deficiency among vegetarians? [online] Nutrition reviews. Available at: https://pubmed.ncbi.nlm.nih.gov/23356638/.

Phillips, A. (2019). Effective Approaches to Health Promotion in Nursing Practice. Nursing Standard, 34(4), pp.43–50. doi:https://doi.org/10.7748/ns.2019.e11312.

Phillips, L.A. and More, K.R. (2022). Evaluating behavior change factors over time for a simple vs. complex health behavior. Frontiers in Psychology, 13. doi:https://doi.org/10.3389/fpsyg.2022.962150.

Phillips, R.L. and Snowdon, D.A. (1983). Association of meat and coffee use with cancers of the large bowel, breast, and prostate among Seventh-Day Adventists: preliminary results. Cancer Research, [online] 43(5 Suppl), pp.2403s2408s. Available at: https://pubmed.ncbi.nlm.nih.gov/6831464/ [Accessed 1 Apr. 2024].

Phillips, R.L., Garfinkel, L., Kuzma, J.W., Beeson, W.L., Lotz, T. and Brin, B. (1980). Mortality among California Seventh-Day Adventists for selected cancer sites. Journal of the National Cancer Institute, [online] 65(5), pp.1097–1107. Available at: https://pubmed.ncbi.nlm.nih.gov/6933241/ [Accessed 31 Mar. 2024].

Phillips, R.L., Lemon, F.R., Beeson, W.L. and Kuzma, J.W. (1978). Coronary heart disease mortality among Seventh-Day Adventists with differing dietary habits: a preliminary report. The American Journal of Clinical Nutrition, 31(10), pp.S191–S198. doi:https://doi.org/10.1093/ajcn/31.10.s191.

Phillips, R.L., Kuzma, J.W., Beeson, W.L., and Lotz, T. (1980). Influence of selection versus lifestyle on risk of fatal cancer and cardiovascular disease among Seventh-Day Adventists.

American Journal of Epidemiology, 112(2), pp.296–314. DOI: 10.1093/oxfordjournals.aje.a112996.

Porter, R., 1999. The Greatest Benefit to Mankind: A Medical History of Humanity. London: HarperCollins. Available at: https://storage.googleapis.com/global-help-publications/books/help_greatestbenefittomankind.pdf [Accessed 24 December 2024].

Pritchard, J. B., 1969. Ancient Near Eastern Texts Relating to the Old Testament. 3rd ed. with Supplement. Princeton, NJ: Princeton University Press. Available at: https://www.tarsus.ie/resources/Wisdom-Lit.-/ANET-PDF.pdf [Accessed 24 December 2024].

Public Health England (2019) PHE Infectious Diseases Strategy 2020-2025: Addressing urgent threats in the 21st century. London: Public Health England. Available at:https://assets.publishing.service.gov.uk/media/5d7a599aed915d522b9ac659/PHE_Infectious_Diseases_Strategy_2020-2025.pdf

Rajan, S., McKee, M., Hernández-Quevedo, C., Karanikolos, M., Richardson, E., Webb, E. and Cylus, J. (2022). What have European countries done to prevent the spread of COVID-19? Lessons from the COVID-19 Health system response monitor. Health Policy, 126(5). doi:https://doi.org/10.1016/j.healthpol.2022.03.005.

Rajaram, S. (2014). Health benefits of plant-derived α-linolenic acid. The American Journal of Clinical Nutrition, 100(suppl_1), pp.443S448S. doi:https://doi.org/10.3945/ajcn.113.071514.

Rawat, D., Roy, A., Maitra, S., Gulati, A., Khanna, P. and Baidya, D.K. (2021). Vitamin C and COVID-19 treatment: A systematic review and meta-analysis of randomized controlled trials. Diabetes & Metabolic Syndrome: Clinical Research & Reviews, 15(6), p.102324. https://doi.org/10.1016/j.dsx.2021.102324

Reddy, B.S., Sharma, C., Darby, L., Laakso, K. and Wynder, E.L. (1980). Metabolic epidemiology of large bowel cancer Fecal mutagens in high- and low-risk population for colon cancer A preliminary report. Mutation Research/Fundamental and Molecular Mechanisms of Mutagenesis, 72(3), pp.511–522. doi:https://doi.org/10.1016/0027-5107(80)90122-0.

Reed, D. (2005). Challenges in Systematic Reviews of Educational Intervention Studies. Annals of Internal Medicine, 142(12_Part_2), p.1080. doi:https://doi.org/10.7326/0003-4819-142-12_part_2-200506211-00008.

Rees, J.R., Simpson, S., Stelmach, I., Kumar, G.T., Urashima, M., Camargo, C.A. and Griffiths, C.J., 2019. Vitamin D supplementation to prevent acute respiratory infections: individual participant data meta-analysis. Health Technology Assessment, 23(2), pp.1-44. DOI: 10.3310/hta23020.

Reno, R.R. (2019). The Healing Ministry of Christ. The Linacre Quarterly, 87(1), pp.97–100. doi:https://doi.org/10.1177/0024363919891309.

Riedel, S.I. and Trecartin, S. (2024). The COVID-19 Crisis, Religiosity and Spirituality Among Seventh-Day Adventist Older Adults. Journal of gerontological social work, [online] 67(4), pp.426–443. doi:https://doi.org/10.1080/01634372.2024.2338062.

Riva, M.A. and Cesana, G. (2013). The charity and the care: the origin and the evolution of hospitals. European Journal of Internal Medicine, 24(1), pp.1–4. doi:https://doi.org/10.1016/j.ejim.2012.11.002.

Rizzo, N.S., Jaceldo-Siegl, K., Sabate, J. and Fraser, G.E. (2013). Nutrient profiles of vegetarian and nonvegetarian dietary patterns. Journal of the Academy of Nutrition and Dietetics, [online] 113(12), pp.1610–9. doi:https://doi.org/10.1016/j.jand.2013.06.349.

Roghmann, M.C., Faulkner, C.T., Lefkowitz, A., Patton, S. and Zimmerman, J., 1999. Decreased seroprevalence for Toxoplasma gondii in Seventh Day Adventists in Maryland. American Journal of Tropical Medicine and Hygiene, 60(5), pp.790-792.

Rothman K., Greenland S., Encyclopedia of Biostatistics, Online © 2005 John Wiley & Sons, Ltd. This article is © 2005 John Wiley & Sons, Ltd. This article was published in the Encyclopedia of Biostatistics in 2005 by John Wiley & Sons, Ltd. DOI: 10.1002/0470011815.b2a03072
https://www.rtihs.org/sites/default/files/26902%20Rothman%201998%20The%20encyclopedia%20of%20biostatistics.pdf

Rouse, I.L., Armstrong, B.K. and Beilin, L.J. (1983). The relationship of blood pressure to diet and lifestyle in two religious populations. Journal of Hypertension, [online] 1(1), pp.65–71. Available at: https://pubmed.ncbi.nlm.nih.gov/6681026/ [Accessed 7 Apr. 2024].

Sahih Muslim, Book 2, Hadith 432. Available at: https://hadithcollection.com/sahihmuslim/sahih-muslim-book-02-purification/sahih-muslim-book-002-hadith-number-0432 [Accessed 27 December 2024].

Sakpal, T.V. (2010). Sample size estimation in clinical trial. Perspectives in clinical research, [online] 1(2), pp.67–9. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3148614/.

Sallis, J.F., Deepti Adlakha, Oyeyemi, A.L. and Salvo, D. (2023). Public health research on physical activity and COVID-19: Progress and updated priorities. Journal of Sport and Health Science, 12(5), pp.553–556. doi:https://doi.org/10.1016/j.jshs.2023.04.002.

Salmon, D.A., Schuh, H.B., Sargent, R.H., Konja, A., Harvey, S.A., Laurie, S., Mai, B.S., Weakland, L.F., Lavery, J.V., Orenstein, W.A. and Breiman, R.F. (2022). Impact of vaccine pause due to Thrombosis with thrombocytopenia syndrome (TTS) following vaccination with the Ad26.COV2.S vaccine manufactured by Janssen/Johnson & Johnson on vaccine hesitancy and acceptance among the unvaccinated population. PLOS ONE, 17(10), p.e0274443. doi:https://doi.org/10.1371/journal.pone.0274443.

Samori, Z., Ishak, A.H. and Kassan, N.H. (2014). Understanding the Development of Halal Food Standard: Suggestion for Future Research. International Journal of Social Science and Humanity, [online] 4(6), pp.482–486. doi:https://doi.org/10.7763/ijssh.2014.v4.403.

Santenna Chenchula, Kota Vidyasagar, Pathan, S., Sharma, S., Madhav Rao Chavan, Akshaya Srikanth Bhagavathula, R. Padmavathi, M. Manjula, Chhabra, M., Gupta, R., Krishna Chaitanya Amerneni, Mohan Krishna Ghanta and Mudda, S. (2023). Global prevalence and effect of comorbidities and smoking status on severity and mortality of COVID-19 in association with age and gender: a systematic review, meta-analysis and meta-regression. 13(1). doi:https://doi.org/10.1038/s41598-023-33314-9.

Santibañez, S., Lynch, J., Paye, Y.P., McCalla, H., Gaines, J., Konkel, K., Torres, L.J.O., North, W.A., Likos, A. and Daniel, K.L. (2017). Engaging Community and Faith-Based Organizations in the Zika Response, United States, 2016. Public Health Reports, 132(4), pp.436–442. doi:https://doi.org/10.1177/0033354917710212.

Saraff, V. and Shaw, N. (2015). Sunshine and vitamin D. Archives of Disease in Childhood, 101(2), pp.190–192. doi:https://doi.org/10.1136/archdischild-2014-307214.

Sasaki, S., Sullivan, M., Narvaez, C.F., Holmes, T.H., Furman, D., Zheng, N.-Y., Nishtala, M., Wrammert, J., Smith, K., James, J.A., Dekker, C.L., Davis, M.M., Wilson, P.C., Greenberg, H.B. and He, X.-S. (2011). Limited efficacy of inactivated influenza vaccine in elderly individuals is associated with decreased production of vaccine-specific antibodies. The Journal of Clinical Investigation, [online] 121(8), pp.3109–3119. doi:https://doi.org/10.1172/JCI57834.

Schwarzer, R. (1992) 'Self-efficacy in the adoption and maintenance of health behaviours: Theoretical approaches and a new model', in Schwarzer, R. (ed.) Self-Efficacy: Thought Control of Action. Washington: Taylor and Francis, pp. 217–243.

SDA Church. (2016). Health Ministries Leader and Assistants - SDA Church. [online] Available at: https://www.sdachurch.com/about/our-approach/job-descriptions/health-ministries/

Secker-Walker, R.H., Gnich, W., Platt, S., et al., 2002. Community interventions for reducing smoking among adults. Cochrane Database of Systematic Reviews, Issue 2. Available at: http://www.mrw.interscience.wiley.com/cochrane/clsysrev/articles/CD001745/frame.html

Segovia-Siapco, G. and Sabaté, J. (2018). Health and sustainability outcomes of vegetarian dietary patterns: a revisit of the EPIC-Oxford and the Adventist Health Study-2 cohorts. European Journal of Clinical Nutrition, [online] 72(1). doi:https://doi.org/10.1038/s41430-018-0310-z.

Semmens, J., Rouse, I., Beilin, L.J. and Masarei, J.R.L. (1983). Relationship of plasma HDL-Cholesterol to testosterone, estradiol, and sex-hormone-binding globulin levels in men and women. Metabolism, 32(5), pp.428–432. doi:https://doi.org/10.1016/0026-0495(83)90002-1.

Serret-Montoya, J., Rodríguez-Ibarra, S.N., Nava-Sánchez, K.D. and Zurita-Cruz, J.N. (2023). Impact of an educational intervention on the knowledge of testicular self-examination and attitudes toward it. Anales de Pediatría (English Edition), [online] 98(1), pp.19–27. doi:https://doi.org/10.1016/j.anpede.2022.11.001.

Shah, K., Sharma, U. and Mavalankar, D. (2022). Does vitamin D supplementation reduce COVID-19 severity?: a systematic review. [online] Oup.com. Available at: https://academic.oup.com/qjmed/article/115/10/665/6528876 [Accessed 17 Jan. 2023].

Sharma, S., Di Castelnuovo, A., Cerletti, C., Donati, M.B., de Gaetano, G., Iacoviello, L. and Bonaccio, M. (2023). Diet Quality and Risk of SARS-CoV-2 Infection or COVID-19: A Systematic Review of Observational Studies. Advances in Nutrition (Bethesda, Md.), [online] 14(6), pp.1596–1616. doi:https://doi.org/10.1016/j.advnut.2023.09.006.

Shiba, K., Cowden, R.G., Gonzalez, N., Ransome, Y., Nakagomi, A., Chen, Y., Lee, M.T., VanderWeele, T.J. and Fancourt, D. (2022). Associations of online religious participation during COVID-19 lockdown with subsequent health and well-being among UK adults. Psychological Medicine, pp.1–10. doi:https://doi.org/10.1017/s0033291722000551.

Shultz, T. (2015). Does Prayer Reduce Anxiety? A Review of Treatment-Related Studies. Journal of Spirituality in Mental Health, 17(1), 3-19. https://doi.org/10.1080/19349637.2014.937803

Shultz, T.D. and Leklem, J.E. (1982). Nutrient intake and hormonal status of premenopausal vegetarian seventh-day adventists and premenopausal nonvegetarians. Nutrition and Cancer, 4(4), pp.247–259. doi:https://doi.org/10.1080/01635588209513765.

Shultz, T. D. & Leklem, J. E. (1983) 'Selenium status of vegetarians, nonvegetarians, and hormone-dependent cancer subjects', The American Journal of Clinical Nutrition, 37(1), pp. 114-118.

Shultz, T.D. and Leklem, J.E. (1987). Vitamin B-6 status and bioavailability in vegetarian women. The American Journal of Clinical Nutrition, 46(4), pp.647–651. doi:https://doi.org/10.1093/ajcn/46.4.647.

Sibanda, B. and Haryanto, B. (2024). Assessing the Impact of COVID-19 Vaccination Programs on the Reduction of COVID-19 Cases: A Systematic Literature Review. Annals of Global Health, 90(1). doi:https://doi.org/10.5334/aogh.4484.

Sinopoli, A., Sciurti, A., Isonne, C., Santoro, M.M. and Baccolini, V. (2024). The Efficacy of Multivitamin, Vitamin A, Vitamin B, Vitamin C, and Vitamin D Supplements in the Prevention and Management of COVID-19 and Long-COVID: An Updated Systematic Review and Meta-Analysis of Randomized Clinical Trials. Nutrients, [online] 16(9), p.1345. doi:https://doi.org/10.3390/nu16091345.

Sisti, L.G., Buonsenso, D., Moscato, U., Costanzo, G. and Malorni, W. (2023). The Role of Religions in the COVID-19 Pandemic: A Narrative Review. International Journal of Environmental Research and Public Health, [online] 20(3), p.1691. doi:https://doi.org/10.3390/ijerph20031691.

Slociak E., Bartnikowska E., (2008) Dietary assessment of males from Seventh-day Adventist Church in Warsaw, Roczniki Panstwowego Zakladu Higieny. PZH. Available at: https://pubmed.ncbi.nlm.nih.gov/19143434/ (Accessed: January 15, 2023).

Smith, T.J. and McClung, J.P. (2021). Nutrition, Immune Function, and Infectious Disease. Medical Journal (Fort Sam Houston, Tex.), [online] (PB 8-21-01/02/03), pp.133–136. Available at: https://pubmed.ncbi.nlm.nih.gov/33666926/#:~:text=Consuming%20a%20diet%20meeting%20energy [Accessed 14 Nov. 2023].

Song, J.W. and Chung, K.C. (2010). Observational Studies: Cohort and Case-Control Studies. Plastic and Reconstructive Surgery, [online] 126(6), pp.2234–2242. doi:https://doi.org/10.1097/PRS.0b013e3181f44abc.

Staetsky, L.D. (2021). Elevated Jewish Mortality from Coronavirus in England and Wales: An Epidemiological and Demographic Detective Story. Contemporary Jewry. doi:https://doi.org/10.1007/s12397-021-09366-2.

Staetsky, L.D. (2024). COVID-19 mortality among Jews in 2020: a global overview and lessons taught about the Jewish longevity advantage. Journal of Biosocial Science, [online] 56(1), pp.15–35. doi:https://doi.org/10.1017/S0021932023000068.

Stavrova, O., Fecthenhauer, D. & Schlösser, T. (2013) 'Why are religious people happy? The effect of the social norm of religiosity across cultures', Social Science Research, 42, pp. 90–105.

Stich, H. F., Hornby, A. P. & Dunn, B. P. (1986) 'Beta-carotene levels in exfoliated mucosa cells of population groups at low and elevated risk for oral cancer', International Journal of Cancer, 37(3), pp. 389-393.

Storz, M.A. (2021). Lifestyle Adjustments in Long-COVID Management: Potential Benefits of Plant-Based Diets. Current Nutrition Reports. doi:https://doi.org/10.1007/s13668-021-00369-x.

Storz, M.A. (2021). What makes a plant-based diet? a review of current concepts and proposal for a standardized plant-based dietary intervention checklist. European Journal of Clinical Nutrition, [online] pp.1–12. doi:https://doi.org/10.1038/s41430-021-01023-z.

Sturges, H.F. (1991). Helicobacter pylori in Seventh-Day Adventists? Archives of Internal Medicine, 151(8), p.1672. doi:https://doi.org/10.1001/archinte.1991.00400080152038.

Suresh, M. E., McElroy-Heltzel, S. E., & Shannonhouse, L. R. (2020). Predicting suicide risk in older homebound adults during COVID-19: The role of religious coping. Journal of Psychology and Christianity, 39(4), pp. 301–312. Available at: https://ixtheo.de/Record/1759055166 (Accessed: 01 January 2025)

Stol, M., 1993. Epilepsy in Babylonia. Leiden: Brill Academic Publishers. Available at: https://archive.org/details/epilepsy-in-babylonia/page/n65/mode/2up [Accessed 23 December 2024].

Tabari, P., Amini, M., Moghadami, M. and Moosavi, M. (2020). International Public Health Responses to COVID-19 Outbreak: A Rapid Review. Iranian Journal of Medical Sciences, [online] 45(3), pp.157–169. doi:https://doi.org/10.30476/ijms.2020.85810.1537.

Tabatabaeizadeh, S.-A. (2022). Zinc supplementation and COVID-19 mortality: a meta-analysis. European Journal of Medical Research, 27(1). https://doi.org/10.1186/s40001-022-00694-z

Tan, M.-M., Chan, C.K.Y. and Reidpath, D.D. (2016). Religiosity, dietary habit, intake of fruit and vegetable, and vegetarian status among Seventh-Day Adventists in West Malaysia. Journal of Behavioral Medicine, 39(4), pp.675–686. doi:https://doi.org/10.1007/s10865-016-9736-8.

Tan, T., Khoo, B., Mills, E.G., Phylactou, M., Patel, B., Eng, P.C., Thurston, L., Muzi, B., Meeran, K., Prevost, A.T., Comninos, A.N., Abbara, A. and Dhillo, W.S. (2020). Association between high serum total cortisol concentrations and mortality from COVID-19. The Lancet.

Diabetes & Endocrinology, [online] 8(8), pp.659–660. doi:https://doi.org/10.1016/S2213-8587(20)30216-3.

Tancredi, S., Stéphane Cullati and Arnaud Chioléro (2022). Biais de surveillance : quand les apparences sont trompeuses. Revue médicale suisse, 18(790), pp.1412–1415. doi:https://doi.org/10.53738/revmed.2022.18.790.1412.

Taneri, P.E., Gómez-Ochoa, S.A., Llanaj, E., Raguindin, P.F., Rojas, L.Z., Roa-Díaz, Z.M., Salvador, D., Groothof, D., Minder, B., Kopp-Heim, D., Hautz, W.E., Eisenga, M.F., Franco, O.H., Glisic, M. and Muka, T. (2020). Anemia and iron metabolism in COVID-19: a systematic review and meta-analysis. European Journal of Epidemiology, 35(8), pp.763–773. doi:https://doi.org/10.1007/s10654-020-00678-5.

Tannenbaum, M. and Sebastian, S. (2021). Levels of Evidence in Medical Research. [online] openmd.com. Available at: https://openmd.com/guide/levels-of-evidence.

Taragin-Zeller, L., Berenblum, T., Brasil, E., Rozenblum, Y. and Ayelet Baram-Tsabari (2023). Religious diversity and public health: Lessons from COVID-19. PLOS ONE, [online] 18(8), pp.e0290107–e0290107. doi:https://doi.org/10.1371/journal.pone.0290107.

Tetens, I., Bendtsen, K.M., Henriksen, M., Ersbøll, A.K. and Milman, N. (2007). The impact of a meat- versus a vegetable-based diet on iron status in women of childbearing age with small iron stores. European Journal of Nutrition, 46(8), pp.439–445. doi:https://doi.org/10.1007/s00394-007-0683-6.

Thacker, P.D. (2021). Covid-19: Researcher blows the whistle on data integrity issues in Pfizer's vaccine trial. BMJ, [online] 375(375), p.n2635. doi:https://doi.org/10.1136/bmj.n2635.

The Embassy of The Kingdom of Saudi Arabia (2023). Government | The Embassy of The Kingdom of Saudi Arabia. [online] www.saudiembassy.net. Available at: https://www.saudiembassy.net/government/?id=Skunk-3593-6229-42-4733.

Thorpe, D.L., Beeson, W.L., Knutsen, R., Fraser, G.E. and Knutsen, S.F. (2021). Dietary patterns and hip fracture in the Adventist Health Study 2: combined vitamin D and calcium supplementation mitigate increased hip fracture risk among vegans. The American Journal of Clinical Nutrition, 114(2), pp.488–495. doi:https://doi.org/10.1093/ajcn/nqab095.

Thygesen, L.C., Hvidt, N.C., Hansen, H.P., Hoff, A., Ross, L. and Johansen, C. (2012). Cancer incidence among Danish Seventh-day Adventists and Baptists. Cancer epidemiology, [online] 36(6), pp.513–8. doi:https://doi.org/10.1016/j.canep.2012.08.001.

Tigbe, W.W., Granat, M.H., Sattar, N. and Lean, M.E.J. (2017). Time spent in sedentary posture is associated with waist circumference and cardiovascular risk. International Journal of Obesity, [online] 41(5), pp.689–696. doi:10.1038/ijo.2017.30.

Tinsley, G.M. and La Bounty, P.M. (2015). Effects of intermittent fasting on body composition and clinical health markers in humans. Nutrition Reviews, [online] 73(10), pp.661–674. doi:https://doi.org/10.1093/nutrit/nuv041.

Timlin, D., McCormack, J.M., Kerr, M., Keaver, L. and Simpson, E.E.A. (2020). Are Dietary Interventions with a Behaviour Change Theoretical Framework Effective in Changing Dietary patterns? a Systematic Review. BMC Public Health, [online] 20(1). doi:https://doi.org/10.1186/s12889-020-09985-8.

Titan, S.M.O. et al. (2001) Frequency of eating and concentrations of serum cholesterol in the Norfolk population of the European prospective investigation into cancer (Epic-Norfolk): Cross Sectional Study, The BMJ. British Medical Journal Publishing Group. Available at: https://www.bmj.com/content/323/7324/1286.1 (Accessed: January 16, 2023).

Tiwana M. H., and Smith, J. (2024). Faith and vaccination: a scoping review of the relationships between religious beliefs and vaccine hesitancy. BMC public health, 24(1). doi:https://doi.org/10.1186/s12889-024-18873-4.

To, J., Shao, Z.Z. and Gandawidjaja, M. (2022) Comparison of the impact of the Mediterranean diet, anti-inflammatory diet, Seventh-day Adventist diet, and ketogenic diet relative to cognition and cognitive decline. Current Nutrition Reports. Available at: https://pubmed.ncbi.nlm.nih.gov/35347664/ (Accessed: January 15, 2023).

Tol, J., Swinkels, I.C., Spreeuwenberg, P.M., Leemrijse, C.J., de Bakker, D.H. and Veenhof, C. (2012). Factors associated with the number of consultations per dietetic treatment: an observational study. BMC Health Services Research, 12(1). doi:https://doi.org/10.1186/1472-6963-12-317.

Tomlinson C. (2018). A cross-sectional survey of health and health behaviours of individuals attending a Seventh-day Adventist Church in Coventry. [online] Available at: https://pureportal.coventry.ac.uk/en/studentTheses/a-cross-sectional-survey-of-health-and-health-behaviours-of-indiv [Accessed 12 Aug. 2023].

Tonstad, S., Stewart, K., Oda, K., Batech, M., Herring, R.P. and Fraser, G.E. (2013). Vegetarian diets and incidence of diabetes in the Adventist Health Study-2. Nutrition, Metabolism and Cardiovascular Diseases, 23(4), pp.292–299. doi:https://doi.org/10.1016/j.numecd.2011.07.004.

Torgerson, C.J. (2002). Educational research and randomised trials. Medical Education, 36(11), pp.1002–1003. doi:https://doi.org/10.1046/j.1365-2923.2002.01335.x.

Treciokiene, I., Postma, M., Nguyen, T., Fens, T., Petkevicius, J., Kubilius, R., Gulbinovic, J. and Taxis, K. (2021). Healthcare professional-led interventions on lifestyle modifications for hypertensive patients – a systematic review and meta-analysis. BMC Family Practice, 22(1). doi:https://doi.org/10.1186/s12875-021-01421-z.

Trepanowski, J.F. and Bloomer, R.J. (2010). The impact of religious fasting on human health. Nutrition Journal, 9(1). doi:https://doi.org/10.1186/1475-2891-9-57.

Tumiran, M.A., Rahman, N.N.A., Saat, R.M., Kabir, N., Zulkifli, M.Y. and Adli, D.S.H. (2018). The Concept of Qailulah (Midday Napping) from Neuroscientific and Islamic Perspectives. Journal of Religion and Health, [online] 57(4), pp.1363–1375. doi:https://doi.org/10.1007/s10943-015-0093-7.

Turner-McGrievy, G., Mandes, T. and Crimarco, A. (2017). A plant-based diet for overweight and obesity prevention and treatment. Journal of geriatric cardiology : JGC, [online] 14(5), pp.369–374. doi:https://doi.org/10.11909/j.issn.1671-5411.2017.05.002.

Tyrväinen, O. and Karjaluoto, H. (2022). Online grocery shopping before and during the COVID-19 pandemic: A meta-analytical review. Telematics and Informatics, [online] 71(101839), p.101839. doi:https://doi.org/10.1016/j.tele.2022.101839.

Ulloque-Badaracco, J.R., Al-Kassab-Córdova, A., Alarcon-Braga, E.A., Hernandez-Bustamante, E.A., Huayta-Cortez, M.A., Cabrera-Guzmán, J.C., Robles-Valcarcel, P. and Benites-Zapata, V.A. (2024). Association of vitamin B12, folate, and homocysteine with COVID-19 severity and mortality: A systematic review and meta-analysis. SAGE Open Medicine, [online] 12. doi:https://doi.org/10.1177/20503121241253957.

Umakanthan, S. (2020). Origin, transmission, diagnosis and management of coronavirus disease 2019 (COVID-19). Postgraduate Medical Journal, [online] 96(1142). doi:https://doi.org/10.1136/postgradmedj-2020-138234.

Vahedian-Azimi, A., Abbasifard, M., Rahimi-Bashar, F., Guest, P.C., Majeed, M., Mohammadi, A., Banach, M., Jamialahmadi, T. and Sahebkar, A. (2022). Effectiveness of Curcumin on Outcomes of Hospitalized COVID-19 Patients: A Systematic Review of Clinical Trials. Nutrients, 14(2), p.256. https://doi.org/10.3390/nu14020256

Van Teijlingen, E.R., Wilson, B.J., Barry, N., et al., 1998. Effectiveness of interventions to promote healthy eating in pregnant women and women of childbearing age: a review. Abingdon, Berks: Health Education Authority (HEA).

Vang, A., Singh, P.N., Lee, J.W., Haddad, E.H. and Brinegar, C.H. (2008). Meats, Processed Meats, Obesity, Weight Gain and Occurrence of Diabetes among Adults: Findings from Adventist Health Studies. Annals of Nutrition and Metabolism, 52(2), pp.96–104. doi:https://doi.org/10.1159/000121365.

Varikasuvu, S.R., Thangappazham, B., Vykunta, A., Duggina, P., Manne, M., Raj, H. and Aloori, S. (2022). COVID-19 and vitamin D (Co-VIVID study): a systematic review and meta-analysis of randomized controlled trials. Expert Review of Anti-infective Therapy, 20(6), pp.907–913. https://doi.org/10.1080/14787210.2022.2035217

Vedhara, K., Royal, S., Sunger, K., Caldwell, D.M., Halliday, V., Taylor, C.M., Fairclough, L., Avery, A. and Welton, N.J. (2020). Effects of Non-Pharmacological Interventions as Vaccine Adjuvants in Humans: a systematic review and network meta-analysis. Health Psychology Review. [online] doi:https://doi.org/10.1080/17437199.2020.1854050.

Venegas-Borsellino, C., Sonikpreet and Martindale, R.G. (2018). From Religion to Secularism: the Benefits of Fasting. Current Nutrition Reports, 7(3), pp.131–138. doi:https://doi.org/10.1007/s13668-018-0233-2.

Visser, M., Schaap, L.A. and Wijnhoven, H.A.H. (2020). Self-Reported Impact of the COVID-19 Pandemic on Nutrition and Physical Activity Behaviour in Dutch Older Adults Living Independently. Nutrients, 12(12), p.3708. doi:https://doi.org/10.3390/nu12123708.

Vu, T.-H.T., Rydland, K.J., Achenbach, C.J., Van Horn, L. and Cornelis, M.C. (2021). Dietary Behaviors and Incident COVID-19 in the UK Biobank. Nutrients, 13(6), p.2114. doi:https://doi.org/10.3390/nu13062114.

Wadman, M. (2020). Vaccines that use human fetal cells draw fire. Science, 368(6496), pp.1170–1171. doi:https://doi.org/10.1126/science.368.6496.1170.

Waibel, R.A. (2019) 'Religion and Dietary Practices' in Hiam, D.S., ed., The Gale Encyclopedia of Diets, 3rd ed., vol. 2, Farmington Hills, MI: Gale, 1100-1104, available: https://link-gale-com.bcu.idm.oclc.org/apps/doc/CX2491000267/GVRL?u=uce&sid=bookmark-GVRL&xid=b8586eab [accessed 27 Dec 2024].

Walden, R.T., Schaefer, L.E., Lemon, F.R., Sunshine, A. and Wynder, E.L. (1964). Effect of environment on the serum cholesterol-triglyceride distribution among seventh-day adventists. The American Journal of Medicine, [online] 36(2), pp.269–276. doi:https://doi.org/10.1016/0002-9343(64)90089-0.

Wallace, T.C. and Frankenfeld, C.L. (2017). Dietary Protein Intake above the Current RDA and Bone Health: A Systematic Review and Meta-Analysis. Journal of the American College of Nutrition, 36(6), pp.481–496. doi:https://doi.org/10.1080/07315724.2017.1322924.

Wan, X., Wang, W., Liu, J. and Tong, T. (2014). Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. BMC Medical Research Methodology, 14(1). doi:https://doi.org/10.1186/1471-2288-14-135.
Wang, X. and Kattan, M.W. (2020). Cohort Studies: Design, Analysis, and Reporting. CHEST, [online] 158(1), pp.72–78. doi:https://doi.org/10.1016/j.chest.2020.03.014.

Waqar, S., Asaria, M., Ghouri, N., Suleman, M., Begum, H. and Marmot, M. (2021). Assessing the impact of Ramadan fasting on COVID-19 mortality in the UK. Journal of Global Health, 11. doi:https://doi.org/10.7189/jogh.11.03060.

Weaver, C.M., Gordon, C.M., Janz, K.F., Kalkwarf, H.J., Lappe, J.M., Lewis, R., O'Karma, M., Wallace, T.C. and Zemel, B.S. (2016). The National Osteoporosis Foundation's position statement on peak bone mass development and lifestyle factors: a systematic review and implementation recommendations. Osteoporosis International, [online] 27(4), pp.1281–1386. doi:https://doi.org/10.1007/s00198-015-3440-3.

Wei, B., Liu, Y., Li, H., Peng, Y. and Luo, Z. (2023). Impact of alcohol consumption on coronavirus disease 2019 severity: A systematic review and meta-analysis. Journal of Medical Virology, 95(2). doi:https://doi.org/10.1002/jmv.28547.

Weir, C.B. and Jan, A. (2023). BMI Classification Percentile And Cut Off Points. [online] PubMed. Available at: https://www.ncbi.nlm.nih.gov/books/NBK541070/.

Wells, G., Shea, B., O'Connell, D., Peterson, J., Welch, V., Losos, M. and Tugwell, P. (2021). The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. [online] www.ohri.ca. Available at: https://www.ohri.ca/programs/clinical_epidemiology/oxford.asp.

West, R.O. and Hayes, O.B. (1968). Diet and serum cholersterol levels. A comparision between vegetarians and nonvegetarians in a Seventh-day Adventist group. The American Journal of Clinical Nutrition, [online] 21(8), pp.853–862. doi:https://doi.org/10.1093/ajcn/21.8.853.

White, E. (1865). Selected Messages Book 2. [online] Available at: https://m.egwwritings.org/en/book/99.1685#1686 [Accessed 18 Mar. 2024].

White, E. (1896). Healthful Living. [online] Available at: https://adventistheritage.org/heritage-shoppe/health-ministry/healthful-living/ [Accessed 14 Mar. 2024].

White, E.G., 1905. The Ministry of Healing. Available at: https://egwwritings.org/ (Accessed: 21 January 2025).

White, E. (1936). Medical Ministry. [online] media2.egwwritings.org/. Available at: https://media2.egwwritings.org/pdf/en_MM.pdf [Accessed 14 Mar. 2024].

WHO (2020). Coronavirus Disease 2019 (COVID-19) Situation Report -51 SITUATION IN NUMBERS Total and New Cases in Last 24 Hours. [online] Available at: https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200311-sitrep-51-covid-19.pdf?sfvrsn=1ba62e57_10.

Widiani, P.R. and Djula, S.H.W. (2022). The Experiences about the Symptoms which Experienced Among the Patients With COVID-19 at Tidar 1 Adventist Church Surabaya. 8ISC Proceedings: Covid-19, [online] pp.1–12. Available at: https://ejournal.unklab.ac.id/index.php/8ISCCO/article/view/650 [Accessed 18 Jan. 2024].

Williams, J.T.B., Fisher, M.P., Bayliss, E.A., Morris, M.A. and O'Leary, S.T. (2020). Clergy attitudes toward vaccines and vaccine advocacy: a qualitative study. Human Vaccines &

Immunotherapeutics, 16(11), pp.2800–2808. doi:https://doi.org/10.1080/21645515.2020.1736451.

Wilson, T. (2021) Fasting and prayer for witnessing, Adventist News Network. General Conference. Available at: https://adventist.news/news/fasting-and-prayer-for-witnessing (Accessed: January 16, 2023).

Wong, K.K., Heilig, C.M., Hause, A., Myers, T.R., Olson, C.K., Gee, J., Marquez, P., Strid, P. and Shay, D.K. (2022). Menstrual irregularities and vaginal bleeding after COVID-19 vaccination reported to v-safe active surveillance, USA in December, 2020–January, 2022: an observational cohort study. The Lancet Digital Health, 4(9), pp.e667–e675. doi:10.1016/s2589-7500(22)00125-x.

Wong, L.-P., Lee, H.-Y., Alias, H. and AbuBakar, S. (2022). Malaysian Parents' Willingness to Vaccinate Their Children against COVID-19 Infection and Their Perception of mRNA COVID-19 Vaccines. Vaccines, 10(11), p.1790. doi:https://doi.org/10.3390/vaccines10111790.

World Health Organization. (2019). Healthy, prosperous lives for all: The European Health Equity Status Report. WHO Regional Office for Europe. Available at: https://iris.who.int/bitstream/handle/10665/326568/9789289013710-eng.pdf.

World Health Organization (2020). Healthy Diet. [online] World Health Organisation. Available at: https://www.who.int/news-room/fact-sheets/detail/healthy-diet.

World Health Organization (2020). Global health estimates: Leading causes of death. [online] World Health Organization. Available at: https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/ghe-leading-causes-of-death.

World Health Organization (2020) Immunization coverage. Available at: https://www.who.int/news-room/fact-sheets/detail/immunization-coverage

Wu, D. and Meydani, S. (2014). Age-Associated Changes in Immune Function: Impact of Vitamin E Intervention and the Underlying Mechanisms. Endocrine, Metabolic & Immune Disorders-Drug Targets, 14(4), pp.283–289. doi:https://doi.org/10.2174/1871530314666140922143950.

World Health Organization (WHO) Regional Office for the Eastern Mediterranean, 2020. Nutrition advice for adults during the COVID-19 outbreak. Available at: https://www.emro.who.int/nutrition/news/nutrition-advice-for-adults-during-the-covid-19-outbreak.html

Wujastyk, D., (2003). The Roots of Ayurveda: selections from Sankskrit medical writings. [online] Available at: https://www.researchgate.net/publication/32897783_The_Roots_of_Ayurveda_selections_from_Sankskrit_medical_writings.

Wynder, E.L., Lemon, F.R. and Bross, I.J. (1959). Cancer and coronary artery disease among seventh-day adventists. Cancer, 12(5), pp.1016–1028. doi:https://doi.org/10.1002/1097-0142(195909/10)12:5%3C1016::aid-cncr2820120523%3E3.0.co;2-2.

www.cochrane.org. (n.d.). How accurate are rapid antigen tests for diagnosing COVID-19? [online] Available at: https://www.cochrane.org/CD013705/INFECTN_how-accurate-are-rapid-antigen-tests-diagnosing-covid-19#:~:text=At%205%25%20prevalence%20using%20summary [Accessed 10 May 2023].

Yakoob, M.Y., Salam, R.A., Khan, F.R. and Bhutta, Z.A. (2016). Vitamin D supplementation for preventing infections in children under five years of age. Cochrane Database of Systematic Reviews. doi:https://doi.org/10.1002/14651858.cd008824.pub2.

Yeary, K.H.K., Sobal, J. and Wethington, E. (2017). Religion and body weight: a review of quantitative studies. Obesity Reviews, 18(10), pp.1210–1222. doi:https://doi.org/10.1111/obr.12569.

Yokoro, M., Wakimoto, K., Otaki, N. and Fukuo, K. (2021). Increased Prevalence of Breakfast Skipping in Female College Students in COVID-19. Asia Pacific Journal of Public Health, p.101053952199886. doi:https://doi.org/10.1177/1010539521998861.

Yu, J., Han, X., Wen, H., Ren, J. and Qi, L. (2020). Better Dietary Knowledge and Socioeconomic Status (SES), Better Body Mass Index? Evidence from China—An Unconditional Quantile Regression Approach. Nutrients, 12(4), p.1197. doi:https://doi.org/10.3390/nu12041197.

Yuan, Y. and Hunt, R.H. (2009). Systematic Reviews: The Good, the Bad and the Ugly. The American Journal of Gastroenterology, [online] 104(5), pp.1086–1092. doi:https://doi.org/10.1038/ajg.2009.118.

Zeballos, E. and Todd, J.E. (2020). The effects of skipping a meal on daily energy intake and diet quality. Public Health Nutrition, [online] 23(18), pp.1–10. doi:https://doi.org/10.1017/s1368980020000683.

Zeigler, R. L., & Mohorn, P. L. (2019). Assessing the influence of religiosity on vaccine hesitancy in a convenience sample of Southeastern United States adults. Vaccine, 37(3), 499-503.

Zimmer, Z., Rojo, F., Ofstedal, M.B., Chiu, C.-T., Saito, Y. and Jagger, C. (2019). Religiosity and health: A global comparative study. SSM - Population Health, 7, p.100322. doi:https://doi.org/10.1016/j.ssmph.2018.11.006.

Zollinger, T.W., Phillips, R.L., and Kuzma, J.W. (1984). Breast cancer survival rates among Seventh-Day Adventists and non-Seventh-Day Adventists. American Journal of Epidemiology, 119(4), pp.503–509. DOI: 10.1093/oxfordjournals.aje.a113767.

Zou, M., Northstone, K. and Perry, R. (2022) The association between later eating rhythm and adiposity in children and adolescents: a systematic review and meta-analysis , Academic.oup.com. Nutrition Reviews, Oxford Academic. Available at:

https://academic.oup.com/nutritionreviews/article/80/6/1459/6395288?searchresult=1 (Accessed: January 16, 2023).

8 Appendix

Appendix 1. Cross-sectional survey questionnaire

"Message to participants: This study aims to assess the lifestyle, mental wellbeing, and the presence of chronic disease among Seventh-day Adventists living in the UK. The study will include a follow-up questionnaire in 2023, which will be sent to participants' email addresses.

Please provide your email address if you consent to participating in the study:

1. Are you a baptised member of the Seventh Day Adventist church? Yes/No
2. Gender Male/Female
3. Please indicate your ethnicity: Asian or Asian British/Black African/Black Caribbean/ White British/White European
4. Age in years
5. What church do you regularly attend?
6. Initials
7. What is your annual household income? £0-£29,000/£29,000-£49,000/£50,000+
8. What is your highest level of education: No GCSEs/GCSEs/A-Levels or BTEC level 3/ Undergraduate Degree/ Master's Degree/Doctorate (Ph.D.,M.D., Ed.D., etc.)
9. Weight in kilograms
10. Height in centimetres (cm)
11. Waist circumference in cm

12. Hip circumference in cm
13. Are you a non-smoker/current smoker?
14. Do you drink alcohol? Y/N
15. Do you regularly eat meat? Y/N
16. Are you a pescatarian? Y/N
17. Are you a vegetarian? Y/N
18. Are you a vegan? Y/N
19. How long have you followed this diet? 1 month or less/1-6 months/6 month to 1 year/1-3 years/more than 3 years/more than 10 years
20. Do you regularly eat breakfast in the morning? YES/NO
21. Do you regularly eat dinner after 6 pm? YES/NO
22. Do you do regular intensive exercise at least 3 times a week? YES/NO
23. Rate your physical activity level during the day: Sedentary/Light/Moderate/Vigorous
24. In the past 4 weeks have you felt calm and peaceful All of the time/Most of the time/Some of the time/A little of the time/None of the time
25. Did you have a lot of energy All of the time/Most of the time/Some of the time/A little of the time/None of the time
26. Have you felt downhearted and depressed All of the time/Most of the time/Some of the time/A little of the time/None of the time

27. Have you been diagnosed with any of the following cardiovascular conditions?
    - High blood pressure Yes/No
      If yes, what year were you diagnosed in?
    - Atherosclerosis Yes/No
      If yes, what year were diagnosed in?
    - Coronary heart disease Yes/No
      If yes, what year were you diagnosed in?
    - Cerebrovascular disease (stroke) Yes/No
      If yes, what year were you diagnosed in?
    - Deep vein thrombosis and pulmonary embolism Yes/No
      If yes, what year were you diagnosed in?
    - Hypercholesterolemia YES/NO
      If yes, what year were you diagnosed in?
28. Have you been diagnosed with type 2 diabetes? YES/NO
    If yes, what year were you diagnosed in?
29. Have you ever been diagnosed with a cancer? YES/NO

If yes,
What type of cancer have you been diagnosed with:
When were you diagnosed with the disease:

COVID-19 related questions

30. Have you had a Covid-19 diagnosis? Yes / No
31. If so, how would you describe your symptoms? No symptoms/Mild symptoms/Moderate symptoms/sever symptoms requiring hospitalisation

32. Have you ever had a diagnosis of anxiety or depression? Yes/No
33. Have you had a formal diagnosis of anxiety or depression since March 2020? Yes/No
34. Since the introduction of government restrictions, has your weight: stayed the same/increased/decreased
35. Since the introduction of government restrictions, have your exercise habits: stayed the same/decreased/increased
36. Have you found it difficult to maintain your devotional/spiritual life without attending being able to attend church? Yes/No
37. Have you been able to maintain your usual diet during the Covid-19 pandemic? Yes/No

Common food items	**Average use in the last year**						
	4 or more/day	2-3/day	1/day	2-4/week	1/week	1-3 /month	Never or less than once/ month
Brown bread and rolls/ Home-made wholemeal bread (wheat)/ Rye bread							
White bread and rolls							
Rice/pasta							
Potato/ Yam/ Sweet potato							
Oatmeal							
Lentils/chickpeas/green peas/beans and other pulses							
Nuts and seeds (walnuts, flaxseeds, chia seeds etc.)							
Nut butters (i.e. peanut butter)							
Green leafy vegetables (i.e. spinach, kale, watercress etc.)							
Cruciferous vegetables (i.e. broccoli or cauliflower)							
Sprouted seeds							
Fruits (Fresh or Frozen)							

	Average use in the last year					
Dairy products and Non-dairy alternatives 1 serving= 1 cup, 1 egg, 1 slice (30g)	5+ / day	2-4/day	1/day	3-5/week	<1/week	<1/month
Cow's milk						
Dairy Cheese						
Soy Milk/ Almond Milk/ Coconut Milk/ Oat Milk						
Vegan cheese and yoghurt alternatives (e.g., Violife)						
Eggs						
Dairy Yogurt						
Butter (1 teaspoon=1 serving)						

Meat products and Meat alternatives (medium serving)	**Organic/free range/neither (select)**	**Average use in the past year**						
		>3 servings/day	1-3 servings /day	Once a day	2-4 times a week	Once a week	1-3 times per month	Less than once a month
Deli meat (e.g., salami, chicken slices, turkey slices etc.)								
Red Meat: Beef (Steak, burgers, etc.), lamb, goat, goat								
Chicken or other poultry								
Fish (fresh or frozen or canned)								
Pork (Sausages, Bacon, Ham, etc.)								
Shellfish (e.g., crabs, prawns, mussels)								
Organ meats								
Tofu (tempeh, seitan etc.)/ Soya meat (e.g., Quorn) or other meat alternatives								

Dietary Supplements (serving=1 capsule, 1 spoonful etc.)	Average use in the last year					
	Daily	3-6 servings/week	1serving /week	1 serving /month	1 serving/6 months	Less than 1/year
Multivitamins						
Vitamin D						
Vitamin B12						
Protein powder						
Herbal supplement						

Drinks (1 serving = 1 cup (250ml))	Average use						
	4 or more/day	2-3/day	1/day	2-4/week	1/week	1-3 /month	Never or less than once/ month
Black/green tea							
Coffee (instant or ground)							
Decaffeinated coffee							
Herbal tea							
Fizzy soft drinks							
Fizzy soft drinks (low calorie or diet)							
Alcoholic beverage							

Appendix 2. 24 Hour Diet Recall

Please list all the food you have eaten in the last 24 hours. Please be as specific and honest as possible. Thank you.

Food Item	Serving Size	Time Consumed	Where

Appendix 3. Participant information sheet for Study 1

POSTGRADUATE STUDENT PROJECTS
SCHOOL OF LIFE SCIENCES
Faculty of HELS,
Birmingham City University

An investigation of the lifestyle, mental wellbeing, prevalence and incidence of self-reported chronic diseases and COVID-19 among the Seventh Day Adventist Christians living in the United Kingdom.

8.1 **Thank you for considering helping one of our students with their research work.** Before you decide to participate, it is important for you to understand why the research is being conducted and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

PURPOSE OF THE RESEARCH The purpose of this project is to assess the prevalence and incidence of self-reported chronic diseases, and COVID-19 among Seventh-day Adventists in the United Kingdom by gathering data in the form of an online questionnaire and a 24-hour diet recall. The study will also aim to assess the health and nutritional status, mental wellbeing, and activity status of participants.
Why have I been chosen? We are approaching all members of the Seventh-day Adventist Church in the United Kingdom, and we are aiming to gather data from as many church members as possible in order to assess
Do I have to take part? You do not have to take part in this research project if you do not want to and you do not need to give any reason if you decide not to take part
What do I have to do? ● **You will be asked to complete a roughly 15-minute-long questionnaire** ● **You will be asked to provide some information on your gender, age and ethnicity as well as household income, medical history, health status, and exercise habits** ● **The questionnaire will ask you to give a measure of your waist and hip circumference** <u>Measuring your waist:</u> When measuring your waist roll your shirt up. Find the bottom of your ribs and the top of your hips. Place a tape measure or a string around the middle, just above the belly button. Breathe out naturally and record the measurement

Measuring your hip: Using the same tool, measure the distance around the largest part of your hips (this is the widest part of your buttocks). ● **By providing your email address, the research team may contact you in with a follow-up questionnaire in 2 years' time**
What are the risks associated with this project? **As this is a survey-based project there are no risks involved. No intervention will be used in this study, therefore there will not be any potential harms to participants' health and wellbeing by participating in this survey.**
What are the benefits of taking part? **By participation you provide valuable data on the health status of the Seventh-day Adventist Church, which may have public health implications.**
Withdrawal options **You are free to stop taking part in this study at any time and you do not have to give any reason for this.**
Data protection & confidentiality Your consent to participate in this study will be confidential and all data collected from the questionnaire on Microsoft forms will be anonymous. No participants can be identified from the data collected. All data will be stored in password protected files and only the researchers will have access to these files. All files will be deleted three months after the completion of this study. ● All data collected will be anonymous ● Data that is stored electronically will use subject codes so that individuals cannot be identified ● All data will also be made available to supervisor.
Who should you talk to if you have questions or you wish to make a complaint If you have any questions or queries Robert Janko will be happy to answer them. If you have any questions about your rights as a participant or feel you have been placed at risk you can speak to Ashok Patel and Irmgard Haussmann.

What will happen with the results of the study?
Any data/ results from your participation in the study will be used by Robert Janko as part of their project work. The data will also be available to Ashok Patel and Irmgard Haussmann. It may also be published in scientific works, but your name or identity will not be revealed.
Who has reviewed this study?
This study has ethical approval from Birmingham City University.
Key contact details
Robert Janko Robert.Janko@mail.bcu.ac.uk **Supervisor:** Ashok Patel (ashok.patel@bcu.ac.uk)

8.2

Appendix 4. Consent form

PARTICIPANT CONSENT FORM

Study Title: Prospective investigation into the lifestyle, mental wellbeing, and the prevalence and incidence of self-reported chronic diseases and COVID-19 among the Seventh Day Adventist Christians living in the United Kingdom.

Name of Researcher: Robert Janko

Project Code:	*Participant identification number:*

Initial box

1. I confirm that I have read the information sheet for this study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my legal rights being affected.	
3. I understand that relevant sections of my self-reported medical history and data collected during the study may be looked at by individuals from Birmingham City University and from regulatory authorities, where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records.	
4. I understand that personal data about me will be collected for the purposes of the research study including [name, email address, date of birth, ethnicity, sexuality and self-reported medical history], and that these will be processed in accordance with the information sheet.	
5. I agree to take part in this study.	

Initial box

	Yes	No
6. I agree to be contacted about ethically approved research studies for which I may be suitable. I understand that agreeing to be contacted does not oblige me to participate in any further studies.		

7. I agree for my anonymised data to be used in future research,* here or abroad, which has ethics approval. (*if some future use may be commercial, state this)		
8. I agree for my anonymised data to be used for teaching purposes.		

______________________	________________	__________________________
Name of Participant	*Date*	*Signature*

______________________	________________	__________________________
Name of Person taking Consent	*Date*	*Signature*

**1 copy for participant; 1 copy for researcher site file;*

Appendix 5. Ethical approval

BIRMINGHAM CITY University

Faculty of Health, Education & Life Sciences Research Office
Seacole Building, 8 Westbourne Road
Birmingham
B15 3TN

HELS_Ethics@bcu.ac.uk

23/Aug/2021

Mr Robert Janko

robert.janko@mail.bcu.ac.uk

Dear Robert ,

Re: Janko /#9410 /sub3 /R(A) /2021 /Aug /HELS FAEC - An investigation of the lifestyle, mental wellbeing, prevalence and incidence of self-reported chronic diseases and COVID-19 among the Seventh Day Adventist Christians living in the United Kingdom.

Thank you for your application and documentation regarding the above activity. I am pleased to take Chair's Action and approve this activity.

Provided that you are granted Permission of Access by relevant parties (meeting requirements as laid out by them), you may begin your activity.

I can also confirm that any person participating in the project is covered under the University's insurance arrangements.

Please note that ethics approval only covers your activity as it has been detailed in your ethics application. If you wish to make any changes to the activity, then you must submit an Amendment application for approval of the proposed changes.

Examples of changes include (but are not limited to) adding a new study site, a new method of participant recruitment, adding a new method of data collection and/or change of Project Lead.

Please also note that the Health, Education and Life Sciences Faculty Academic Ethics Committee should be notified of any serious adverse effects arising as a result of this activity.

If for any reason the Committee feels that the activity is no longer ethically sound, it reserves the right to withdraw its approval. In the unlikely event of issues arising which would lead to this, you will be consulted.

Keep a copy of this letter along with the corresponding application for your records as evidence of approval.

If you have any queries, please contact HELS_Ethics@bcu.ac.uk

I wish you every success with your activity.

Yours Sincerely,

Dr Loukia Tsaprouni

On behalf of the Health, Education and Life Sciences Faculty Academic Ethics Committee

Appendix 6. Consent form for educational intervention study

PARTICIPANT CONSENT FORM

Study Title: An online educational intervention study to assess the diet and nutritional supplement knowledge of Seventh Day Adventist Christians.

Name of Researcher: Robert Janko

Project Code:	*Participant identification number:*

Initial box

9. I confirm that I have read the information sheet for this study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
10. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my legal rights being affected.	
11. I understand that relevant sections of my self-reported medical history and data collected during the study may be looked at by individuals from Birmingham City University and from regulatory authorities, where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records.	
12. I understand that personal data about me will be collected for the purposes of the research study including [name, email address, date of birth, ethnicity, sexuality and self-reported medical history], and that these will be processed in accordance with the information sheet.	
13. I agree to take part in this study.	

Initial box

	Yes	No
14. I agree to be contacted about ethically approved research studies for which I may be suitable. I understand that agreeing to be contacted does not oblige me to participate in any further studies.		
15. I agree for my anonymised data to be used in future research,* here or abroad, which has ethics approval. (*if some future use may be commercial, state this)		
16. I agree for my anonymised data to be used for teaching purposes.		

______________________	________________	__________________________
Name of Participant	*Date*	*Signature*

______________________	________________	__________________________
Name of Person taking Consent	*Date*	*Signature*

8.3

8.4

Appendix 7. Participant information sheet for educational intervention study

PARTICIPANT INFORMATION SHEET (PIS)
POSTGRADUATE STUDENT PROJECTS
SCHOOL OF LIFE SCIENCES
Faculty of HELS,
Birmingham City University

BIRMINGHAM CITY University

An online educational intervention study to assess the diet and nutritional supplement knowledge of Seventh Day Adventist Christians.

My name is Robert Janko and thank you for considering helping with my research work.
Before you decide to participate, it is important for you to understand why the research is being conducted and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

PURPOSE OF THE RESEARCH 8.5 The purpose of this study is to investigate the efficacy of an educational intervention delivered by a nutrition expert on the nutrition knowledge and behaviour as well as the supplementation use, in the context of vegan diets and COVID-19 disease treatment and prevention, of Seventh-Day Adventists.
Why have I been chosen? We are approaching all members of the Seventh-day Adventist Church in the United Kingdom, and we are aiming to gather data mainly from church members who follow a vegan or vegetarian diet.

Do I have to take part? You do not have to take part in this research project, if you do not wish to do so, and you may withdraw from the study at any point until 1 month after the follow-up questionnaire is sent to you.
What do I have to do? ● You will be asked to attend an online lecture held by the researcher, who will conduct a presentation about nutrients and supplement use on a plant-based diet. The lecture will last a maximum of 60 minutes. ● In addition, you will be asked to fill in a nutrition knowledge quiz before the lecture. The quiz will be anonymous so you cannot be identified from the assessment. ● At the end of the lecture, you will be asked to take the same quiz again. ● Within 2-months after the study, you will be contacted via email to fill in a third questionnaire. ● Please use the same participant code.
What are the risks associated with this project? Undertaking the questionnaire may cause psychological stress in some people. You are not required to provide your name on the questionnaire; therefore, you will not be identified. You will only need to use the participant code provided to you via email, which we have not kept a record of, which means you cannot be identified from the questionnaires. Furthermore, you are welcome to contact me or any member of the research team if you experience any psychological stress during this study or if you have any questions.
What are the benefits of taking part? By participating you provide valuable data towards identifying any shortfalls in the nutrition knowledge of plant-based Seventh-day Adventists. The study will also inform us about the potential efficacy of an educational intervention in improving participants knowledge of nutrients and supplements.
Withdrawal options You are free to stop taking part in this study at any time and you do not have to give any reason for this.
Data protection & confidentiality Your consent to participate in this study will be confidential and all data collected from the questionnaire will be anonymous. No participants can be identified from the data collected. The only personal data collected from you is an email address to allow me to contact you

with a follow-up questionnaire 2 months after the study. Your email address will be stored in a password protected file on the university's system and only the researchers will have access to these files. The file containing your email address will be deleted 3 months after data analysis is completed. ● All data collected will be anonymous ● Data that is stored electronically will use subject codes so that individuals cannot be identified ● All data will also be made available to my supervisors
Who should you talk to if you have questions or you wish to make a complaint If you have any questions or queries Robert Janko will be happy to answer them. If you have any questions about your rights as a participant or feel you have been placed at risk you can speak to Ashok Patel and Irmgard Haussmann.
What will happen with the results of the study? Any data/ results from your participation in the study will be used by Robert Janko as part of their project work. The data will also be available to Dr. Ashok Patel and Dr. Irmgard Haussmann. It may also be published in scientific works, but this will not include any personal identifiers.
Who has reviewed this study? This study has ethical approval from Birmingham City University.
Key contact details Robert Janko Robert.Janko@mail.bcu.ac.uk **Supervisor:** Ashok Patel (ashok.patel@bcu.ac.uk)

Appendix 8. Follow up questionnaire for cross-sectional survey

1. Please indicate your gender
2. What diet do you follow?
3. Have you had COVID-19 since the last time you filled in the questionnaire (2022 Dec)?
4. If you answered Yes to the previous questions, how severe were your symptoms?
5. Have you had vaccination against COVID-19 in the past 12 months?
6. If you had a COVID-19 vaccine in the last 12 months, please mention if you suffered any side-effects:
7. If you have been infected with COVID-19, what treatment(s) did you use? (leave blank if not applicable)
8. Have you started taking any dietary supplements in the past 12 months? (If so, please list the supplements you started taking)
9. Please list all the foods and beverages you consumed in the past 24 hours
10. Have you had any persistent symptoms of COVID-19 (also called Long Covid) even after recovering from the disease? If so, please state what symptoms have you been suffering from?
11. Please provide your initials or email address so we can match your response to the first questionnaire

Appendix 9. Pre- and post-lecture questionnaire for educational intervention

Please provide the first three letters of your surname and the first three letters you were born in:

1. Please insert the participant ID you have been provided with:

2. Which of the below diets do you follow:

a. Vegan
b. Vegetarian
c. Pescatarian

3. Do you think that eating meat is unethical or immoral?

a. Yes
b. No
c. Don’t know

4. Please indicate which of the supplements below do you take daily or at least 3 times a week (select all that applies):

a. Multivitamin
b. Vitamin C
c. Omega 3 fats
d. Protein powder
e. Iodine
f. Calcium
g. Iron

5. Which of the below supplements do you take regularly:

    a. Vitamin B12
    b. Vitamin D
    c. Both
    d. Neither

6. Do you think a plant-based diet can provide all the essential vitamins and minerals needed for health without taking additional supplements?

a. Yes
b. No
c. Unsure

7. Processed foods are energy-dense and are high in sugar, fat and salt, and contain additives.
   Which of the below is more important for you regarding your diet:

a. It should consist of no processed foods.
b. It can consist of small amounts of processed foods.
c. I don't know.

8. Which of the below applies to your diet

   a. It is based on current scientific evidence as reflected in the official guidelines.
   b. It is based on the Bible and the writings of Ellen G. White.
   c. It is based on both of the above.

9. Do you think vitamin and mineral supplements can be part of a healthy diet?

a. Yes
b. No
c. Don't know

If you answered no to question 7, which of the following best describes your reason for your answer:

a. They are synthetic and not safe.
b. They have no effect.
c. They are not needed (A good diet provides everything you need).

10. Do you think protein supplements in the form of pre-prepared liquid shakes are beneficial?

A. Yes, they are good to have after any exercise.
B. No, they are not as beneficial as high protein natural foods.
C. No, they contain artificial sweeteners, which are not good for you.
D. Don't know.

11. Do you think protein supplements in the form of powder are beneficial?

a. Yes, they are useful.
b. No, they are not safe.
c. I don't know.

12. How many portions of fruit and vegetables should we consume daily according to experts?

a. 3

b. 5
c. 7

13. The increased consumption of what type of fat is associated with an increased risk of heart disease?

a. Omega 3 fats
b. Saturated fat
c. Omega 6 fats
d. Don't know

14. Which of the following vitamins should vegans use regularly?

a. Vitamin C
b. Vitamin B12
c. Vitamin K
d. All of them
e. Don't know.

15. Which of the below foods is a source of Vitamin D?

a. Spinach
b. Lentils
c. Salmon
d. Don't know.

16. Which is the least biologically active form of vitamin D?

a. Vitamin D2
b. Vitamin D3
c. Don't know

17. Dairy milk is a rich source of
a. Calcium
b. Omega 3 fats
c. Iron
d. Don't know.

18. Which of the below foods interferes with the absorption of iron?

a. Fruits
b. Vegetable oils
c. Dairy products
d. Don't know

19. Which of the below is not a source of omega 3 fats?

a. Almond
b. Flaxseed
c. Soy products
d. Don’t know.

20. Which of the following foods contains the most iron per 100-gram dry weight?

a. Spinach
b. Sesame seeds
c. Beetroot
d. Don’t know

21. What is a source of dietary heme iron?

a. Red meat
b. Dairy products
c. Broccoli
d. None of them
e. Don’t know.

22. Which of the following vitamins increases the absorption of nonheme iron?

a. Vitamin A
b. Vitamin B6
c. Vitamin C
d. Don’t know

COVID-19 specific questions:

23. Do you take herbal supplements such as mint tea, turmeric extract, Echinacea etc. to treat or prevent disease?

a. Yes
b. no

24. Have you been vaccinated against COVID-19?
a. Yes
b. No

If answered No, which of the following reasons best describes your decision not to have a COVID-19 vaccination:

a. Worried about vaccination side effects
b. Worried about negative information about COVID-19 vaccinations on the internet

c. I had natural immunity
d. I don’t believe in taking any vaccines
e. No access to COVID-19 vaccination
f. Underlying medical conditions meant I could not get the vaccine

25. Do you think herbal or dietary supplements can cause less side-effects than COVID-19 vaccines?

a. Yes
b. No
c. Not sure

26. Herbal supplements are as or more effective than medications such antibiotics or antiviral drugs against infectious diseases.

a. Agree
b. Disagree
c. Don’t know

27. Vitamin D supplements may reduce the risk of COVID-19 infection:

a. Agree
b. Disagree
c. Don’t know

28. There is not sufficient evidence to show that vitamin D supplements reduce COVID-19 related hospitalisation.

a. Agree
b. Disagree
c. Don’t know

29. Vitamin D supplements may reduce the risk of admission to an intensive care unit due to COVID-19 infection.

a. Agree
b. Disagree
c. Don’t know

30. Vitamin D supplements may reduce the risk of death due to COVID-19 infection.

a. Agree
b. Disagree
c. Don’t know

31. Zinc supplements may reduce the risk of death due to COVID-19 infection.

a. Agree
b. Disagree
c. Don’t know

32. Vitamin C has no effect on the length of hospitalisation due to COVID-19 infection.

a. True
b. False
c. Disagree

33. Higher doses of vitamin C have been shown to be more effective against COVID-19 than lower doses.

a. Agree
b. Disagree
c. Don’t know

34. Vitamin C supplements have been shown to effectively lower the risk of death due to COVID-19 infection.
a. Agree
b. Disagree
c. Don’t know

35. There is no evidence that curcumin supplements can lower the inflammatory response to COVID-19 infection.

a. Agree
b. Disagree
c. Don’t know

36. Curcumin supplements can decrease the symptoms of COVID-19

a. Agree
b. Disagree
c. Don’t know

37. Taking probiotic capsules which contain gut friendly bacteria may significantly reduces the risk of death due to COVID-19 infection.

a. Agree
b. Disagree
c. Don’t know

38. Taking probiotic capsules which contain gut friendly bacteria may significantly reduce the symptoms of COVID-19 infection.

a. Agree
b. Disagree
c. Don’t know

39. In children, Vitamin A supplements may reduce the risk of death due to COVID-19 related pneumonia.

a. Agree
b. Disagree
c. Don’t know

40. Vitamin A, alongside conventional treatment, may shorten hospitalisation due to COVID-19 pneumonia in children.

a. Agree
b. Disagree
c. Don’t know

Appendix 10. One-month follow up questionnaire for educational intervention

1. What is your age and gender:
2. Have you made a change to your diet since attending the educational lecture?

a. Yes
b. No

If you answered Yes, please indicate what has changed about your diet:

a. I now consume meat products
b. I now consume dairy products
c. I now consume fish
d. I have used more fortified foods
e. Other

3. Do you think the educational lecture was informative and useful?

a. Yes, because it addressed concerns that are common among Seventh-Day Adventists
b. No, because I don't trust the scientific studies presented.

4. Did the educational lecture enable you to put into practise any of the information presented?

a. Yes, as the lecture included the nutritional content of specific food items and exact dosages regarding supplements.
b. No.

5. How difficult was it to understand the information presented in the educational lecture?

a. I understood all the information presented.
b. I understood most of the information presented.
c. I did not understand most of the information presented.

6. Did the qualification of the presenter influence your trust in the presented information?

a. Yes, I trusted it more due to his high qualification.
b. No, it did not make a difference.

7. The lecture presented information not only from scientific sources, but from Seventh-Day Adventist books and websites (Ellen G. White's writings and the official website of the General Conference of the Seventh-Day Adventist Church). Did this have an impact on your confidence in the presented information?

a. Yes, it made me trust it more.
b. No, the scientific information would have been sufficient.

8. Did you feel motivated after the lecture to make adjustments to your diet?

a. Yes
b. No

9. As a Seventh-Day Adventist, do you think that eating meat is unethical or immoral?

d. Yes
e. No
f. I am still unsure

10. Since you attended the lecture, have you started taking any new dietary supplements?

a. Yes
b. No

If you answered yes, please indicate what supplements you have started taking:

11. How has the lecture impacted your views regarding diet and supplements:

a. I now pay more attention to what nutrients my diet may be lacking, and I supplement accordingly.
b. I am still sceptical about the use of certain dietary supplements.

12. Do you think a plant-based diet can provide all the essential vitamins and minerals our needed for health <u>without</u> taking additional supplements?

d. Yes
e. No
f. I am still unsure

13. Which of the below do you now consider important about diet:

d. It is based on current scientific evidence as reflected in the official guidelines.
e. It is based on the Bible and the writings of Ellen G. White.
f. It is based on both of the above.

14. Do you think vitamin and mineral supplements can be part of a healthy diet?

d. Yes
e. No
f. I am still unsure.

If you answered No to question 9, which of the following best describes your reason for your answer:

d. They are synthetic and not safe.
e. They have no effect.
f. They are not needed (A good diet provides everything you need).

15. Do you now think protein supplements can be part of a healthy diet?

E. Yes
F. No
G. Still unsure.

16. Do you think the questionnaires you had to fill in before and after the educational lecture influenced how much you learned from the lecture?

a. Yes, they motivated me to pay more attention an do better on the second questionnaire.
b. No, it caused unnecessary stress.

COVID-19 specific questions:

17. Have you had COVID-19 disease since the lecture?

a. Yes
b. No

18. Have you started taking any supplements that were discussed in the lecture to prevent or treat any respiratory tract infections, including COVID-19, since the lecture?

a. Yes
b. No

If you answered Yes, please explain which supplements you have started taking:

19. Have you been vaccinated against COVID-19 since the lecture, or would you take a COVID-19 vaccine in the future?

c. Yes
d. No

20. Have your views changed regarding the treatment or prevention of COVID-19 since the lecture?

d. Yes – I now think dietary and herbal supplements can be effective in the treatment or prevention of COVID-19.
e. Yes – I now do not think supplements are as effective as I thought.
f. No – my views stayed the same.

21. Has the lecture encouraged you to consult with a dietician or nutrition professional in the future regarding any questions you may have about diet or supplements?

a. Yes
b. No

Appendix 11. NEWCASTLE-OTTAWA QUALITY ASSESSMENT SCALE FOR COHORT STUDIES

Selection

1) Representativeness of the exposed cohort

a) Truly representative of the average _______________ (describe) in the community □
b) S omewhat representative of the average ______________ in the community □
c) Selected group of users e.g. nurses, volunteers
d) No description of the derivation of the cohort

2) Selection of the non exposed cohort

a) Drawn from the same community as the exposed cohort □
b) Drawn from a different source
c) No description of the derivation of the non exposed cohort

3) Ascertainment of exposure

a) Secure record (e.g. surgical records) □
b) Structured interview □
c) Written self report
d) No description

4) D emonstration that outcome of interest was not present at start of study

a) Yes □
b) No

Comparability

1) Comparability of cohorts on the basis of the design or analysis

a) Study controls for _____________ (select the most important factor) □
b) Study controls for any additional factor □ (This criteria could be modified to indicate specific control for a second important factor.)

Outcome

1) Assessment of outcome

a) Independent blind assessment □
b) Record linkage □
c) Self report
d) No description

2) Was follow-up long enough for outcomes to occur

a) Yes (select an adequate follow up period for outcome of interest) □
b) No

3) Adequacy of follow up of cohorts

a) Complete follow up-all subjects accounted for □
b) Subjects lost to follow up unlikely to introduce bias-small number lost -> ____ % (select an adequate %) follow up, or description provided of those lost) □
c) Follow up rate < ____% (select an adequate %) and no description of those lost
d) No statement

Appendix 12. NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE (adapted for cross sectional studies)

Selection: (Maximum 5 stars)
1) Representativeness of the sample:
a) Truly representative of the average in the target population. * (all subjects or random sampling)
b) Somewhat representative of the average in the target population. * (nonrandom sampling)
c) Selected group of users.
d) No description of the sampling strategy.
2) Sample size:
a) Justified and satisfactory. *
b) Not justified.
3) Non-respondents:
a) Comparability between respondents and non-respondents characteristics is established, and the response rate is satisfactory. *
b) The response rate is unsatisfactory, or the comparability between respondents and non-respondents is unsatisfactory.
c) No description of the response rate or the characteristics of the responders and the non-responders.
4) Ascertainment of the exposure (risk factor):
a) Validated measurement tool. **
b) Non-validated measurement tool, but the tool is available or described.*
c) No description of the measurement tool.
Comparability: (Maximum 2 stars)
1) The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled.
a) The study controls for the most important factor (select one). *
b) The study control for any additional factor. *
Outcome: (Maximum 3 stars)
1) Assessment of the outcome:
a) Independent blind assessment. **
b) Record linkage. **
c) Self report. *
d) No description.
2) Statistical test:
a) The statistical test used to analyze the data is clearly described and appropriate, and the measurement of the association is presented, including confidence intervals and the probability level (p value). *
b) The statistical test is not appropriate, not described or incomplete.

Appendix 13. Data extraction form for systematic reviews

Bibliographic Information: ● Study Title: ● Authors: ● Publication Year: ● Journal:
Study Characteristics: ● Study Design (e.g., cohort, case-control, cross-sectional): ● Country/Region of Study: ● Study Duration: ● Data Collection Period:
Participant Demographics: ● Total Number of Participants: ● Age Range of Participants: ● Gender Distribution: ● Ethnicity of Participants:
Adventist Lifestyle Assessment: ● Criteria Used to Define Adventist Lifestyle: ● Specific Lifestyle Factors Assessed (e.g., diet, physical activity, smoking):
Control Group Presence: ● Was there a Control Group? (Yes/No): ● If Yes, Description of Control Group:
Infectious Disease Outcomes: ● Type(s) of Infectious Diseases Assessed: ● Method of Disease Diagnosis or Assessment:
Prevalence/Incidence Rates: ● Prevalence/Incidence of Infectious Diseases in Adventists: ● Prevalence/Incidence of Infectious Diseases in Control Group (if applicable):
Statistical Analysis: ● Statistical Methods Used: ● Key Findings: ● Adjustments for Confounding Factors (Yes/No/Details):

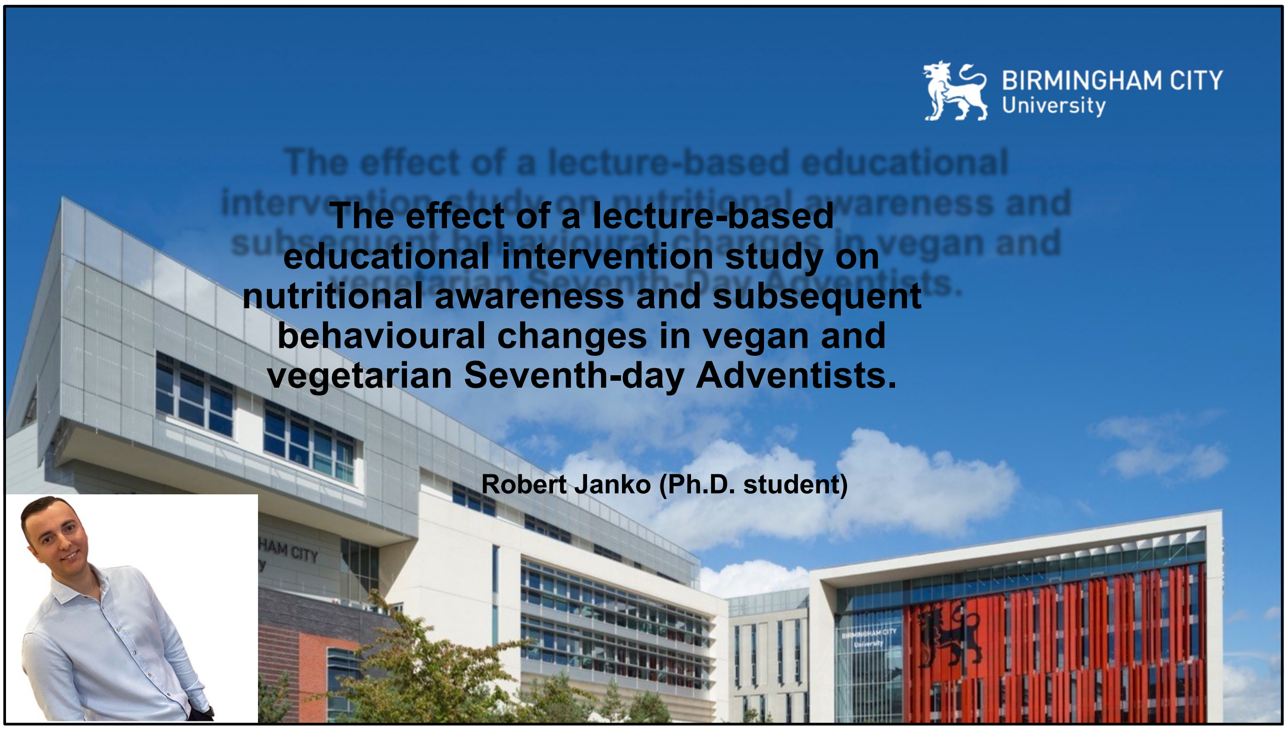
Funding and Conflict of Interest:

- Funding Source(s):
- Declared Conflicts of Interest:

Additional Notes:

- Further Observations:
- Comments on Methodology:
- Additional Relevant Information:

Appendix 14. Educational Intervention Lecture Slides

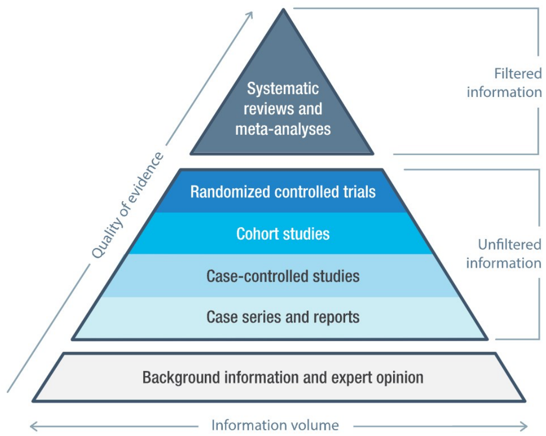


BIRMINGHAM CITY University

Lecture objectives

- Introduction
- Pros and cons of a vegan diet
- Position of the Adventist Church regarding plant-based diets • Nutrients of special important and supplementation strategies •
  Supplements for COVID-19 prevention and treatment
- Post-lecture questionnaire

The evidence hierarchy



https://openmd.com/guide/levels-of-evidence

Source: The Health Connection Newsletter | 3rd Quarter 2016

The Seventh-day Adventist Church encourages a balanced vegetarian diet. "The diet God ordained in the Garden of Eden–the vegetarian diet–is the ideal, but sometimes we cannot have the ideal. In those circumstances, in any given situation or locale, those who wish to stay in optimum health will eat the best food that they can obtain." — *Seventh-day Adventists Believe*, p. 286.

Review of Religious Research (2021) 63:535–557

Total *N* = 56.215	Vegan	Vegetarian	Pescatarian	Meat 1 × per week of less	Meat few times per week	Meat most days
West-Central Africa *N* = 2180	5.3%	13.9%	11.1%	23.7%	29.1%	22.0%
East-Central Africa *N* = 6927	11.4%	30.3%	15.7%	24.8%	14.4%	33.4%
Southern-Africa & Indian Ocean *N* = 4845	4.7%	10.8%	12.1%	34.0%	26.0%	12.4%
South America *N* = 14,239	1.8%	7.3%	6.7%	24.0%	31.6%	28.5%
Inter-America *N* = 4346	2.6%	11.0%	9.4%	41.5%	25.1%	10.4%
North America *N* = 1696	15.7%	35.1%	8.8%	20.6%	13.6%	10.4%
Trans-European *N* = 1184	6.2%	19.0%	11.7%	33.0%	23.7%	6.3%
Inter-European *N* = 3735	3.7%	17.4%	6.6%	41.5%	25.0%	5.7%
Euro-Asia *N* = 2095	2.2%	13.2%	8.1%	45.4%	24.4%	6.6%
North Asia–Pacific *N* = 2770	5.8%	15.6%	22.0%	32.3%	13.9%	10.4%
Southern Asia–Pacific *N* = 6258	4.9%	10.9%	16.2%	43.2%	18.4%	6.3%
Southern Asia *N* = 2822	6.5%	11.4%	4.0%	40.6%	29.8%	7.7%

BIRMINGHAM CITY University

Dietary practices of Seventh-Day Adventists across the globe

5

BIRMINGHAM CITY University

The benefits of plant-based diets

- Vegans have a lower BMI, cholesterol levels and blood pressure (Fraser, 2003)
- Vegan and vegetarian Adventists have lower colon and prostate cancer risk (Fraser, 1999).
- A meta-analysis revealed vegetarians and vegans had a 25% reduced risk of incidence and mortality from ischemic heart disease and an 8% reduced risk of cancer. Vegans had a 15% lower risk of cancer (Dinu et al. 2017).

Plant-based diets tend to be higher in fibre and other protective plant-compounds and they are lower in saturated fat (lower CVD risk).

1. Fraser G. Riskfactorsanddiseaseamongvegans. In: Fraser Ged. Diet, lifeexpectancy, andchronicdisease. Studiesof Seventh-dayAdventistsand other vegetarians. NewYork, NY: Oxford UniversityPress, 2003:231–9.
2. Associationsbetweendietandcancer, ischemicheartdisease, andall-causemortalityinnon-HispanicwhiteCaliforniaSeventh-dayAdventists. (88%higher riskamongnon-vegetarians) 3. https://pubmed.ncbi.nlm.nih.gov/26853923/
4. https://www.mja.com.au/journal/2013/199/4/omega-3-polyunsaturated-fatty-acids-and-vegetarian-diets

Potential concerns of plant-based diets

BIRMINGHAM CITY University

- Whilst plant-exclusive diets may contain high amounts of vitamin C, fiber, and other important nutrients, a 2021 systematic review showed that vegans might be at an increased risk of nutritional deficiencies: B , [2]Niacin (B), [3]B , D, iodine, zinc, calcium, potassium, selenium.
- According to a systematic review, vegetarians have a higher prevalence of depleted iron stores.
- Vegans are reported to have an increased risk of bone fractures.
- Omega 3 (EPA and DHA) blood and tissue levels are lower in vegetarians

1. https://pubmed.ncbi.nlm.nih.gov/33341313/
2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6367879/
3. https://pubmed.ncbi.nlm.nih.gov/30376075/#:~:text=Compared%20with%20omnivores%2C%20vegetarians%20and,CRD42017055508.

BIRMINGHAM CITY University

Key points of diet guidelines

Fiber: Fiber-rich foods like whole grains, legumes, and fruits promote healthy digestion and can reduce the risk of chronic diseases such as heart disease and type 2 diabetes
5-a-Day Fruits and Vegetables: Strive to consume at least five servings of fruits and vegetables daily (at least 400 grams).
Consume a balanced Plate: Create a balanced plate by incorporating a variety of food groups. A typical meal should include lean protein, whole grains, and colorful vegetables. This ensures a well-rounded intake of nutrients.
Limit Sugary and Processed Foods: Minimize the consumption of sugary beverages and processed foods high in added sugars, salt, and unhealthy fats. These can contribute to weight gain and health issues.
Portion Control: Be mindful of portion sizes to avoid overeating. Limit total fat intake to less than 30% of energy intake to manage calories.
Hydration Matters: Stay adequately hydrated by drinking water throughout the day. Limit sugary drinks and excessive caffeine intake. **Moderate Alcohol**: Limit alcohol consumption, but those choosing to consume it, limit to no more than 1 serving at a time.

Position on plant-based diets:

International guidelines acknowledge that well-planned plant-based diets can provide all the essential nutrients needed for health, including protein, vitamins (e.g., vitamin C, folate), and minerals (e.g., iron, calcium), but some nutrients may require supplementation.

1. https://www.dietaryguidelines.gov/sites/default/files/2021-03/Dietary_Guidelines_for_Americans-2020-2025.pdf
2. https://www.who.int/news-room/fact-sheets/detail/healthy-diet

There are different types of vegetarian diets including total (animal free), ovo-lacto (the most widely followed in the SDA church), and pesco (vegetarian with a little fish added). For those who live where there is an abundance of fortified food products, a healthy totally vegetarian diet may be the ideal with the following considerations:

- Choose ample whole grains, vegetables, legumes, fruits, nuts, seeds and berries.
- Avoid replacing animal foods with refined, sweet, fatty commercial products—even if these are from plant sources.
- Take a supplement of vitamin B12 regularly (remember, deficiency symptoms may take 4-6 years to appear).
- Obtain adequate sunlight, and emphasize high-calcium vegetables, and/or supplement your diet with calcium and Vitamin D.
- Consider the use of ground flax and or chia seeds or supplements high in omega-3 fatty acids, especially during reproductive years.
- Assure adequate dietary zinc, especially for young and adolescent boys.

https://www.healthministries.com/seventh-day-adventists-and-nutrition/

Vitamin B12

The role of vitamin B12:

Vitamin B12 is essential for the synthesis of nucleic acids (DNA), red blood cells and in the maintenance of myelin that covers neurons. Deficiency in vitamin B12 results in a variety of neurological symptoms.

1. https://pubmed.ncbi.nlm.nih.gov/2380031/#:~:text=Vitamin%20B12%20levels%20among%20the,higher%20than%20among%20the%20controls. 2. https://pubmed.ncbi.nlm.nih.gov/24667752/
3. Neufingerl & Eilander, 2021. Nutrient Intake and Status in Adults Consuming Plant-Based Diets Compared to Meat-Eaters: A Systematic Review

Vegans are at an increased risk of vitamin B12 deficiency

Vitamin B12 deficiency has been reported to be as high as 45% among vegan infants and 39% among pregnant women.

Solution:

Average vitamin B12 intake from food sources was shown to be below the Estimated Average Requirements (EAR) for vegans from food sources.

In studies that assessed intake from foods and <u>supplements,</u> all dietary patterns had a mean vitamin B12 intake <u>above</u> the EAR.

Neufingerl & Eilander, 2021

Iron status in vegans

Iron deficiency = inadequate iron intake and lower bioavailability of non-heme iron from plant foods compared to heme-iron in meat (especially red meat).

Iron deficiency anaemia symptoms may include decreased cognition, fatigue, less than optimal immune function, pregnancy complications

- Although vegetarians overall do not seem to have an increased prevalence of anaemia, vegan Adventist females may have an increased risk of low ferritin and haemoglobin levels

- Non-heme iron is less bioavailable, compared to heme iron, because of the naturally occurring absorption inhibitors, which mainly include phytate, oxalate, and polyphenols as well calcium in dairy products. However, vitamin C can increase its absorption.

Iron requirement:

•8.7mg a day for men aged 19 and over •14.8mg a day for women aged 19 to 49 •8.7mg a day for women aged 50 and over

Plant sources of iron:

- Beans, peas, and lentils are rich in iron (1 cup = 4.5mg) • Leafy Greens (half a cup = 3 mg)
- Seeds (100 g of sesame seeds = 14.5 mg) • Seaweed (dried)

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6367879/#:~:text=Likewise%2C%2013%25%20of%20vegan%20participants,%3C12%20%C2%B5g%2FL).&text=In%20this%20study%2C%20the%20percentage,(13%25%20vs%2010%25)
2. https://www.nhs.uk/conditions/vitamins-and-minerals/iron/

Omega 3 fatty acids

Alpha linoleic acid (ALA): Nuts and seeds (walnuts, chia seeds and flaxseeds, NOT almonds)
Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA): Fatty fish and algae

Health effect of omega 3 fats:

Higher blood levels of EPA and DHA are associated with lower risk of mortality.

Vegans show high intakes of ALA but very low intakes of the preformed omega 3 fats.

Harisetal. Bloodn-3 fattyacidlevelsandtotal andcause- specific mortalityfrom17prospectivestudies

Omega 3 fatty acids

- High dose flaxseed seed oil supplements, • Double intake of ALA and reduce Linoleic Acid

However, microalgal oil supplementation provided no increases to Omega 3 index and some studies showed reductions.

Solution:

- *Directly supplement with algae oil:* A supplement of 200–300 mg/day of DHA and increased O3I levels for all studies.
- EPA is suggested for those with increased needs, such as pregnant and lactating women and those with reduced conversion ability, such as older people or those who have chronic dsease (eg, diabetes).

https://pubmed.ncbi.nlm.nih.gov/33576691/

https://pubmed.ncbi.nlm.nih.gov/24679552/#:~:text=The%20omega%2D3%20index%20increased,little%20docosahexaenoic%20and%20eicosapentaenoic%20acids

	AI		
Sex and age group	Combined EPA + DHA + DPA	ALA	Suggested ALA for vegetarians[20]
Men	160 mg	1.3 g	2.6 g
Women	90 mg	0.8 g	1.6 g
Pregnant	115 mg	1.0 g	2.0 g
Lactating	145 mg	1.2 g	2.4 g
Children			
1–3 years	40 mg	0.5 g	1.0 g
4–8 years	55 mg	0.8 g	1.6 g
Boys 9–13 years	70 mg	1.0 g	2.0 g
Boys 14–18 years	125 mg	1.2 g	2.4 g
Girls 9–13 years	70 mg	0.8 g	1.6 g
Girls 14–18 years	85 mg	0.8 g	1.6 g

Vitamin D

Vitamin D deficiency is linked to:

- Musculoskeletal diseases (rickets, bone fractures, osteomalacia, osteopenia, osteoporosis, and muscle weakness)
- Cardiovascular disease (congestive heart failure, myocardial infarction, atrial fibrillation and hypertension)
- Infections
- Autoimmune conditions

Table 22.1 Vitamin D status guidelines.

Vitamin D status	25OHD (nmol/L)	25OHD (ng/mL)
Deficiency	<50	<20
Insufficiency	50–75	20–30
Sufficiency	75–100	30–44
Toxicity	>250	>100

Price et al. 2020. Molecular Nutrition

Forms and sources of vitamin D

Sun exposure: 7-dehydrocholesterol (7DHC) activation in the lower layers of the skin by UV B light produces vitamin D

Diet:

- Vitamin D3: cholecalciferol (Salmon and dairy) – Biologically active form • Vitamin D2: ergocalciferol (Mushroom, fortified foods) Supplementation

Risk factors for vitamin D deficiency

- inadequate sun exposure, limited oral intake,
- impaired intestinal absorption, long-term use of medications (glucocorticoids, antiepileptic drugs)
- aging.

https://pubmed.ncbi.nlm.nih.gov/22552031/

The importance of Vitamin D supplementation

BIRMINGHAM CITY University

Risk of vitamin D deficiency is greater in vegans (Selinger et al. 2022)

Vegans are at a greater risk of bone fractures (Rees et al., 2021).

supplementation

Parameter	Vegans	Omnivores	p	Reference intervals
25-hydroxyvitamin D (nmol/L)	68.6 (21.5–88.1)	45.4 (34.6–68.6)	0.34	20–150

Weikert et al. 2020.

BIRMINGHAM CITY University

Dietary supplements for COVID-19 disease

Vitamin D Supplementation

BIRMINGHAM CITY University

- Reduction in COVID-19 positivity *(54%)* - Reduction in COVID-19 symptoms
- Reduction in ICU admission *(65%)* - Reduction in mortality *(54%)*

But

- There is insufficient evidence to show that vitamin D can reduce the risk of hospitalization

Minimum dose used in the studies: 2000 IU/day

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8862170/
https://pubmed.ncbi.nlm.nih.gov/35631275/

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8862170/
https://pubmed.ncbi.nlm.nih.gov/35631275/

Zinc

BIRMINGHAM CITY University

- Zinc supplementation led to a 43% lower risk of mortality.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9125011/

Vitamin C

- Supplementation can effectively lower the length of hospital stay
- It can also lower the risk of dying from COVID-19 (independent of dose)

https://pubmed.ncbi.nlm.nih.gov/34739908/ https://pubmed.ncbi.nlm.nih.gov/36235869/

Curcumin

- Supplementation can improve inflammatory response: cytokine storm (IL1β and IL6)
- It can lead to a decrease in COVID-19 symptoms including a reduction in thromboembolic events.

Dosing: At least 160mg/day (multiple doses)

https://pubmed.ncbi.nlm.nih.gov/35057437/

Probiotic Supplements

BIRMINGHAM CITY University

Clinical efficacy of probiotics in the treatment of patients with COVID-19: A systematic review and meta-analysis of randomized controlled trials

Jheng-Yan Wu [1], Po-Yu Huang [2], Ting-Hui Liu [3], Chia-Yin Kuo [1], Ya-Wen Tsai [4], Hung-Jen Tang [2], Chih-Cheng Lai [5] [6]

Results: Eight RCTs with 900 patients were included. The study group receiving probiotics had a non-significantly lower rate of mortality than the control group had, but this difference was not significant (risk ratio [RR], 0.51; 95% CI, 0.22 to 1.16). However, the study group had significantly lower rates of dyspnea (RR, 0.11; 95% CI, 0.02 to 0.60), fever (RR, 0.37; 95% CI, 0.16 to 0.85) and headache (RR, 0.19; 95% CI, 0.05 to 0.65). Higher complete remission of COVID-19-associated symptoms was observed in the study group than the control group (RR, 1.89; 95% CI, 1.40-2.55).

- Reduction in COVID-19 symptoms -
No significant reduction in mortality

BIRMINGHAM CITY University

Vitamin A

A meta-analysis published in 2022 (October) that included 15 clinical trials on children showed that vitamin A supplementation alongside conventional treatment:

shortened the time of hospitalization due to COVID-19 pneumonia, but did not lower mortality rate

https://pubmed.ncbi.nlm.nih.gov/36281101/

Appendix 15. Checklist for Reporting Results of Internet E-Surveys (CHERRIES)

Checklist Item	***Explanation***	***Description***
Describe survey design	Describe target population, sample frame. Is the sample a convenience sample? (In "open" surveys this is most likely.)	The study employed a quasi-experimental design and collected cross-sectional data before and after an online educational intervention. The study utilised convenience sampling. Adult Seventh-day Adventists living in the UK who followed a vegan, vegetarian, or pescatarian diet were recruited.
IRB approval	Mention whether the study has been approved by an IRB.	This study received ethical approval from the Health Education and Life Sciences Faculty Academic Ethics

		Committee of Birmingham City University.
Informed consent	Describe the informed consent process. Where were the participants told the length of time of the survey, which data were stored and where and for how long, who the investigator was, and the purpose of the study?	Participants were provided with a Participant Information Sheet which contained all essential information about how their data would be stored and for how long. Participants were required to provide informed consent by agreeing to the provided Consent Form.
Data protection	If any personal information was collected or stored, describe what mechanisms were used to protect unauthorized access.	The only personal data collected was the email addresses of participants and this was stored in encrypted files.
Development and testing	State how the survey was developed, including whether the usability and technical functionality of the electronic questionnaire had been tested before fielding the questionnaire.	The pre- and post-intervention questionnaires developed for this study were validated through a small pilot involving 6 Adventists. The questionnaire demonstrated high internal consistency (Cronbach's alpha = 0.873) and test-retest reliability (Pearson's r = 0.85, p = 0.03).
Open survey versus closed survey	An "open survey" is a survey open for each visitor of a site, while a closed survey is only open to a sample which the investigator knows (password-protected survey).	The survey was only available to participants who attended the online lecture. It was shared with participants at the time of the lecture, therefore it can be considered as a closed survey since no one outside the lecture had access to it.
Contact mode	Indicate whether or not the initial contact with the potential participants was made on the Internet. (Investigators may also send out questionnaires by mail and allow for Web-based data entry.)	Initial contact was made with participants via email on the internet.
Advertising the survey	How/where was the survey announced or advertised? Some examples are offline media (newspapers), or online (mailing lists – If yes, which ones?) or banner ads (Where were these banner ads posted and what did they look like?). It is important to know the wording of the announcement as it will heavily	The study was advertised on social media channels to Seventh Day Adventists but participants who had taken part in previous research were also contacted via email.

	influence who chooses to participate. Ideally the survey announcement should be published as an appendix.	
Web/E-mail	State the type of e-survey (eg, one posted on a Web site, or one sent out through e-mail). If it is an e-mail survey, were the responses entered manually into a database, or was there an automatic method for capturing responses?	The e-survey was created in Microsoft Forms. The survey link was shared during the meeting with particicpants. The FU survey was sent to them via email.
Context	Describe the Web site (for mailing list/newsgroup) in which the survey was posted. What is the Web site about, who is visiting it, what are visitors normally looking for? Discuss to what degree the content of the Web site could pre-select the sample or influence the results. For example, a survey about vaccination on a anti-immunization Web site will have different results from a Web survey conducted on a government Web site	The survey was not shared publicly. It was only shared with the consenting participants who attended the lecture.
Mandatory/voluntary	Was it a mandatory survey to be filled in by every visitor who wanted to enter the Web site, or was it a voluntary survey?	Participation was voluntary, but only participants who attended the lecture had access to it.
Incentives	Were any incentives offered (eg, monetary, prizes, or non-monetary incentives such as an offer to provide the survey results)?	No incentives were offered to participants.
Time/Date	In what timeframe were the data collected?	Data collection took place between December, 2023 and February, 2024.
Randomization of items or questionnaires	To prevent biases items can be randomized or alternated.	No randomization was used.
Adaptive questioning	Use adaptive questioning (certain items, or only conditionally displayed based on responses to other items) to reduce number and complexity of the questions.	Adaptive questioning was used for COVID 19 related questions. For example, only participants who indicated a COVID-19 infection were asked regarding symptom severity.

Number of Items	What was the number of questionnaire items per page? The number of items is an important factor for the completion rate.	
Number of screens (pages)	Over how many pages was the questionnaire distributed? The number of items is an important factor for the completion rate.	Microsoft Forms does not present the questionnaire on separate pages, but it was a continuous survey with an estimated completion rate of 6 minutes for the pre-lecture questionnaire and 4 minutes for the post-lecture questionnaire. The pre-lecture questionnaire contained 41 questions in total, whilst the post-lecture questionnaire had 29 questions.
Completeness check	It is technically possible to do consistency or completeness checks before the questionnaire is submitted. Was this done, and if "yes", how (usually JAVAScript)? An alternative is to check for completeness after the questionnaire has been submitted (and highlight mandatory items). If this has been done, it should be reported. All items should provide a non-response option such as "not applicable" or "rather not say", and selection of one response option should be enforced.	All questions were mandatory, therefore the questionnaire could not be sumitted by the participants if they have not answered all the questions. Non-response items such as "I don't know" and "Unsure" were also used.
Review step	State whether respondents were able to review and change their answers (eg, through a Back button or a Review step which displays a summary of the responses and asks the respondents if they are correct).	They could scroll up and down on the survey page which included all questions, which means they had the option to review and change their answers.
Unique site visitor	If you provide view rates or participation rates, you need to define how you determined a unique visitor. There are different techniques available, based on IP addresses or cookies or both.	Not applicable
View rate (Ratio of unique survey	Requires counting unique visitors to the first page of the	Not applicable since it was not an online survey. All 37 participants

visitors/unique site visitors)	survey, divided by the number of unique site visitors (not page views!). It is not unusual to have view rates of less than 0.1 % if the survey is voluntary.	who attended the lecture and visited the survey page also completed the questionnaire.
Participation rate (Ratio of unique visitors who agreed to participate/unique first survey page visitors)	Count the unique number of people who filled in the first survey page (or agreed to participate, for example by checking a checkbox), divided by visitors who visit the first page of the survey (or the informed consents page, if present). This can also be called "recruitment" rate.	Not applicable since it was not an online survey. All 37 participants who attended the lecture and visited the survey page also completed the questionnaire.
Completion rate (Ratio of users who finished the survey/users who agreed to participate)	The number of people submitting the last questionnaire page, divided by the number of people who agreed to participate (or submitted the first survey page). This is only relevant if there is a separate "informed consent" page or if the survey goes over several pages. This is a measure for attrition. Note that "completion" can involve leaving questionnaire items blank. This is not a measure for how completely questionnaires were filled in. (If you need a measure for this, use the word "completeness rate".)	Not applicable since it was not an online survey. All 37 participants who attended the lecture and visited the survey page also completed the questionnaire.
Cookies used	Indicate whether cookies were used to assign a unique user identifier to each client computer. If so, mention the page on which the cookie was set and read, and how long the cookie was valid. Were duplicate entries avoided by preventing users access to the survey twice; or were duplicate database entries having the same user ID eliminated before analysis? In the latter case, which entries were kept for analysis (eg, the first entry or the most recent)?	No cookies were used. However, duplicate entries were avoided by asking participants to provide the first three letters of their surname and the first three letters of the month they were born in. This also allowed us to match the before and after questionnaire responses. This served as their participant ID.

IP check	Indicate whether the IP address of the client computer was used to identify potential duplicate entries from the same user. If so, mention the period of time for which no two entries from the same IP address were allowed (eg, 24 hours). Were duplicate entries avoided by preventing users with the same IP address access to the survey twice; or were duplicate database entries having the same IP address within a given period of time eliminated before analysis? If the latter, which entries were kept for analysis (eg, the first entry or the most recent)?	No, this was not done.
Log file analysis	Indicate whether other techniques to analyze the log file for identification of multiple entries were used. If so, please describe.	Not applicable
Registration	In “closed” (non-open) surveys, users need to login first and it is easier to prevent duplicate entries from the same user. Describe how this was done. For example, was the survey never displayed a second time once the user had filled it in, or was the username stored together with the survey results and later eliminated? If the latter, which entries were kept for analysis (eg, the first entry or the most recent)?	Duplication was avoided by asking for participants to provide their unique participant ID (described above). The number of responses were counted up and compared to the number of lecture attendees, both of which were 37.
Handling of incomplete questionnaires	Were only completed questionnaires analyzed? Were questionnaires which terminated early (where, for example, users did not go through all questionnaire pages) also analyzed?	Only completed questionnaires were analyzed.
Questionnaires submitted with an atypical timestamp	Some investigators may measure the time people needed to fill in a questionnaire and exclude questionnaires that were	No cut off was used.

	submitted too soon. Specify the timeframe that was used as a cut-off point, and describe how this point was determined.	
Statistical correction	Indicate whether any methods such as weighting of items or propensity scores have been used to adjust for the non-representative sample; if so, please describe the methods.	No such statistical adjustment has been made.