

Health and Well-being Impact of Coronavirus: A Case study of West Midlands vs England

1st Diana Haidar
Computing and Digital Technology
Birmingham City University
Birmingham, United Kingdom
diana.haidar@bcu.ac.uk

2nd Nora Hérault
ISIS Engineering School
INU Champollion
Castres, France
noraherault@yahoo.fr

3rd Abdel-Rahman Tawil
Computing and Digital Technology
Birmingham City University
Birmingham, United Kingdom
abdel-rahman.tawil@bcu.ac.uk

4th Nigel Sharratt
Information Technology & Digital Services
Birmingham City Council
Birmingham, United Kingdom
Nigel.Sharratt@birmingham.gov.uk

5th Konstantinos Vlachos
Computing and Digital Technology
Birmingham City University
Birmingham, United Kingdom
konstantinos.vlachos@bcu.ac.uk

6th Edlira Vakaj
Engineering and the Built Environment
Birmingham City University
Birmingham, United Kingdom
edlira.vakaj@bcu.ac.uk

Abstract—The COVID-19 pandemic represents a global public health emergency that is becoming an economic crisis, a social crisis and a well-being crisis. Countries around the world have taken unprecedented precautionary measures against COVID-19 to control the spread of the disease and to ensure the well-being of their people. This study investigates the health and well-being impact of COVID-19 based on a case study of West Midlands - a region having several big local authorities including Birmingham, the second biggest UK city - compared to England. The data used in this study are open data from the Office for National Statistics¹. In collaboration with Birmingham City Council and using data analysis techniques and Business Intelligence tools and strategies we demonstrate how to convert raw survey data into actionable and coherent information. The output from our research can be used by local governments to better understand the impact of the Coronavirus and ensued lock-downs on the health and well-being of West Midlands citizens with the aim to support decision making and to direct the provisioning of services. Our analysis showed that the dimensions of well-being (e.g. worthwhile, satisfaction, happiness, anxiety) are improving for West Midlands and England citizens, and that citizens are less worried about the effect of the coronavirus outbreak (from 76% in mid February to 57% in mid May in West Midlands), however, they are less optimistic about when life will return to normal (*more than a year*). In addition, utilising Linear Regression and correlation analysis, it was proven that the COVID-19 economic and social issues have an influence on the well-being of citizens, thus emphasising the importance of addressing these issues which will consequently mitigate their effect on well-being.

Index Terms—COVID-19, data analysis, business intelligence, linear regression, correlation analysis

I. INTRODUCTION

On 30 January 2020, the World Health Organization (WHO) declared the coronavirus outbreak a Public Health Emergency of International Concern [1]. On 5 March 2020, Public Health England (PHE) confirmed the first case of COVID-19 in Birmingham - West Midlands, England. Since then, more than

113K have died in England, more than 4.26M have tested positive for COVID-19, and many more are suffering from long term effects of the virus [2].

The pandemic and the ensuing lockdown measures that were regularly updated since 23 March 2020 in the United Kingdom (UK), have had a detrimental impact on the physical and mental health and well-being of West Midlands' citizens. Indeed, dimensions of economic and social impacts of COVID-19 are likely to have an impact on the well-being of the population. There is substantial evidence that COVID-19 will have long-term consequences on well-being, and it is important that local governments focus their efforts and resources on addressing these consequences for their citizens' best interest. This will further help councils to be more prepared for any ripple-effects as a consequence of the pandemic in the future.

In this paper, we investigate the impact of the COVID-19 pandemic on health and well-being of adults (aged 16 years and over) living in West Midlands compared to that in England. Further, our study explores if the COVID-19 economic and social impacts affect the health and well-being of West Midlands' citizens, with the aim to understand how Birmingham City Council (BCC) should better target its efforts and resources.

The rest of this paper is organised as follows. In Section II, we give a brief background on the approaches addressing the impact of COVID-19 on well-being. In Section III, we present our approach to analyse the impact of COVID-19 on the health and well-being of the population in West Midlands compared to that in England. We also perform Linear Regression (LR) modelling and correlation analysis to examine the influence of economic/social factors on well-being. Finally, we conclude this paper in Section IV.

II. BACKGROUND

Simon et al. [3] explored the impacts of the Covid-19 lockdown and relevant vulnerabilities on well-being, mental

¹The Office for National Statistics (ONS) represent the executive office of the UK Statistics Authority reporting directly to the UK Parliament.

health and social support in Austria. The study was based on cross-sectional data collected via an online survey where 560 respondents were included in the analysis. 31% of the respondents reported low mental well-being such that 30% of them have received mental health treatment prior to the pandemic. The limitation of their study is that the respondents completed survey questions referring to the lockdown period (more than one month before) which may have introduced some recall bias.

Favieri et al. [4] conducted an online survey on the Italian population to assess their general psychological well-being and their perceptions about the life impact of the COVID-19 outbreak. The survey included 1639 respondents and revealed positive linear correlations between age and most dimensions of psychological well-being (e.g. anxiety, depression, self-control, etc.). Their study also performed Logistic regression and found that being a woman from the age groups of 18–29 and 30–49 with the presence of health risk factors represent higher risk for experiencing low psychological well-being.

In the UK, a study on the population was conducted by White and Van Der Boor [5] on an online survey completed by a total of 600 participants who answered demographic and COVID-19 related questions. The study shows that self-isolation was associated to higher levels of depression symptoms, and participants with better connections to the local community have lower levels of depression symptoms. The limitation of this study is that it does not track over time the impact of the COVID-19 pandemic and lock-down restrictions on mental health and well-being.

The Meaningful Integration of Data Analytics and Services (MIDAS) platform was explored by Costa et al. [6] who described how its resources were refocused to address public health priorities related to COVID-19. The authors mentioned, for instance, how the MIDAS pilot in Finland focused on the prevention of mental health problems in young people, however, did not present a use case evaluation using MIDAS.

III. APPROACH

In this section, we detail our approach to understand the impact of coronavirus on health and well-being in West Midlands compared to that in England. Fig. 1 presents an overview of our approach architecture and its different components. In this study, we utilised the ‘‘Coronavirus and the social impacts on Great Britain’’ (CSI) survey data set [7] available from the Office for National Statistics (ONS) website. The open survey data is ingested to the ‘data preprocessing’ component where the Key Performance Indicators (KPIs) are identified, then data extraction and transformation followed by cleaning is performed using a Python script to prepare the data for the ‘data analysis’ component. In the latter component, we use PowerBI and R script visuals to visualise and analyse the data. We also performed LR modelling and correlation analysis using Python scripts to identify correlations between economic and social factors and well-being level.

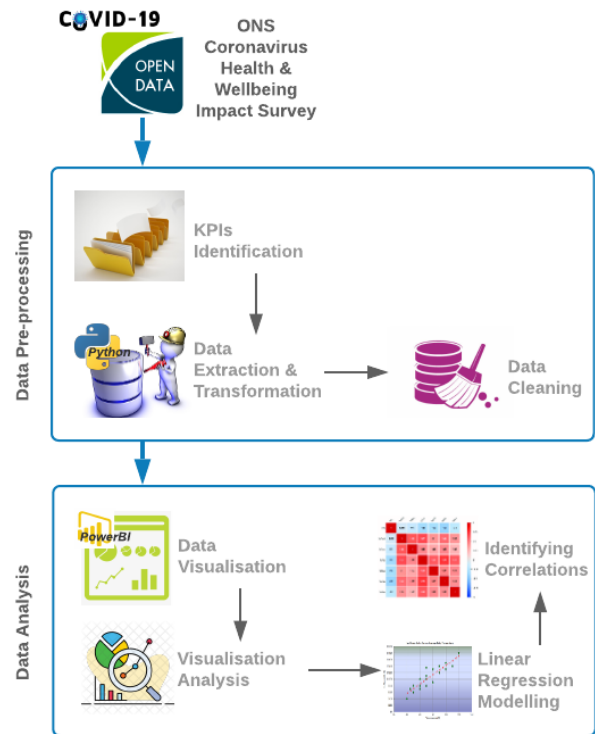


Fig. 1: Approach overview for understanding the coronavirus impact on Health and well-being.

A. Description of Data Set

The CSI data set contains data and indicators from a module being undertaken through the Opinions and Lifestyle Survey (OPN) [8] and has weekly releases covering the period from March 2020 to May 2021. Since March 2020, the OPN survey became weekly with the aim to understand how the Coronavirus pandemic is affecting living in Great Britain. Each week, around 6000 adults (aged 16 years or older and living in Great Britain) are contacted to fill in an online self-completion questionnaire, which can be done via the telephone if requested. The achieved sample for the OPN is currently approximately 4000 to 4500 individuals per week which corresponds to an average response rate of 72%.

The CSI data contains as well estimates with their associated Lower and Upper 95% Confidence Levels (LCL and UCL respectively) and is broken down by age, sex, region and country. In our study, we focused on the region ‘West Midlands’ and the country ‘England’ breakdowns. The sample size of the data we used for England is approximately 4000 compared to approximately only 400 for West Midlands. In order to make the sample of the survey representative of the population, responses are weighted. ‘Weighted count’ provides the representative count for each breakdown. In addition, all estimates in this data are rounded to whole numbers thus totals may not add exactly.

B. Data Preprocessing

The CSI data provided on the ONS website is raw survey data of percentage or mean values of responses to questions

including single-response and multiple-response questions. As stated above, it is broken down to age, gender, countries in UK (including England, Wales and Scotland), and regions in England (including West Midlands, etc.).

In our collaboration with BCC, we are interested to study the case of Birmingham, however, due to the unavailability of health and well-being data at the level of the city, we focused our study on West Midlands which has Birmingham as its biggest city. In our study, we also used data on England to compare the level of health and well-being of the West Midlands population to that in England. Wales and Scotland were excluded from our study and are considered outside the scope for our study, also, the estimates in Wales and Scotland are based on very low sample sizes and analysis on these data are considered not reliable. Furthermore, we excluded age and gender from our study as these breakdowns are over the whole of the UK but not available at sufficient levels of granularities to be considered in our study (e.g. regions, constituents or wards). Despite that, it is worth noting that the sample size for males and females are approximately equal, and we hypothesise the case is the same over West Midlands and UK, thus there is no gender bias in the data.

We will detail below the identification of Key Performance Indicators (KPIs) in the CSI data, and then explain the steps of data extraction and transformation performed to make the data ready for analysis.

1) *KPIs Identification*: The CSI data contains multiple tables of questions that address different coronavirus impacts including health, well-being, economic, social, vaccine uptake and sentiment related questions, etc. The focus of this work is on selecting the health, well-being, economic, and social questions of interest to present the KPIs of our study. Below we list the KPIs as categories of metrics:

- **Health and well-being metrics**: Low levels of life satisfaction, Low levels of worthwhile, Low levels of happiness, High levels of anxiety, Worry about the effect that the Coronavirus outbreak is having on your life, Life returns to normal, Access to healthcare and treatment for non-coronavirus related issues is being affected, My access to paid or unpaid care is being affected, My exercise routine is being affected, My health is being affected, My well-being is being affected
- **Economic metrics**: My work has been affected, My household finances are being affected
- **Social metrics**: Access to groceries, medication and essentials are being affected (e.g. depending on others to shop for me), My relationships are being affected, My caring responsibilities are being affected

2) *Data Extraction and Transformation*: Based on the identified KPIs of interest, we implemented a Python script (Python 3.8.3 64-bit — Qt 5.9.7 — PyQt5 5.9.2) to extract the KPIs for West Midlands and England from the CSI raw survey data and transform it to a structured format suitable to use in our analysis. A limitation of the CSI data is that the format of provided data and questions may differ across releases based on updates to questions. To address this, we

focused our analysis on the latest releases where data started to be consistent in format. Our aim is to analyse the current level of well-being for the population in West Midlands vs England, together with examining the trend of change in levels over time. The new structured format of the data consists of the following features: date, region, metric, sub_metric, value, LCL, UCL, sample_size, weighted_count.

Furthermore, we performed some data cleaning steps on the CSI data as described in the following to ensure data is properly ready for analysis. The data includes estimates with ‘.’ which refer to statistics on small sample sizes (10 or fewer respondents) that have been suppressed due to uncertainty. We replaced these estimates with null to exclude from our analysis. Also, it includes estimates with ‘< 1’ which refer to float values, because all estimates are rounded to whole numbers in the survey, so we replaced these estimates with 0.9.

C. Data Analysis and Discussion

After the data processing is completed, we fed the structured data to the ‘data analysis’ component where its role is detailed below.

1) *Data Visualisation and Analysis*: We utilised the PowerBI Business Intelligence (BI) tool (Version: 2.90.782.0 64-bit) to create PowerBI visuals and R script visuals (Version 1.4.1106) integrated in PowerBI that helped in understanding the data and provided insights about the level of well-being for the population in West Midlands and compared to the average of that in England.

In Fig. 2, we present the well-being levels of adults in West Midlands and England in percentages. The blue and red shades represent the 95% confidence interval (bounds between LCL and UCL). We can observe that the percentages of adults reporting *Low levels of worthwhile, life satisfaction and happiness* has slightly decreased compared to mid February 2021. Regarding the percentage of people reporting *High level of anxiety*, even though it has decreased slightly, there is still a considerable percentage of anxious adults (West Midlands: 29%, England: 32%).

Fig. 3 shows the percentages of adults *Worried or unworried about the effect that the Coronavirus outbreak is having on their lives*. We can notice that the overall trend is approximately the same in West Midlands and England. The percentages of people *Very or somewhat worried* remain high ($\approx 55\%$) in both regions, however, it have been decreasing since mid February: from 76% to 57% in West Midlands in mid May; and from 71% to 55% in England.

Fig. 4 shows the responses of citizens in West Midlands and England to the question *How long do you think it will be before life returns to normal?*. The vertical dotted lines represent the timeline of measures undertaken by the UK government. We notice that, since 24 March 2021, the citizens in West Midlands and England became less optimistic than before, where the majority of responses were for *More than a year*. We also notice that the percentage of respondents to *6 months or less* and the percentage of *7 to 12 months* increased and decreased respectively after Step 1 of easing restrictions.

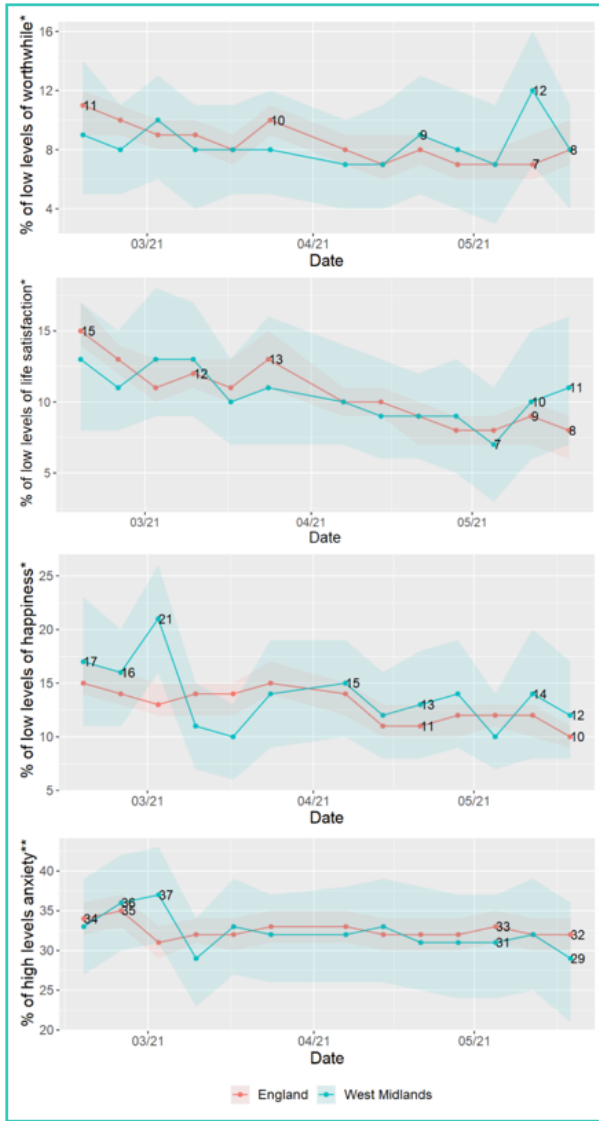


Fig. 2: well-being levels - Worthwhile, life satisfaction, happiness and anxiety (%)

*Score of 4 or below for their respective questions.

**Score of 6-10 for the question "How anxious did you feel yesterday?"

As mentioned earlier, we also extracted from the CSI data survey KPIs related to coronavirus and how it's affecting adult's health (e.g. *My access to paid or unpaid care is being affected*, *My exercise routine is being affected*, *My health is being affected*, *My well-being is being affected*). In both West Midlands and England, *My well-being is being affected* has the highest percentage of respondents over time with last report of approximately 40% on the 19th of May 2021. This percentage is almost double or more than double the percentage of respondents for each of the other coronavirus ways affecting adult's health. Hence, well-being is the mostly affected and should be given a vital priority in addressing the current and long-term effects of the coronavirus.

2) *LR Modelling and Correlation Analysis*: The rest of this section addresses the influence of the economic and social factors on the well-being of citizens in West Midlands and

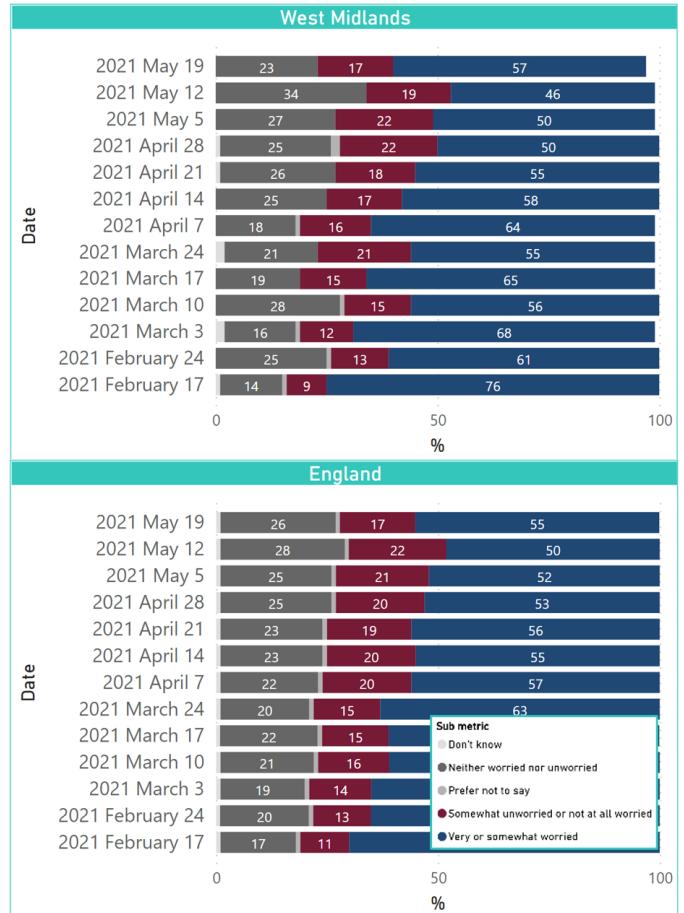


Fig. 3: Worried or Unworried about the effect that the Coronavirus outbreak is having on their life (%)

England using LR modelling and correlation analysis. We implemented a Python script (Python 3.8.3 64-bit — Qt 5.9.7 — PyQt5 5.9.2) to generate LR models and to calculate the Pearson and Spearman correlation coefficients.

In order to understand the underlying relationships between the economic/social factors and well-being, we performed LR modelling as shown in Fig. 5. In England, we observe that the linear regression lines fit the relationships with a high confidence (small area of confidence interval) for each of the economic/social factors with respect to (w.r.t.) well-being metrics except for *High levels of anxiety*, where it shows low confidence. On the other hand, in West Midlands, the linear regression lines do not fit the relationships and the results are displayed with low confidence.

Given the results of the LR models, we used the Pearson correlation coefficients to capture the linear relationships between the economic/social factors and well-being as shown in TABLE I. It is worth noting that we tried the Spearman correlation coefficients to explore if there exists non-linear relationships, however, the results for Pearson correlation were better than that for Spearman correlation, so the latter was excluded from our analysis. For England, we notice a positive correlation with mostly very high significance ($p < 0.001$) between the economic/social factors and the well-being met-

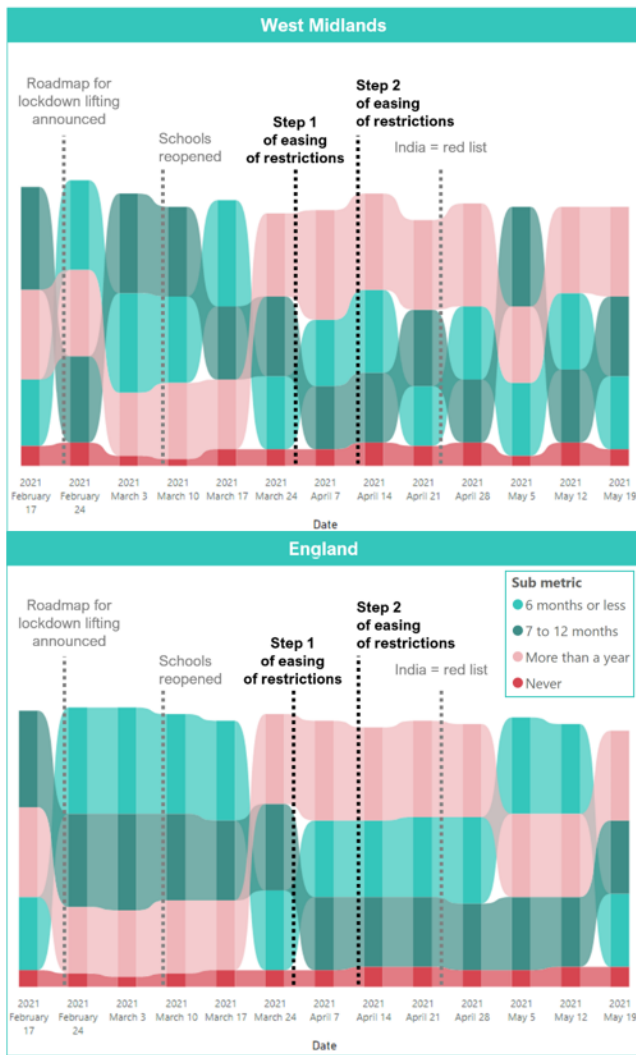


Fig. 4: Life returns to normal (%)

rics except for *High levels of anxiety*. For West Midlands, the results mostly show very low correlation with no significance for most of the relationships except for an average positive correlation with significance ($p < 0.05$) between *My Work has been affected* and all the well-being metrics excluding *Low levels of worthwhile*, as well as between each of the social factors and selected well-being metrics. The results reconfirm our earlier analysis for LR modelling.

We hypothesise that the results with no significance for most of the relationships between the economic/social factors and well-being for West Midlands are due to its small sample size (≈ 400) available in the CSI data compared to the sample size available for England (≈ 4000). Thus, if the sample of West Midlands is well enriched with more respondents, this correlation captured for England can also be deduced for West Midlands, and the economic/social factors influence on well-being will become more evident. This implies the importance of putting more efforts in addressing the COVID-19 economic/social consequences which in turn will mitigate its negative well-being consequences on people.

IV. CONCLUSION

This study analyses the change in well-being levels of the West Midlands' citizens compared to England, and examines its correlation to economic and social factors during the COVID-19 pandemic. Across all the indicators, we noticed that the Coronavirus is less and less affecting the adults' well-being in West Midlands and England. Indeed, all the well-being levels are improving, nevertheless, the percentage of adults with high levels of anxiety is still high ($\approx 30\%$). In addition, the percentage of people *Very or somewhat worried* has fallen by 19% in West Midlands and approximately the same in England (16%). Even though the well-being levels have been improving and lock-down restrictions are regularly eased, citizens have started to be less optimistic about when life will return to normal since the 24th of March 2021. The significant findings in this study emphasises the great impact of the Coronavirus on well-being, thus we aimed to examine the influence of the economic and social impacts on the well-being. We proved that there exist clear correlations between economic and social factors with well-being levels for England. We hypothesise that these correlations also apply for West Midlands but it was not evident due to the limited data samples available for West Midlands and its fluctuations.

In our future work, we will examine correlations between vaccination uptake and number of positive cases tested with well-being levels of West Midlands' citizens. We will also search for data with finer granularity at the level Birmingham and the Birmingham wards to help BCC in better targeting its resources to the wards mostly affected by the COVID-19 economic, social, and well-being consequences.

REFERENCES

- [1] "Statement on the second meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV)," [https://www.who.int/news/item/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-\(2005\)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-\(2019-ncov\)](https://www.who.int/news/item/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov)), 2020, [Online; accessed 30-06-2021].
- [2] "COVID-19 cases overview in England - Google News," <https://news.google.com/covid19/map?hl=en-GB&mid=%2Fm%2F02jx1&gl=GB&ceid=GB%3Aen>, 2021, [Online; accessed 05/07/2021].
- [3] J. Simon, T. M. Helder, R. G. White, C. van der Boor, and A. Łaszewska, "Impacts of the covid-19 lockdown and relevant vulnerabilities on capability well-being, mental health and social support: an austrian survey study," *BMC public health*, vol. 21, no. 1, pp. 1–12, 2021.
- [4] F. Favieri, G. Forte, R. Tambelli, and M. Casagrande, "The italians in the time of coronavirus: psychosocial aspects of the unexpected covid-19 pandemic," *Frontiers in psychiatry*, vol. 12, 2021.
- [5] R. G. White and C. Van Der Boor, "Impact of the covid-19 pandemic and initial period of lockdown on the mental health and well-being of adults in the uk," *BJPsych open*, vol. 6, no. 5, 2020.
- [6] J. P. Costa, M. Grobelnik, F. Fuat, L. Stopar, G. Epelde, S. Fischaber, P. Poliwooda, D. Rankin, J. Wallace, M. Black *et al.*, "Meaningful big data integration for a global covid-19 strategy," *IEEE Computational Intelligence Magazine*, vol. 15, no. 4, pp. 51–61, 2020.
- [7] "Coronavirus and the social impacts on Great Britain," <https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthandwellbeing/datasets/coronavirusandthesocialimpactsongreatbritaindata/current>, 2021, [Online; accessed 23-06-2021].
- [8] "Opinions and Lifestyle Survey," <https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthandlifeexpectancies/methodologies/opinionsandlifestylesurveyqmi>, 2021, [Online; accessed 23-06-2021].

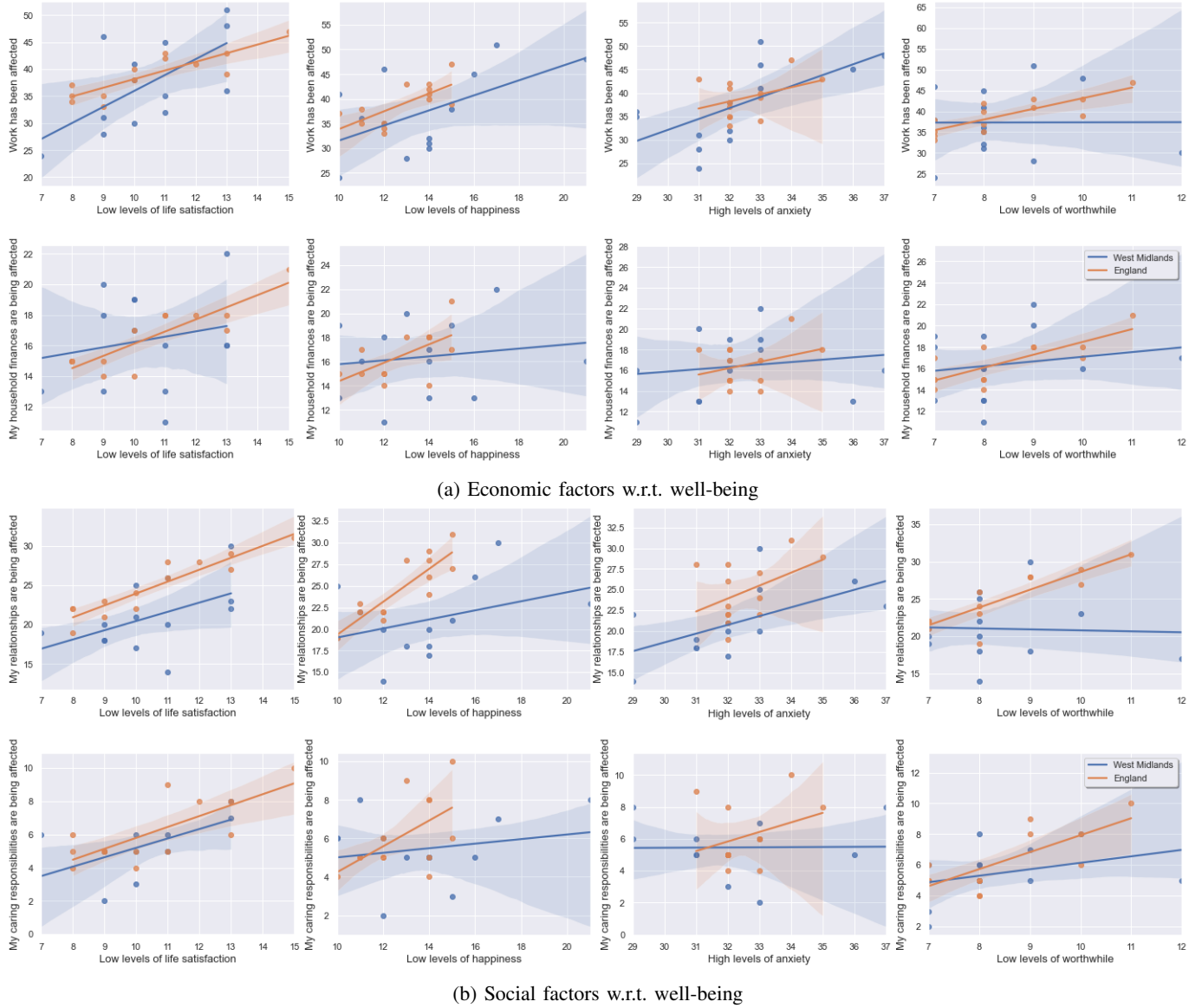


Fig. 5: Linear Regression modelling for economic/social factors w.r.t. well-being metrics.

Region		My work has been affected	My household finances are being affected	My relationships are being affected	My caring responsibilities are being affected
West Midlands	Low levels of life satisfaction	0.6388*	0.1955	0.4997	0.5980*
	Low levels of happiness	0.5556*	0.1532	0.3788	0.2128
	High levels of anxiety	0.6446*	0.1655	0.5770*	0.0129
	Low levels of worthwhile	0.0033	0.1876	-0.0425	0.3399
England	Low levels of life satisfaction	0.8559***	0.8574***	0.9255***	0.7482**
	Low levels of happiness	0.7020**	0.5975*	0.8547***	0.5599*
	High levels of anxiety	0.3812	0.3161	0.4505	0.3222
	Low levels of worthwhile	0.8156***	0.7702**	0.8683***	0.7486**

TABLE I: Pearson Correlation coefficients of each of the economic/social factors and well-being metrics.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Statistically significant coefficients ($p < 0.05$) in **bold**