Sustainable Practices in the Animal Health Industry: A Stakeholder-Based View.

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Abstract

The animal health industry provides treatments and pharmaceuticals for live animal welfare and it is essential to ensure food security and meet sustainable development goals (SDGs). Still, its complexity makes it difficult to identify the driving factors in the adoption of sustainability practices let alone offer recommendations to foster their implementation, resulting in a comparative lack of academic research in this area and several gaps in the overall comprehension of the phenomenon. Building on the stakeholder theoretical framework and adopting multi-country field research, this article offers both a theoretical and empirical contribution, highlighting the role of stakeholder perceptions in driving the adoption of ESI (environmental sustainable initiatives) and emphasising the need for effective communication, transparency and a consistent educational framework. Our findings also demonstrate that, by adopting overarching sustainability approaches such as the 'One Health' philosophy, animal health firms can integrate environmental sustainability initiatives into their operations, embedding the expectations and priorities of various stakeholders. This holistic approach will not only promote the well-being of animals and humans but also help protect ecosystems and ensure the long-term viability of the veterinary pharmaceutical industry.

Keywords: sustainable health, sustainability, stakeholder engagement, animal health

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1. The Animal Health Industry. An Introduction.

The animal health industry consists of a variety of products and services, from providing treatments for live animal welfare to pharmaceuticals for livestock. Animal health companies (among which Zoetis, Boehringer Ingelheim, Bayer and Ceva Sante are market leaders) address health threats to the human-animal-ecosystem interface, including antimicrobial resistance, food-borne zoonosis, and food safety. Veterinarians and paraprofessionals are the critical links between companies and their customer bases, prescribing and advising on medicines, vaccines, nutrition, and general health care products. The numbers are significant: if the livestock market generated $38 billion turnover in 2021, growing at a yearly rate of about 12%, the global animal health market reached $44.59 billion in 2022, and it is expected to grow at an annual rate of 8.2% to reach $83.39 billion by 2030 (Green view research, 2022).

Disease outbreaks in animals have major economic costs, with direct impacts on the incomes of rural communities that rely on livestock production for survival (WOAH, n.d.). The impact on health is even more critical as 75% of emerging infectious human diseases have an animal origin. By providing treatments for diseases and improving health and well-being, animal health companies contribute (Sreenivasan & Reddy, 2019) to sustainable development goals (SDGs), including ensuring food security, economic growth, and environmental protection. Few industries have had such a positive impact on society.

However, the animal health industry is also a polluting industry, with a high waste-to-output ratio (Bengtsson-Palme et al., 2018; Sheldon, 2017). Materials and substances may be released into the environment through the air, water in wastewater, and land in the form of solid waste while producing animal health firms. The main route of the release of drugs into the environment is likely to be through waste effluents produced during the cleaning of equipment used in the production process, the disposal of waste material, excretion by grazing animals, spillage during the external application, or direct exposure/discharge to the environment (Boxal et al., 2004). Besides releasing large amounts of greenhouse gas (GHG), these products can contaminate soil and water and may have negative effects on terrestrial biota if applied at rates exceeding recommended levels.

The pharmaceutical industry, including the animal health sector, has a high environmental impact due to its high energy consumption (Wernet et al., 2010), chemical waste (De Soete et al., 2014), and greenhouse gas emissions (Jimenez-Gonzalez & Overcash, 2014). Energy consumption accounts for 65-85% of its environmental impact and 90-95% of its total carbon footprint, costing around $1 billion annually (Chaturvedi et al., 2017). There has been increasing awareness of the negative environmental impacts of some medicines (Perkins et al., 2020), leading to efforts by major players in the industry to become carbon-neutral and reduce their environmental impact (CCS, 2021). Sweden has also developed an action plan to reduce the environmental impact of pharmaceutical companies and incentivise sustainability measures through guided medicine procurement based on costs and environmental impact (IVL, 2019). Due to the fact that domesticated animals outnumber humans (FAO, 2021), the externalities in the animal health industry are even higher compared to human healthcare.

Despite the recent stakeholder interest, however, and a few initiatives of environmental sustainability initiatives (ESI), there is still a limited understanding of the industry as a whole (Krieger et al., 2020; Sinclair et al., 2017) of the phenomenon in all its implications, let alone

a clear framework for comprehensive and coherent action. it has not adequately evaluated their expectations. Even in terms of reporting, ESIs in the animal health industry lack precision and consistency (Milanesi et al., 2020; Rajic et al., 2022). Although corporate reporting of sustainability measures has improved over the years (Schneider & Sachs, 2017), there are still wide discrepancies in the metrics and the transparency and verification of reporting (Demir & Min, 2019).

On the other hand, the stakeholders' expectation within the animal health context is complex due to the multi-faceted nature of livestock's diseases and treatment requirements (Vogus & McCelland, 2016). For example, environmental and labour issues are relatively well aligned between companies, but supply chains are seldom transparent, and a thorough assessment of their sustainability is an almost impossible challenge.

Even more challenging but increasingly unavoidable is a holistic approach.

Although the One Health concept, which recognises the interdependence of various stakeholders (e.g., human, animal, and plant health) and their connection to the overall health of ecosystems originated about a century ago (WOAH, n.d.), business, management and organisational (BMO) literature has not explored its potential for stakeholder-oriented preventive health action and risk management for a sustainable animal health system, (FAO, 2022).

The lack of awareness in the animal health sector comes, therefore, hardly as a surprise.

The systematic review of Koytcheva et al. (2021) only found three peer-reviewed opinion articles on veterinary medicine that focused on identifying constraints and recommendations for sustainable improvement without considering the broader implications for sustainability in its three dimensions (environmental, social, and economic). Important gaps also exist in waste management, the economic impact of new drugs, the contribution of ESIs on animal health

companies' social and economic sustainability, and the comparison between the perception and consumption of sustainable products between emerging and mature markets. And while there has been some research on the constraints and challenges of animal health service delivery in developing countries, such as Ethiopia (Kebede et al.,2014), there is a clear gap in the knowledge in terms of comprehensive studies exploring the integration of sustainability approaches, stakeholder engagement and their impact on animal health firm performance by environmental, social, and economic sustainability dimensions on one side and the One Health philosophy on the other.

This is exactly what this article intends to address.

By exploring the synergies between the variously identified sustainability approaches and stakeholder engagement in the animal health industry and assessing various ESIs, our study contributes to the knowledge and offers some insights into possible ways forward in terms of more sustainable corporate practices in the sector. Three research questions guide the study:

RQ1. Which environmental sustainability initiatives (ESI) do the leading animal health companies currently implement, and how effective are they in reducing the industry's environmental impact?

RQ2. To what extent do animal health providers communicate the environmental impacts of the products and their production processes?

RQ3. How do stakeholders perceive and prioritise sustainability in the animal health industry?

After critically reviewing the sustainability approaches (including the ones based on the stakeholder theory) according to four dimensions (environmental, social, and economic sustainability and the One Health philosophy), this study employs a multi-stakeholder case study method to investigate the impact of ESIs on the social and economic performances of

animal health firms, stakeholder perceptions, sustainable purchasing decisions, and drivers for sustainable healthcare in the animal health industry. The data collection involved interviews with key stakeholders (i.e., veterinary practitioners, farmers, pharmaceutical professionals, corporate veterinary group professionals, academics, researchers, and consultants) from 11 countriesto provide diverse and culturally balanced perspectives. Findings from this study will facilitate the animal health industry to embark on a sustainability-based differentiation strategy and respond to stakeholders' expectations more holistically. This will bring direct benefits to animal health firms in an area of rapidly increasing criticalities and growing relevance.

The paper has been organised as follows. Section 2 critically analyses the contemporary research to identify knowledge gaps and provide the interpretative framework. Section 3 discusses the methodology, while Section 4 analyses the data and presents findings. The theorisation of the ESI in animal health care is provided in section 4 as well. Finally, section 5 takes stock of the results, highlighting the theoretical and empirical contributions, and Section 6 presents conclusions, limitations, and avenues for future research.

2. The Animal health industry. The existing framework and its limitations

2.1 The stakeholder theory

The stakeholder theory (Freeman, 2015)provides the theoretical underpinning to our attempt to determine what ESIs can realistically deliver to animal health companies.

The stakeholder theory shifts a narrow focus on shareholder value to a broader recognition of firm responsibilities towards multiple stakeholders. Over time, it has expanded to include sustainability, ethical practices, and the pursuit of shared value, postulating that firms must balance their financial interest with social and environmental responsibilities (Lozano et al., 2015), integrating socio-environmental considerations into core business strategies. As such,

companies that initially focused on implementing environmental management systems in response to stakeholder requirements gradually shift towards sustainable business strategies, innovation agendas, and broader governance processes for sustainability (Chang et al., 2017), a systemic change driven by the recognition that firms' sustainability depends on factors beyond their direct control – e.g., human resources, industry standards, and business environment.

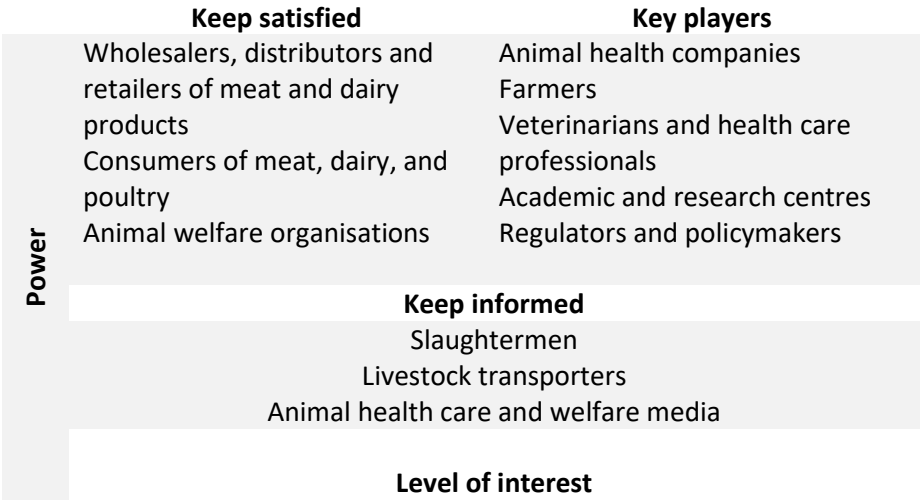

Figure 1: Power and interest of animal health care stakeholders. Source : (Pyatt et al., 2017; Sinclair et al, 2017)

Stakeholder theory builds a solid foundation for environmentally focused research streams such as environmental risks and performance assessment; environmental reporting practices and communication; environmental strategy; and environmental cooperation between firms and their diverse stakeholders(Céspedes-Lorente et al., 2004). Several studies (e.g., King, 2007; Onkila, 2009; Zhao et al., 2012) have addressed environmental and social sustainability issues through the stakeholder theory. More specifically, Marasca et al. (2020) adopted the theoretical perspective to explore how and why public healthcare organisations adopt integrated reporting practices. Due to its holistic, multidimensional view of firms, the stakeholder theory identifies

and establishes best environmental practices, the reporting of such practices and cooperation among various stakeholders (Figure 1) within the animal health industry (e.g., farmers, veterinarians, healthcare product manufacturers and suppliers, productivity consultants and unions) for environmental sustainability. Veterinarians and paraprofessionals are the critical links between animal health companies and farmers. They prescribe, advise, and inform farmers about healthcare products and thus position themselves as a key stakeholder.

Pharmaceutical companies recognise the importance of stakeholder engagement in their business practices to address sustainability issues and provide ethical guidelines for environmental codes of conduct. ESIs are viewed in terms of competitive advantage, to attract and retain talent and build strong relationships with customers and other stakeholders. Min & Desmoulins-Lebeault (2018) clearly identify key environmental goals (such as environmental footprint reduction, material reduction, sustainable workforce, and access to health care) and ESIs (e.g., employee safety, product stewardship, safe handling of unused medicines, supplier management, and employee/community involvement) in pharmaceutical companies' sustainability reports. Pharmaceutical companies also promote transparency in communication and accountability of their actions with customers, employees, and the broader community (Azim & Azam, 2013).

Complementing the stakeholder theory is a set of sustainability approaches that individually contribute to the four dimensions identified above, as discussed in the following sections.

2.2 Environmental sustainability approaches in the pharmaceuticals industry: Cleaner Production.

Managing stakeholders' expectation of health care is a complex issue due to the multi-faceted nature of livestock's diseases and treatment requirements (Vogus & McCelland, 2016), and, given the parallels between human and animal healthcare industry, it is possible to design a

common conceptual framework (Pyatt et al., 2017), outlining key stakeholders' ESIs and their impact on sustainable performance. This will help address the lack of research in the animal health industry when it comes to identifying strategies necessary for a sustainability transition. In both cases, human and animal, environmental sustainability is a major concern, as the current system is resource-intensive and wasteful. A recent review of environmental sustainability in veterinary practice (Koytcheva et al., 2021) proposes five main physical changes within the current practice structure (i.e., energy efficiency, water conservation, waste management, sustainable procurement, and transportation) and behavioural changes at the individual, group, and organisational levels (Table 1).

Table 1 Change requirement for animal health practice sustainability

Change requirements		Strategies
Physical Changes	Energy Efficiency	Use renewable energy sources, e.g., solar electricity, ground source heat pumps, and combined heat and power systems. Implement energy-saving practices such as thermostat adjustments, using ceiling fans, and upgrading window technology.
	Water Conservation	Install flow restriction devices and low-flow toilets. Fix plumbing leaks. Harvest and recycle rainwater. Use water-saving technologies (i.e., eco-friendly autoclaves and ozone laundry)
	Waste Management	Reduce waste creation by using less packaging and purchasing reusable alternatives. Properly dispose of waste and use green cleaning products. Implement recycling, re-processing, and donation programs. Use sharps containers and sustainable surgical practices.
	Procurement	Evaluate product supply chains and life-cycle assessments (LCAs) Hold companies accountable for sustainable products. Use environmental impact factor labels to guide purchasing decisions.
	Transportation	Promote alternative transportation methods like public transportation, biking, carpooling, and electric or low-emissions vehicles. Provide incentives and infrastructure support for alternative transportation. Utilise telemedicine or teleconferencing services. Offset carbon emissions from air travel through carbon offsets.
Behaviour Change		Encourage pro-environmental attitudes and behaviours at the individual, group, and organisational levels. Provide training and education, set environmental goals, and offer feedback and incentives. Foster management support and a culture of sustainability

Source: Koytcheva et al. (2021)

Milanesi et al. (2020) revealed that cleaner production (Belkhir & Elmeligi, 2019; Kaenzig et al.,2011; Veleva & Cue, 2017), green supply chains, green human resource management (HRM), and green materials are the key ESIs initiated by pharmaceutical companies as a whole. In terms of cleaner production, Kaenzig et al. (2011) and Veleva & Cue (2017) found that companies frequently fail to comprehensively understand their products' ecological impact across their entire life cycle. As Belkhir & Elmeligi's (2019) assessment revealed, carbon emissions in the pharmaceutical sector are even higher than those in the automotive, highlighting the need for measures that provide a complete picture of the sector's carbon footprint. Chung & Meltzer (2009) found that branded pharmaceutical products are less emission-intensive than generic products as branded products are generally produced in developed countries, with tighter environmental regulations and higher investment in ESIs (Bengtsson-Palme et al., 2018). Li and Hamblin (2016) highlight the importance of ISO14001 certifications in encouraging the adoption of cleaner production practices by pharmaceutical companies.

The literature on cleaner production generally looks at the manufacturing end of the value chain to identify environmental interventions. Li et al. (2011) saw a reduction in coal and water use in China's case by 2.2% and 1.5% and solid waste generation by 3.1%, contributing to an economic benefit of 44.8 million renminbi (€5.9 million). Similarly, Bellgran et al. (2019) suggest that a green performance map in pharmaceutical manufacturing helps save direct manufacturing costs. On the other hand, Yang et al. (2019) identified that API synthesis (42.9%), galenic formulation (compounding of medicines) (41.9%) and packaging (15.2%) are the three most significant emission factors during the production stage in China, while similar findings came from Indian pharmaceutical companies (Prashar, 2020). Biswas (2019) and Janatyan et al. (2021) showed a significant association between optimised manufacturing and innovation and market orientation.

2.3 Green chemistry (GC) and Lifecycle analysis (LCA)

Other sustainability approaches have been considered in the literature to ensure sustainability, starting with green chemistry (GC).

Roschangar et al. (2015) demonstrate that GC provides proven benefits to cleaner production. Adopting GC principles facilitates designing and synthesising healthcare products more sustainably, including animal health firms, whose manufacturing processes can be optimised to reduce energy consumption, waste generation, and greenhouse gas emissions. Veleva & Cue (2017) compared the practices of generic and innovative pharmaceutical companies, finding that the average GC score was lower for generic drug producers, which represent about 90% of US prescription market sales (Sreenivasan & Reddy, 2019). Onken et al. (2019) developed a scorecard for Active Pharmaceutical Ingredient (API) manufacturing to support GC implementation. They found that energy consumption accounted for only 1% of CO2 emissions, with the majority coming from the incineration of organic waste.

Waste management in the pharmaceutical sector affects the environment, with broader implications for social sustainability and the economic impact of waste disposal. Jones & West (2019) discussed the environmental impact of anaesthesia agents used in veterinary practices, such as nitrous oxide and isoflurane. To manage this waste, they proposed carbon sequestration, using filters and gas reservoirs and reducing flow rates. Reusable equipment, reduced pharmaceutical waste, and rechargeable batteries minimise clinical waste, while telemedicine reduces emissions related to travel. Water pollution from pharmaceutical products is also getting more attention as it contributes to the proliferation of drug-resistant bacteria, which poses a significant threat to global public health. GC helps waste reduction by identifying more sustainable raw materials, synthesis routes, and product packaging with recycled or easy-to-recycle materials.

Life cycle analysis (LCA) is, however, the one that can best provide a better understanding of the environmental impact of treatments within the healthcare industry, including animal health. LCA can be adapted to compare the environmental effects of different animal health firms and supply chain strategies, such as local suppliers or more sustainable packaging materials. Debaveye et al. (2020) used LCA to compare the Quality-Adjusted Life Years (QALY) and Disability-Adjusted Life Years (DALY) of a specific treatment through a measure called the Relative Sustainability Benefit Rate (RSBR). Previous studies (Debaveye et al., 2019; 2016) have shown that LCA is useful for improving healthcare sustainability by examining hospitals' environmental impact, including the procurement of pharmaceuticals. McGain and Naylor (2014) and Connor et al. (2011) both found that procurement accounted for substantial emissions in UK hospitals (about 35%), together with medical equipment (25%), building energy use (13%), and logistics (15%). Transportation is another major contributor to the environmental impact in logistics (Bouchery & Fransoo, 2015). Jabbarzadeh et al. (2019) developed an optimisation model for a supply chain using a postponement strategy to achieve economic and environmental benefits.

Similarly, green materials (GM) can be used for cleaner production, with sustainable resources like algae to produce therapeutic agents (Sudhakar et al., 2019). Manda et al. (2014) have proposed innovative membrane technologies to eliminate pharmaceutical residues from water sources. Other research (e.g., Blum-Kusterer & Hussain, 2001; Rezai et al., 2016) focuses on understanding the determinants of green activities in the pharmaceutical industry, such as the orientation of entrepreneurs.

2.4 Social sustainability approaches

Other approaches look instead to the ‘social’ and ‘managerial’ aspects of the phenomenon, although they still represent under-researched areas. Milanesi et al. (2020) categorise, for instance, social sustainability approaches as green human resource management (green HRM),

equal access to pharmaceutical products, social impacts of the pharmaceutical supply chain, product packaging, and consumer behaviour. Green HRM enhances a company's reputation and brand image, improves employee morale and engagement, and reduces the environmental impact of an organisation's operations (Caligiuri et al., 2013); it often previews company-led volunteering programs for employees, conducted in collaboration with NGOs. Green HRM can align business strategies with environmental sustainability not only in developed economies but also in newly industrialised economies (Yong et al., 2020).

Saeed et al. (2019) and Zaid et al. (2018) show that green HRM practices positively affect employees' pro-environmental behaviour and economic performance, and not only in the pharmaceutical industry. Delmas & Pekovic (2013) found a 16% productivity increase, whereas Heras-Saizarbitoria et al. (2015) identified reduced waste in companies that voluntarily adopted green HRM practices.

Quak et al. (2019) propose using indicators to assess pharmaceutical companies' ability to ensure access to medicines in the developing world, as this represents one of the main issues to the sector. Kebede et al. (2014) show how poor access to livestock health services is a major constraint to livestock production in Ethiopia, while government veterinary clinics were found to have inadequate services and resources. Selected indicators can provide a tool to raise awareness among pharmaceutical companies about the importance of improving drug access (Nematollahi et al., 2018), while privatisation with a properly resourced government service, implementation of cost recovery programs, clear policies and regulations, and phased privatisation can all help the sector's transition to sustainability. Sahu and Kohli (2019) explore healthcare systems to understand the interplay between pharmaceutical companies and hospitals, diverse drug prescription systems and consumption behaviour to align pharmaceutical practices with patient-centric care. On the other hand, Weraikat et al. (2016) emphasise exploring sharing mechanisms among pharmaceutical stakeholders to enhance

access performance and encourage users to return unused drugs to be distributed to underserved populations. The argument for equal access is supported by proposal of universal design packaging to create products and environments that are usable and accessible to the widest range of people, regardless of their abilities or disabilities (Lorenzini et al., 2018).

2.5 Economic sustainability approaches in pharmaceutical GSCs.

The identification of economic sustainability approaches for the pharmaceutical industry is another pillar of the conceptual framework presented here, with cost control, standardisation, R&D, and internationalisation among the ones more often identified in the literature.

The discussion on economic sustainability often includes analysing patenting, as proposed by Azad et al. (2018) for large pharmaceutical companies in Bangladesh. Technical efficiency, particularly scale inefficiency, plays a significant role in achieving sustainability. In the case of small and medium-sized enterprises (SMEs) in the Indian pharmaceutical industry, Nino-Amezquita et al. (2017) investigate the relationship between economic sustainability and factors such as exports, R&D expenditure, and profits. The study suggests that SMEs should focus on internationalisation and value creation through R&D investment for long-term growth and survival. Aquino et al. (2018) also highlight the potential revolutionary role of 3D printing in reconciling the standardisation and personalisation of medications.

Rao and Holt (2005)'s analysis shows that the green supply chain (GSC) positively impacted competitiveness and economic performance. Similarly, Hosseini-Motlagh et al. (2021), Jabbarzadeh et al. (2019), and Milanesi et al. (2020) discuss reverse logistic-based GSC, demonstrating that, in addition to financial benefits, reverse logistics programs receive reduced government penalties and improve corporate social responsibility (CSR) standards. This does not come without costs. Kumar et al. (2019) identify a series of risks in GSC implementation within the veterinary pharmaceutical industry due to a complex supply chain that involves

multiple stakeholders, manufacturers, distributors, and veterinarians. Coordinating and aligning the efforts of these different stakeholders is challenging and, at times, risky. Lack of awareness and understanding, limited data and research, regulatory barriers and costs and financial considerations are listed among the key challenges to GSC implementation since the animal health industry requires multiple stakeholders' concerted effort and cooperation.

Still, the pharmaceutical industry's sustainability orientation and socioeconomic return are controversial. While Chaturvedi et al. (2017), Dzomonda (2021), López-Toro et al. (2021), and Mihaiu et al. (2021) demonstrate a positive correlation between sustainability and economic performance, Menzel et al. (2010) reported non-significant-relationship between green manufacturing and financial performance, suggesting that the findings do not confirm the expected positive impact of greener manufacturing on corporate performance. Dranev et al. (2020) find a negative correlation between sustainability and profitability goals, concluding that policymakers should incentivise pharmaceutical companies to divert resources to sustainability goals to offset adverse impacts on performance. To address the discrepancies, Jabbarzadeh et al. (2019) explored the integration of economic and environmental objectives in supply chain planning and reverse logistics operations.

2.6 A turning point: Stakeholder ESIs for the animal health industry and the One Health philosophy

The review of the literature, as highlighted in the previous sections, demonstrates a growing recognition of the importance of environmental sustainability in the pharmaceutical sector, as a whole and across the dimensions as identified and individually discussed, i.e., LCA and GM, green HRM first. These dimensions are all crucial to addressing ecological issues and reducing the environmental impact of pharmaceutical production and distribution.

In their recent work, Perry et al. (2018) added the One Health philosophy to the sustainability discourse of the animal health industry, a collaborative and comprehensive approach involving various sectors of society and government to effectively understand, anticipate, and address global health risks, including animal health (Noordhuizen et al., 1996). This is an important conceptual step, highlighting the importance of addressing the negative health externalities associated with livestock systems and improving animal health as a pathway towards more sustainable livestock production, an often-overlooked aspect. As livestock systems have negative health externalities, including zoonotic diseases, antimicrobial resistance, and non-communicable illnesses, improving animal health through disease-specific control, productivity enhancement, poverty-focused interventions, and gender-sensitive, systems-based, and climate-sensitive approaches. This entails ensuring ecosystem appropriateness in livestock sector planning. Livestock systems should be adapted to local conditions, and animal health support should be tailored to the specific needs of different production systems and disease risks. Importing livestock products from areas with higher safety standards and lower environmental costs may be more appropriate than intensifying local production in some cases.

More in general, there is a clearly identified need for a value chain-based holistic approach to sustainability in the pharmaceutical industry, encompassing profits, people, and the planet (Chaturvedi et al., 2017), which requires the alignment of sustainability initiatives with business goals and measuring, valuing, and controlling sustainability in all dimensions –i.e., environmental, social, and economic aspects. Vihari et al. (2019) emphasise the significance of organisational learning and business model innovation in driving corporate sustainability, specifically in the value proposition, value creation, and value capture system, strategic alliances with non-governmental organisations (Hansen et al., 2010), sustainable supply networks (Bravo & De Carvalho, 2015), supplier engagement in sustainability initiatives

(Villena, 2019), sustainable design (Janatyan et al., 2018) and sustainable product returns, and recycling (Padhi et al., 2018) are all identified as crucial components of sustainability.

Therefore, a stakeholder theory-based sustainability approach must include stakeholder identification and engagement, as shown in Figure 1. We apply the stakeholder theory to the animal health industry according to four dimensions (environmental sustainability, social well-being, economic viability, and One Health), as summarised in Table 2. As such, the framework emphasises the importance of engaging stakeholders and addressing their interests to achieve a balanced and sustainable approach in the industry.

Table 2 Stakeholder-based ESIs for the sustainable animal health industry

SUSTAINABILITY APPROACHES	ENVIRONMENTAL SUSTAINABILITY	SOCIAL SUSTAINABILITY	ECONOMIC SUSTAINABILITY	ONE HEALTH
CLEANER PRODUCTION	Understanding the environmental impact of products	Green HRM practices	Cost control, standardisation, R&D, patenting, internationalisation	Integration of human, animal, and environmental health considerations in production processes
GREEN CHEMISTRY	Reduced manufacturing costs, waste disposal	Equal access to pharmaceuticals	Green supply chain	Minimising the negative impacts of chemicals on human, animal, and environmental health
GREEN MATERIALS	Use of sustainable resources for production	Social impacts of supply chain	3D printing	Integrating human, animal, and environmental health in the sourcing and use of materials
PHARMACEUTICAL WASTE MANAGEMENT	Proper disposal of pharmaceutical waste	Product packaging	Patent activities	Preventing the spread of antimicrobial resistance and other health risks associated with improper waste management
LIFE CYCLE ANALYSIS (LCA)	Assessing the environmental impact of treatments	Consumer behaviour	Export and R&D investment	Taking a holistic approach to understanding and addressing the health and environmental impacts throughout the lifecycle of products and treatments
STAKEHOLDER THEORY	Considering the interests of all stakeholders	Collaboration with NGOs	Balancing the interests of stakeholders	Recognising the interconnectedness of human, animal, and environmental well-being in decision-making and stakeholder engagement

3. The Methodological Approach. The Coding Process.

The lack of solid literature in the animal healthcare context requires an exploratory study (Saunders et al., 2009). To address this, our study adopts a wide-scope qualitative approach, i.e., a multi-stakeholder case study method that can lead to in-depth insights (Eisenhardt, 1989; Yin, 2009) supporting data extraction and cross-validation through interviews. In addition to that, multi-country interviews with broad participation of relevant stakeholders provide the best context and access to rich and in-depth data, enhancing external validity, lowering observer bias (Barratt et al., 2011), offering triangulation and, eventually, a more robust research design (Eisenhardt et al., 2016; Yin, 2009).

We carried out interviews in 11 market-leading countries in animal health and cattle industry adopting stringent and progressive pharmaceutical and environmental regulations. This primary data collection allowed us to investigate stakeholder perception and impact of ESIs, sustainability-guided purchasing decisions of healthcare products, and choice dilemmas and drivers for sustainable healthcare. The unit of analysis was the individuals providing and receiving health care for animal farms producing meat and dairy products, while the cases were selected according to their ability to generate new insights for theory development (Eisenhardt & Graebner, 2007).

The selected sample included veterinary practitioners (9), farmers (5), veterinary pharmaceutical professionals (3), corporate veterinary group professionals (2), and academics, researchers, and consultants (4), with some of the participants covering multiple roles (e., farm owning veterinary professionals and /or union representatives). Such an inclusive range of highly knowledgeable industry actors provides farm, industry, and macro-level perspectives on the focal phenomena (Eisenhardt & Graebner, 2007).

We determined the relevance of our interviewees based on four criteria (i.e., the relevance of sustainability to the role, influence on the livestock industry, representative of customer insight and overall impact on sustainability).

A pilot study was carried out with one farm and one healthcare manufacturer to refine the research questions and generate new themes (Van Teijlingen & Hundley, 2001; Bryman & Bell, 2007). Following Yin's (2009) call for multiple sources of evidence, we then conducted

23 semi-structured interviews, reaching a satisfactory level of theoretical saturation to support the introduction of new codes. The newly collected data reinforced previously identified categories (Pagell & Wu, 2009).

Table 3 provides the respondent profiles.

Table 3 Profiles of interviewees and their influence on sustainability

Interviewee profile	Relevance of sustainability to the role	Influence on the livestock industry	Representative of customer insight	Sustainability Impact Score	Country
Corporate sustainability officer	5	4	1	3	UK
Farmer	2	4	4	3	UK
Veterinary practitioner and corporate lead	4	5	3	4	UK
Veterinary practitioner	2	2	4	3	UK
Veterinary practitioner and corporate lead	4	5	5	5	UK
Beef and sheep farmer	1	2	5	3	UK
Farm animal vet	3	4	3	3	UK
Clinical vet	3	4	3	3	UK
Farmer and animal vet	3	4	3	3	Australia
Researcher in animal anatomy	3	4	3	3	Brazil
Technical services manager	3	4	3	3	Germany
Veterinary practitioner and farm consultant	2	1	5	3	Denmark
Clinical director	3	4	4	4	UK
Academic	5	3	1	3	UK
Veterinary surgeon	3	3	2	3	UK
Academic and farm consultant	5	3	2	3	Spain
Mixed practice vet	3	4	3	3	UK

Interviewee profile	Relevance of sustainability to the role	Influence on the livestock industry	Representative of customer insight	Sustainability Impact Score	Country
Global Head Public Affairs & Sustainable Development, Animal Health	5	4	2	4	Germany
Veterinary practitioner and beef farmer	2	2	5	3	Ireland
Dairy farmer, representative of European Dairy Farmers union	1	3	5	3	Netherlands
Veterinary practitioner and practice owner	2	3	4	3	Austria
Vet practitioner and farm adviser	2	3	3	3	Italy
Academic and farm health consultant	1	3	3	2	Belgium

The data collection took place between November 2021 and November 2022, with MS Team-based interviews of 45-60 minutes on average. A semi-structured script was developed from the literature (appendix 1), adapting questions as appropriate depending on the specific profile of the responders and their field of expertise. When interviewing pharmaceutical company professionals, we focused on the ESIs, including the challenges of their implementation and opportunities, while the emphasis was on ESI perception in the case of veterinarians. The critical incident technique was also adopted, asking the interviewees to consider the non-work environment and behaviours beyond hypothetical situations (Bell et al., 2019). These interviews were supplemented by secondary data derived from manufacturers of healthcare products, product development, trial, manufacturing, and marketing regulations to provide a regulatory context and validate our findings from primary interviewees.

We followed qualitative data procedures (Eisenhardt, 1989; Miles et al., 2014), establishing rigour through confirmability, dependability, credibility, and transferability measures. We derived criteria for measuring the level of environmental sustainability initiatives (ESI) and the results of those initiatives from our literature review while we used the human healthcare industry criteria as proxies because there are, to date, no widely established criteria for the animal healthcare industry itself.

Various steps have been undertaken to ensure reliability and validity (Miles & Huberman, 1994), including a systematic literature review based on initial coding, data triangulation through document analyses, and multiple interviews (Stake, 1995; Yin, 2009). This systematic analysis aided rigour and increased confidence in our findings.

In the coding process, we looked for patterns based on frequency, commonalities, and differences (Saldaña, 2013). A coding frame (appendix 2) was initially developed and subsequently changed when new codes emerged until reaching a consensus. Such rigorous coding allowed us to develop analytical categories, conceptualised in theoretical dimensions (Figure 2), which link key codes identified from the literature to the more specific codes inductively derived that feed into the aggregate theoretical dimensions.

Transcribed data were analysed using the NVivo12 software, which enhanced our reflexivity by organising the data and providing an audit trail (Bryman & Bell, 2007) although resulting in a degree of unavoidable overlap between data collection and analysis (Pratt, 2009).

A working set of codes (appendix 2) was produced based on the themes identified from the literature on ESI on the rationale that, since provisional codes are essential to answer the research questions, they can also facilitate analysis and provide a robust empirical grounding for emergent theory (Eisenhardt, 1989; Saldaña, 2013). We conducted a cross-case analysis, where the veterinarians and farmers were organised according to their perceived degree of environmental sustainability to determine a more interpretive level of coding.

As such, the 'lack of information' code was initially identified as a barrier leading to negative purchasing decisions for ES products and, as the analysis progressed, 'lack of information' was interpreted as involving elements of social greenwashing, transparency, and lack of trust. The initial descriptive code was elaborated to distinguish between the 'ESI drivers for the manufacturer' and 'information asymmetry'. The information obtained from interviews was validated by checking documents and observation notes, identifying converging perspectives of healthcare manufacturers and other industry actors. Cross-case analysis was also undertaken to search for patterns, i.e., similarities and differences between the coded categories across the seven suppliers.

In the second analytical stage, we applied theory building to categorise the purchasing decision factors, with a broad set of codes taken from the literature and analytical categories inductively derived from the data through an iterative process. Coding was used to identify the factors leading to ESI-based purchasing decisions (e.g., personal sustainability interest, market forces, and user demands for sustainable products) and included if meeting at least one of the following conditions: (1) farmers voluntarily made this decision out of their own environmental consciousness after consulting their vets, (2) farmers complied with the regulatory and industry

requirements, (3) farmers are not affected by environmental regulation and therefore making cost-efficacy based purchasing decisions.

Through constant comparison and interpretation, we were able to inductively derive seven factors (Figure 2) that influence ESI-based purchasing decisions of animal health care products (Eisenhardt et al. 2016): (1) ESI drivers for the user, (2) ESI drivers for the manufacturer, (3) Information asymmetry, (4) dilemma of choice, (5) cost and efficacy-based purchasing decision, (6) green manufacturing and (7) waste management.

The factors were constructed to reflect as many nuances in the data as possible.

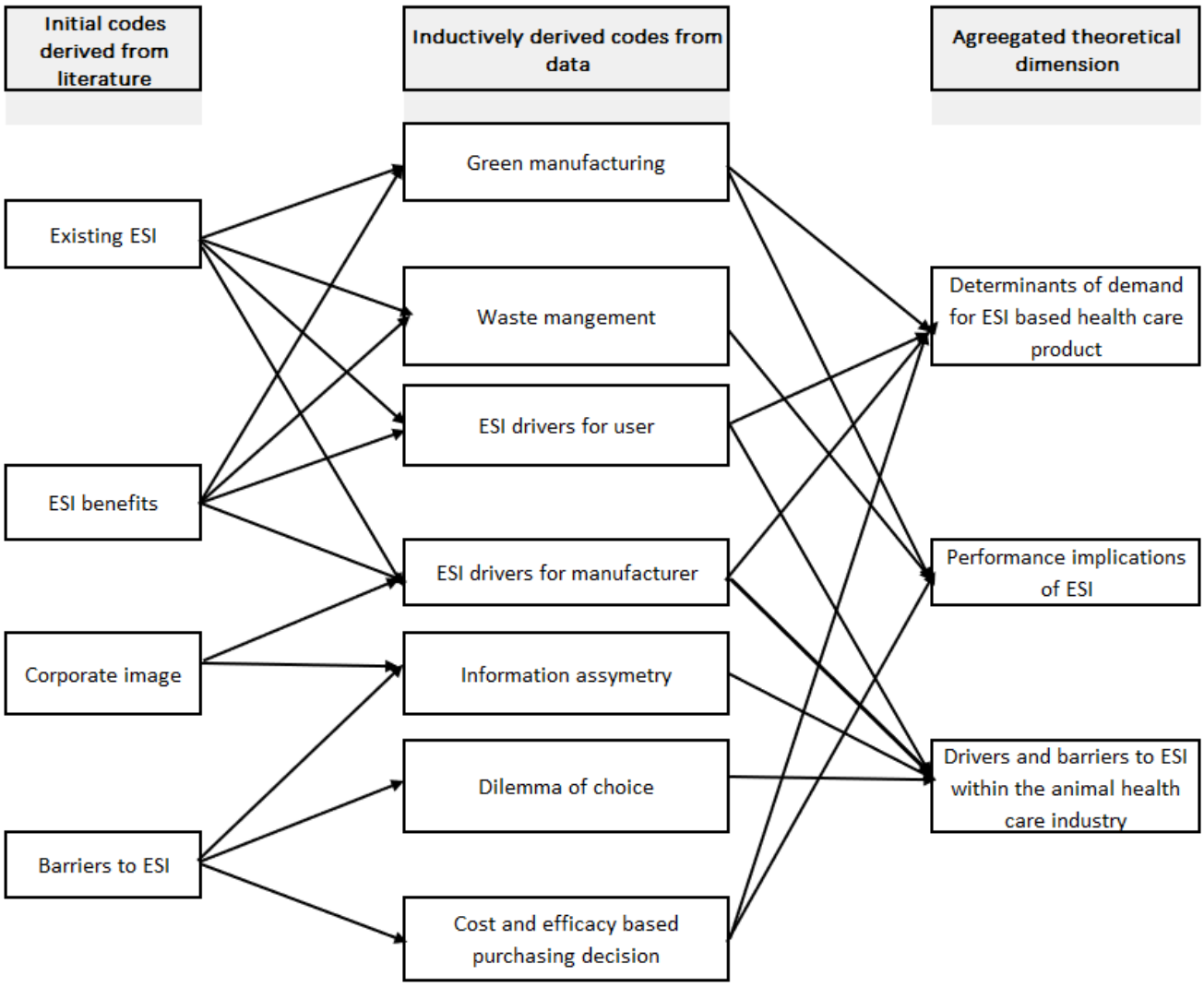

Figure 2 Coding process

The evidence that emerged from the data suggested that these factors could be described according to three theoretical dimensions:

(1) drivers of ESI within the animal healthcare industry,

(2) determinants of demand for ESI-based healthcare products,

(3) performance implications of ESI.

We included ESI drivers for users and manufacturers to the drivers of ESI within the animal healthcare industry, grouping Information asymmetry, the dilemma of choice and cost and efficacy-based purchasing decisions into determinants of demand for ESI-based healthcare products. Green manufacturing and waste management were captured within the performance implications of ESI.

4. Data Presentation and Analysis of the Findings

We have organised the interview findings on ESI practice according to the respondent profiles, labelled as Pharma (healthcare product manufacturing companies and veterinary corporate groups: Table 4); Vet (Veterinary Practitioners: Table 5); Farmer (Farming companies and individuals: Table 6); Researcher (Research community: Table 7). Quotations from the interview transcripts have been inserted when relevant and articulated by themes.

Table 4. Current state of ESI practice by veterinary pharmaceuticals

Code	**Role profile**	**Company size**	**Company location**	**Overall Environmental sustainability**	**Carbon footprint in production**	**Water footprint in production**	**Resource depletion in the production**	**Carbon footprint in logistics**	**Use in animals and impact on human**	**Product residue in the environment**	**Disposal of packaging**
Pharma 1	Corporate sustainability officer	medium	UK	very high	high	high	low	moderate	very high	very high	high
Pharma 2	Corporate lead for veterinary group	medium	UK	very high	high	high	low	moderate	very high	very high	high

Code	Role profile	Company size	Company location	Overall Environmental sustainability	Carbon footprint in production	Water footprint in production	Resource depletion in the production	Carbon footprint in logistics	Use in animals and impact on human	Product residue in the environment	Disposal of packaging
Pharma 3	Corporate lead for veterinary group	medium	UK	very high	high	high	low	moderate	very high	very high	high
Pharma 4	Technical services manager	large	Germany	very high	high	high	low	moderate	very high	very high	high
Pharma 5	Global Head Public Affairs & Sustainable Development, Animal Health	large	Germany	very high	high	high	low	moderate	very high	very high	high

Our findings strongly suggest that the animal health industry is steadily transitioning towards sustainability, driven by various factors and stakeholders (Pharma 1-5). Interviewees from all the locations, independent of company size, demonstrated environmental sustainability concerns; some of them had already achieved carbon-neutral status. Due to the high entry barriers, animal health firms are less vulnerable to disruption from green start-ups, thanks to the greater resources, capabilities, and long-term investment requirements. However, the existing companies see achieving net-zero status as a competitive advantage, and for some [Pharma 4], sustainability efforts are their core business strengths. Firms are poised to leverage their extensive R&D capacities for the green transition. As we found from our multi-

Table 5. ES issues influencing veterinary practices.

				Production stage			Use stage		Disposal stage	
Code	**Role profile**	Location	Overall Environmental sustainability	Carbon footprint in production	Water footprint in production	Resource depletion in the production	Carbon footprint in logistics	Use in animals and impact on human	Product residue in the environment	Disposal of packaging
Vet 1	Veterinary practitioner and beef farmer	Italy	moderate	moderate	moderate	moderate	moderate	very high	moderate	high
Vet 2	Veterinary practitioner and practice owner	UK	Moderate	moderate	moderate	moderate	moderate	very high	moderate	high
Vet 3	Vet practitioner and farm adviser	Australia	high	low	low	low	low	very high	moderate	very high
Vet 4	Clinical vet	UK	high	low	high	low	moderate	very high	moderate	high
Vet 5	Clinical director	UK	moderate	moderate	moderate	low	moderate	very high	moderate	high
Vet 6	Veterinary practitioner and practice owner	Ireland	moderate	moderate	moderate	moderate	moderate	very high	moderate	high
Vet 7	Mixed practice vet	UK	high	high	moderate	moderate	low	very high	moderate	very high
Vet 8	Vet practitioner and farm adviser	Austria	high	high	moderate	moderate	low	very high	moderate	very high
Vet 9	Veterinary practitioner	UK	high	high	moderate	moderate	low	very high	moderate	very high

stakeholder interviews, key stakeholders (e.g., veterinary associations, farming unions, supermarkets, and regulators) play a critical role in shaping this transition.

Most animal health firms in our data set undergo an environmental, social and governance (ESG) review, set sustainability-based Key Performance Indicators (KPIs), and partner with non-governmental organisations (NGOs).

> *People think sustainability is an extra burden and will cost us money and profitability. And what I would like us to see and where we need to get to is that actually sustainability is a legitimate and beneficial business proposition. It makes business sense to do the right thing to do. Good thing.* [Pharma 1]

Table 6 ESI influence on purchasing decision and illustrative quotations

ESI	Level of Influence	Illustrative quotations
Efficacy	Very high	1. But the price, it's obviously one of the big parts, the price is okay, because I also have to sell it. The price has to be okay. [source Farmer 3]
Packaging	Very high	2. Maybe one super practical example is sometimes medicines, are packed 1 by 1 in plastic and look very expensive packaging, and you have a lot of disposals of it. [source: Farmer 2] 3. There seems to be a huge amount of emphasis on the end of life, whether something can be recycled. I think the emphasis maybe needs to shift further up the chain to say, do we actually need to produce all this packaging in the first place?' [source: Pharma 1]
Product-specific ESI information	High	4. I think that what is missing is that there is not enough information on the products to indicate whether there is a lot of water, or if there is a lot of it has a big footprint, carbon footprint. So I would make decisions based on the sustainability but out there is not enough information. [Source Vet 3] 5. I think we'd like to align ourselves obviously with suppliers that have a similar vision to us. And but when push came to shove, its business at the end of the day, and I think probably the pounds shillings and pence will matter. So, I think it's probably on a product-by-product basis, rather than just a company that says they're going to do something but hasn't done it with individual products. [Source Pharma 4]
Evidence of environmental impact	Moderate	6. what evidence there is for environmental impact or lack of environmental impact and robust information for the people using it about how to use it appropriately to minimise the environmental impact. [Source: Farmer 4]
WTP	High	7. You know, if the green product is twice the price, but just does the same job then he probably not going to buy the green product unless some of the something else is pushing you that way' [source: Farmer 5]

4.1 ESIs: supply-chain and waste management

All the corporate interviewees [Pharma 1-5] claimed that green chemistry, green supply chain, and green HRM are increasingly used in veterinary medicine, as suggested by Milanesi et al.

(2020). Chemical usage, waste management, transportation and emissions are a few primary concerns upstream of the supply chain to select suppliers based on concrete evidence of sustainability.

> *My primary considerations are supply chain……. I would be the kind of person to look at an environmental policy of a supplier. I think what I'd look for an environmental policy as specifics rather than vague statements. So rather than just saying we're seeking to reduce our carbon footprint, you know, I'd like to see a statement that says something like we have measured our carbon footprint and we are going to reduce it by x per cent over the next X amount of time*. [Pharma 1]

This transition is challenging due to strategic, operational, and regulatory requirements.

Temperature-controlled logistics is often a prerequisite due to the chemical composition of health products; Bouchery & Fransoo (2015) and McGain & Naylor (2014) also found similar issues in the human healthcare context.

[Researcher 1] highlighted that Clinical and farming waste are critical issues for the animal health industry not only from the environmental sustainability point of view but also for health due to the proliferation of drug-resistant bacteria (Singh et al., 2016). Improper and largely unstandardised waste disposal procedures pose a significant issue in farming practices in developing countries. Responsible waste disposal practices can contribute to environmental sustainability, reduce the risk of land, water, and air contamination, and promote healthier farming systems.

4.2 ESIs and social benefits

ESIs also contribute to broader social goals and have far-reaching positive implications.

One of the key social benefits of ESIs is the improvement of public health and well-being, contributing to social equity and environmental justice. Implementing green manufacturing practices can reduce pollution in low-income neighbourhoods often disproportionately affected by industrial activities, while ESG-based supplier selection promotes fair labour practices, human rights, and diversity and inclusion, ensuring suppliers align with social values and contribute to a more equitable society.

Table 7. ES issues influencing purchasing decisions by farmers

					Production stage			Use stage		Disposal stage	
Code	Farm type	Farm Location	Farm Size	Overall Environmental sustainability	Carbon footprint in production	Water footprint in production	Resource depletion in the production	Carbon footprint in logistics	Use in animals and impact on human	Product residue in the environment	Disposal of packaging
Farmer 1	Beef and sheep	UK	large	high	moderate	moderate	very low	moderate	very high	high	moderate
Farmer 2	Beef and sheep	UK	medium	moderate	moderate	moderate	moderate	moderate	high	moderate	moderate
Farmer 3	Beef and dairy	Ireland	medium	moderate	moderate	moderate	moderate	moderate	very high	high	high
Farmer 4	Beef and dairy	Netherlands	medium	moderate	very low	low	low	very low	moderate	high	moderate
Farmer 5	Dairy farmer	Australia	large	high	high	moderate	moderate	low	very high	high	high

Another social benefit of environmental sustainability initiatives is job creation, and green human resource management (Milanesi et al.,2020) is emerging as a prominent sustainability practice within animal health companies. [Pharma 4, 5, and Vet 1] noted the necessity to include sustainability in human resource management and recruitment.

There is a growing recognition that the new generation of employees, particularly the Millennials and Generation Z, expect companies to take sustainability seriously [Farmer 3, Vet 7]. They actively seek organisations committed to sustainability and view it as a fundamental requirement for their future employers [Pharma 5]. Younger and recently qualified veterinarians were more aware and keener to embed sustainability in their practice than more senior vets, probably due to their extensive exposure to the discourse on environmental issues

from an early age, in a generational trend also common in other industries (e.g., textile and clothing; Gazzola et al., 2020) where sustainability and environmental footprint are major concerns.

4.3 ESIs and economic benefits

ESIs can stimulate economic growth by driving innovation, attracting investment, and fostering entrepreneurship for animal health companies (Li et al., 2011), although a linkage with economic performance is contested due to insufficient concrete evidence (Yang et al.,2021). While some studies (Dranev et al., 2020; Mihaiu et al., 2021; Yang et al., 2019) have reported positive associations between environmental sustainability and economic performance, these findings are often context-specific and subject to various influencing factors.

The respondents in our sample were unsure how to quantify environmental sustainability initiatives' economic benefits, due to the comprehensive data collection and analysis required, complex and resource intensive.

> *if you were to develop a methodology to measure that, to give it to companies and say, hey, you know, if you apply this tool, you will see that it actually makes business sense you would, you would make a huge difference because that's sorely missing.* [Pharma, 1]

Nonetheless, there is a growing understanding that environmental sustainability can yield long-term economic benefits, in terms of cost savings through resource efficiency, improved brand reputation, and access to new markets driven by evolving consumer preferences.

A relationship between ownership structure and a firm’s sustainability orientation also emerged.

Family-owned business structures allow for a longer-term focus on sustainability than publicly traded companies' short-term focus [Pharma 4]. While the relationship between ownership structure and corporate social responsibility (CSR) has already been tested in various contexts resulting in a positive correlation between foreign/institutional ownership, board size, and CSR performance (Aksoy et al., 2020; Kumar et al., 2022; Salvioni & Gennari, 2016), the one between sustainability orientation and private ownership is novel and adds a specific nuance to our findings.

4.4 ESIs: Challenges and opportunities.

The absence of strong socio-economic outcomes emerges as a barrier for ESIs within the animal health industry, which must balance the need for medical treatments and preventive measures with minimising waste in the animal health industry [Researcher 3].

Our data sample presents a range of sustainability concerns and measures undertaken, often because of normative actions. Regulations were referenced multiple times as a motivator by all the corporate interviewees, indicating that both incentives and punitive measures are necessary:

> *An incentive of shame for those who are not, and I, I hope there's gonna be a race away from the bottom because it's gonna be so embarrassing to be at the end of the.* [Pharma 5]

Regulations are driving environmental sustainability through growing sustainability performance payments across Europe, with restrictions on antimicrobials in many markets and on the supply of medicines.

On the other hand, animal health firms are slow to reduce emissions at the manufacturing stage due to the industry's highly regulated nature, a barrier already associated with human pharmaceutical manufacturing process changes (Low et al., 2016). Interviewees involved in

business operations [Pharma 2, 3] suggested that once a drug's materials, processing and manufacture have been established and registered, they are unchangeable.

4.5 ESI influence on purchasing decisions

As veterinary practitioners are the prescribers or advisers of health care products, they have a critical role in how farmers make their purchasing decisions, and health care manufacturers supply the products. There is also another, crucial concern: residues in the environment and safe disposal of packaging, currently a hot topic within the agricultural and veterinary industries (Perkins et al., 2020) and will have contributed to this result, as shown below in Table 8.

Among others, cost, usability, and availability dominate the decision-making process for acquiring healthcare products. It is not surprising that the efficacy of the medicine is prioritised due to their professional requirement of diagnosing, prescribing, and administering medication to maintain good health and cure diseases in animals.

Table 8. Sustainability awareness among the research community

			Production stage			Use stage		Disposal stage	
Code	Location	Overall Environmental sustainability	Carbon footprint in production	Water footprint in production	Resource depletion in the production	Carbon footprint in logistics	Use in animals and impact on human	Product residue in the environment	Disposal of packaging
Research 1	Brazil	Very high	very low	moderate	very low	Low	very high	very high	high
Researcher 2	UK	Very high	moderate	moderate	very low	Low	very high	very high	high
Research 2	Spain	Very high	moderate	moderate	very low	Low	very high	very high	high
Researcher 3	Belgium	Very high	moderate	moderate	very low	Low	very high	very high	high

Regarding the significance of ESI in purchasing, supplying, and advising on healthcare products, we found mixed responses. For farmers (Farmers 1-5, Table 6), the importance of

overall sustainability ranges from very low to very high. We found response variations according to farm type, size, and location. Interviewees suggest that evidence for environmental impact and medicinal efficacy is expected. Sustainability matters more for large farms compared to smaller ones.

Among other stakeholders, the animal health research community demonstrates a significantly higher awareness and concern for environmental sustainability. Their responses are similar to the other stakeholders on disaggregated sustainability issues. Interviewing the research community, including academics, doctoral researchers, and consultants, provided much-needed validation for our findings. Excessive packaging and a critical lack of sustainability information on product packaging appeared to be a serious concern across the board, partly because it has the most visible impacts and associated disposal costs (Table 8, quotes 2 and 3). The current literature, however, had minimal coverage of packaging.

5. Discussion of the results

Considering the findings highlighted and analytically presented in the previous section from a broader perspective, there are a few common points that emerged, which have been discussed below.

5.1 The Need for Transparency and LCA

First of all, the value of communication which was highlighted as a way to promote ESIs.

It is evident, for instance, that farmers initiated changes upon 'recommendations' from others, and social media was identified as a critical facilitator for such peer influence.

All the corporate respondents are committed to becoming net zero and have already been offsetting emissions, although none published carbon offsetting activities for fear of being labelled as greenwashing. These findings are consistent with the literature. Orange & Cohen

(2010) identified similar behaviour around sustainability. Still, sustainability measures increase the reputation and allow corporates to command leadership in sustainable practice. By aligning company value propositions with sustainability, healthcare companies can establish a differentiated positioning in an oligopolistic pharmaceutical industry of listed companies, with shorter-term, stock market-related responsibilities (Elzinga & Mills, 1997).

Another essential element of stakeholder expectation is transparency from big pharma about their ESIs and their potential benefits and disbenefits. Our data revealed that stakeholders would expect full disclosure of sustainability policy or the impact of a product. Increasingly, the use of social media encourages animal health companies to prioritise sustainability in their corporate strategies. Suggestions [Table 5, quote 4] were offered of using non-governmental organisation (NGO) standards to allow comparison. The Animal care group, for example, achieved carbon-neutral status in 2020 by adopting various emission-reducing practices, partnering with a sustainability NGO in 2021 (Animalcare, 2021) to network, learn and promote sustainable practices transparently.

Such specificity of ESI data and transparency can only be delivered with LCAs within the animal health industry (Connor et al., 2011), modelled on the human health care LCA approach to mirror its sophistication, practicality, and rigour. The LCA concept within the human healthcare industry was extended with a series of studies by Debaveye et al. (2020; 2019; 2016), which combine the benefit of a human treatment or human health handprint, as measured by an increase in Quality-Adjusted Life Years (QALY), with the disease-oriented Disability-Adjusted Life Years (DALY) of treatment because of adverse environmental impacts of its production. This handprint vs footprint analysis combines the result into a single score, the Relative Sustainability Benefit Rate (RSBR). Performing a cross-functional audit of the highest priority products within each area using the LCA framework would identify

necessary interventions. Figure 3 illustrates an animal-tailored LCA approach applied from resource extraction to the impact of the health care product.

Conducting LCAs at the R&D stage to assess the environmental impact will allow animal health product manufacturers to compare the environmental effects of different manufacturing processes and supply chain strategies (e.g., local suppliers, sustainable logistics and packaging).

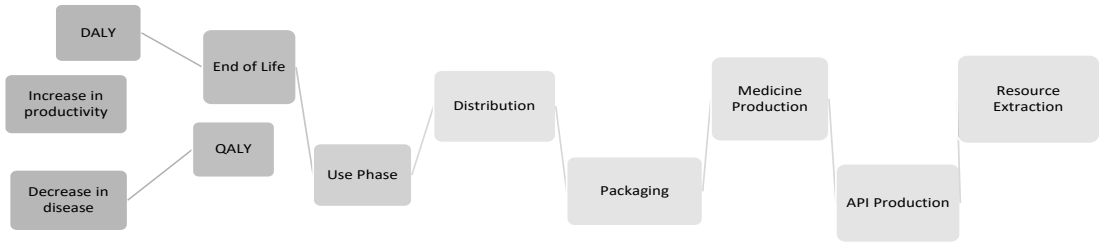

Figure 3 LCA for the animal health care industry. (Source: Debaveye et al., 2020; 2019; 2016)

5.2 Stakeholders' Willingness to Pay a Sustainability Premium

Another important point relates to the stakeholders' general attitude toward the so-called 'sustainability premium'.

Given a relatively strong demand for sustainable healthcare products, we must establish if incumbents are willing to pay (WTP) (Breidert et al., 2006) a higher price for sustainable products (Bengtsson-Palme et al., 2018). Table 9 presents the aggregated perceptions of the four stakeholder categories on various ESI-related issues.

Table 9 Key sustainability issues according to stakeholders' perception

Area of **concerns**	**Farmers**	**Pharmaceuticals**	**Veterinary professionals**	**Research community**
Evidence of efficacy or clinical benefit	very high	very high	very high	very high
Environmental impact, residues, and packaging	low	very high	low	moderate
Cost	very high	high	low	high
Appropriate use and licence	very high	high	very high	moderate
Ease of use	high	high	moderate	moderate
Availability of sustainable product/material	low	moderate	low	low
Pharmacy's support to local farms	moderate	high	moderate	high

Cost clearly appears to be the key driver for the environmental initiative within the healthcare sector. All farmers, for instance, suggested that the ecological benefit had to be significant enough to justify any financial and convenient impact to prompt a change in medicine buying or advising habits. The WTP responses [appendix 1, set 2, Q.8-10] also revealed that the increased return on investment scenario elicited the most significant extra value gained, at 15%. We found that there is a demographic (women and younger respondents opted for higher WTP) perceived value and efficacy. Noor Aizuddin et al. (2012) identified demographic factors (e.g., age, education, income, dependency ratio/ household size, locality rural/ urban), consumer perception, service quality, and customers' ability to pay determine the WTP for healthcare. For sustainable products, willingness-to-pay is often motivated by both private (energy cost savings) and public (environmental) benefits (Ward et al., 2011). Given the hypothetical nature of scenario analysis, however, it is important to note that these valuations do not automatically translate into purchasing behaviour even if respondents provided their accurate estimations of value (Nessim & Dodge, 1995).

Multi-country data availability allowed us to compare the perceptions and approaches of veterinary professionals, farmers, and researchers across countries. Farmers from the UK suggested that the 'generic' competitor offer would drive their purchasing decisions if manufacturers' evidence of sustainability is not clarified when choosing between two similarly priced and effective healthcare products (see, for instance, quote 7, Table 8). Our findings

suggested that health products will not gain acceptance unless their efficacy is at the expected level, as consumers resist price premiums at the time of actual purchase unless they perceive a tangible benefit equivalent to the premium paid (Tey et al., 2018). Aspirations for sustainability were overall and consistently high, although adoption levels varied according to the socio-economic context of the country (e.g., Brazilian vets [Researcher 1] and farmers [Farmer 3] are behind in their ESIs compared to their European counterparts, whereas the WTP was much higher in Australia due to larger profit margins [Researcher 1].

To identify the specific drivers and barriers to sustainable purchasing decisions, we asked both probing and hypothetical questions [appendix 2, set 2, Q.11], as this increasing environmental awareness is most critical. Responses ranged from a preference for syringes containing recycled plastic, recycling of plastics, solar panels and fuel-efficient farming equipment, and less use of resources in clothes and rearing of own meat. The factors that influenced this were minimising resource and energy use, minimising waste, and the desire to make a small change that would have a major impact over time. By coding this aspect of our data transcription as 'personal sustainability interest' the sustainability approaches of our data sample and a context for the case for environmental sustainability were established. Table 10 summarises the drivers and barriers with illustrative comments.

Table 10 Drivers and barriers to ESI-based purchasing decision

Factor	Driver/ barrier	Illustrative quotations
Convenience	Barrier	1. So we don't want to stop using medicines just because they've got, you know, a bit of a carbon footprint issue when the problem is solved; and it's probably a lot bigger than what it cost to produce. [source: Farmer 3]
External pressures	Driver	2. Companies are now so aware of it and incentivized to have proper, transparent sustainability plans in place. I think increasingly because of the corporatization of our industry. [source Pharma 2]
		3. Well, as of last night, we had a carbon budget announced here, so we have to cut our emissions by 50% across the board by 2030 or 51%, actually…So it's definitely going to change how we farm and how we work with Vets…. I think we're going to have massive production stock numbers, [to] actually meet those

Factor	Driver/ barrier		Illustrative quotations
			emission targets, whether we like it or not. And even things in terms of fertiliser production, stuff that's all going to change. We're going to have to use more natural slurry methods and things like to fertilise land. So yeah, there's big changes coming. [Source: pharma 1]
Trustworthiness	Barrier	4.	External, trustworthy? NGO evaluated sustainability traits, I guess, would be great. And comparable, comparable with other companies? What if there would be something like where you can measure the carbon footprint or the sustainability of a company? Yeah, that would be helpful. [Source Farmer 4]

The 'excessive packaging issues' resurfaced, and the reduced packaging and carbon footprint scenarios provided the same mean increase of 12%, somehow high for no tangible benefit for the user in the carbon footprint scenario but lower than anticipated for the packaging scenario. Opportunities and challenges faced by stakeholders are presented Table 11, with ESI-based brand strategy and competitive advantage, willingness to adopt sustainable products, and engagement in an industry-wide dialogue identified as the main opportunities.

Table 11 Opportunities and challenges facing stakeholders.

Stakeholders	Opportunities	Challenges
Veterinary pharmaceuticals	One health approach based on sustainability	Lack of understanding of a sustainability-oriented prevention and cure approach
	Adopting ESIs at the R&D stage	Absence of a tested sustainable business model
	Reduction of GHGs across the value chain	Absence of a methodology to adopt and implement ESIs
	Stakeholder engagement through effective communication	Poor communication of ESIs to stakeholders
	Sustainability-based marketing strategy	Absence of a practical sustainability measurement tool
	Sustainability as a competitive advantage	
	Progressive regulatory support	
Veterinary professionals	Willingness to adopt sustainable products	Excessive focus on efficacy
	Willingness to positively influence farmers purchasing decisions for sustainable product	Lack of awareness, knowledge, and skills to apply ESIs
Farmers	Opportunity to engage in sustainability approach through stakeholder engagement	Excessive focus on cost and efficiency

Stakeholders	Opportunities	Challenges
	Policy influences through collective bargain	Lack of environmental awareness footprint of healthcare products
	Sustainability-oriented marketing orientation	Putting convenience over the environment
	Access to green finance	Absence of a practical sustainable performance measurement tool for farms
		Scarcity of resource

Whereas lack of awareness, knowledge, and skills to adopt a sustainable approach and the absence of a proven business model and methodology for ESIs are challenges we need to address.

5.3 One Health: The Fourth Dimension of Sustainability

Finally, One Health (WOAH, n.d.; FAO, 2022).

Displayed in Figure 4, One Health represents the fourth dimension of sustainability in our model, as an integrated approach that recognises the interconnectedness of human health, animal health, and the environment, embedding all the dimensions of sustainability previously discussed. In the context of animal health firms, it provides an opportunity to integrate stakeholders, environmental sustainability initiatives, and socio-economic performance into a cohesive framework[1].

[1] An analytical discussion of each of the findings it obviously outside the scope of this work. Still, it is worth mentioning here that a large pharmaceutical in our sample holds regular dialogues with its stakeholders to figure out how to address sustainability issues together, consistently with the One Health Approach. Persistent questions [e.g., can they stop the next animal pandemic sustainably? Would customers pay a sustainability premium?] appears in our transcripts. In relation to this, the Global Head for Public Affairs & Sustainable Development [Pharma 5] from one of the top 10 animal health firms provided the animal sleeping sickness example and how his organisation is finding a solution. It is a disease that affects cattle in 36 nations in Sub-Saharan Africa, mostly impacting smallholder farmers who rely on their cows for food security and socio-economic well-being. The disease has a total economic impact of $4.5 billion annually and is the region's most prominent animal disease. The current solution for preventing and treating the disease is over 50 years old and is no longer effective, with a lot of resistance and counterfeit products. His company, with the support of the Gates Foundation, is working on a new and more efficacious solution for the disease, though it is expensive to

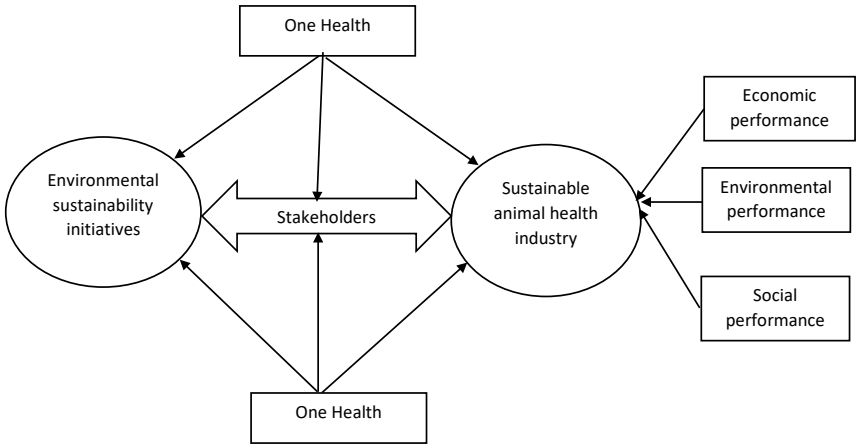

Figure 4 One Health- Fourth Dimension of Sustainability

Noordhuizen & Welpelo (1996) explore how the Hazard Analysis Critical Control Point (HACCP) concept can be applied to animal health management to achieve sustainable animal health care, involving quality control at both the production process and product level and comparing it to the 'One Health' strategies such as disease risk identification, herd health management, insurance, and certification. HACCP offers comparable preventive health action and risk management at a relatively low-cost regarding labour, finance, and documentation. Veterinary practitioners play here a crucial role. By incorporating One Health concepts into the curriculum, veterinary schools can equip students with the knowledge and skills to address the complex interconnections between animal health, human health, and the environment. Two key pedagogic areas (interdisciplinary education and environmental & ecosystem health) are critical for implementing One Health, and they can be significantly improved in how they embed environmental sustainability. At the moment, the veterinary curriculum does not always adequately address sustainability issues due to limited resources, time, and awareness. As a senior academic in our sample suggested:

produce, and there is uncertainty about profitability. The hope is that the new solution will significantly and positively impact the lives of farmers in the region.

> *We teach our students about regenerative agriculture and carbon-capturing soils and the role of grazing remnants, but, it in reality, I might have an hour to try and explain the whole disease process to them. I don't know how formally it's done, I guess that many schools in particular, the curriculums often so full that there is hardly any room to bring additional elements. I think it's one of the big challenges we have*. [Research 2]

Sustainability education is resource-intensive, as it often requires additional faculty, course materials, and other resources. Additionally, the veterinary curriculum is comprehensive and covers a wide range of topics, including basic and clinical sciences, animal behaviour, and clinical skills, leaving limited time for the inclusion of additional topics, such as sustainability. Moreover, academic leaders may lack awareness of the importance of sustainability in the veterinary profession and the role veterinarians can play in promoting sustainable practices. Veterinary schools must recognise the importance of sustainability in the veterinary profession and consider ways to incorporate sustainability education into the curriculum. This involves collaborating with academic leaders to develop sustainability-focused courses and curricula and incorporating sustainability concepts into existing courses and programs.

6. Conclusions

The animal health industry is a complex system involving various interrelated factors, including environmental, social, and economic impacts. This complexity makes it difficult to adequately capture the full picture when it comes to identifying the driving factors in the adoption of sustainability practices let alone to offer recommendations to foster their implementation. Studies like this article intend to offer both a theoretical and empirical contribution, highlighting the importance of sustainability practices in the animal health

industry and the role of stakeholder perceptions in driving their adoption, and emphasising the need for effective communication, transparency, and a broader interpretative framework.

First of all, our analysis contributes to an enhanced understanding of the factors leading to environmental sustainability for the animal health industry. One of our fundamental theoretical contributions is demonstrating how various ESIs impact customers' purchasing behaviour, their willingness to pay a higher price for sustainable products, transparency in communicating sustainable practice and the LCA process for firms to enhance sustainability. In this way, we help define the broader theme of implementing environmental sustainability in a highly regulated industry and provide a specific solution to some of the identified challenges. In practical terms, it offers insights to firms within the extended animal health industry value chain to remodel their business practice.

We have discussed the similarities and interconnectedness between animal and human healthcare systems in Section 2. Our theoretical framework borrowed substantially from the sustainability studies in the context of human health (e.g., Debaveye et al., 2020; 2019), and our findings correspond to the findings of studies (e.g., Hensher, 2020; Janatyan et al., 2021) in this context. Therefore, our findings could contribute to the ESIs within human health care. For example, the ‘one health’ based philosophy is equally appealing for human health care. Other findings, i.e., excessive packaging, their safe disposal and possible recyclability, regulatory incentives and burden, and sustainability-oriented health curriculum, could also apply to human health care.

In more specific terms, and adopting multistakeholder and multi-country field research, we found that the efficacy of healthcare products is still the top priority for practitioners in the

industry, with cost, usability, and availability also being significant considerations. Sustainability is now perceived as important, but with mixed responses regarding its relative importance compared to other factors. The value of communication resulted as essential to promote ESIs, while the main interventions expected from animal health companies regarding ESI improvements were environmental residues and product packaging. These interventions were due to the visibility of packaging at the consumer level and reflected public pressure and awareness of residues and packaging waste, particularly plastic. The study also identifies a lack of transparency and information on the sustainability of product packaging and a willingness to pay a premium for sustainable products among certain stakeholder groups.

The most impactful contribution to the sustainability discourse, however, is our proposal of the 'One Health' based approach to sustainability. By adopting the One Health approach, animal health firms can integrate environmental sustainability initiatives into their operations, embedding the expectations and priorities of various stakeholders. This holistic approach not only promotes the well-being of animals and humans but also helps protect ecosystems and ensure the long-term viability of the veterinary pharmaceutical industry. Animal health companies can ensure that their actions align with stakeholder expectations and contribute to positive societal outcomes by actively involving stakeholders in decision-making and addressing their concerns. However, successfully implementing such a strategy will require training and the evolution of a professional mindset, with the necessary inclusion of a sustainability curriculum for the training of the most important stakeholder, the veterinary professionals.

We particularly faced two critical limitations during our research, i.e., data availability and regulation. Almost all our respondents were either unaware of the availability of the

environmental footprint data, or such data was completely non-existent, and sustainability leads within our sample did recognise a critical absence of measurable data. However, it is expected that such data will be more accessible in future due to regulatory pressure and stakeholder expectations. Moreover, we did not capture the regulatory environment from the regulator's perspective due to their absence in our data sample. As an exploratory study, nonetheless, our paper sets the foundation for future studies. Future work can capture extensive quantitative data sets from countries beyond Europe to provide a more in-depth understanding of the sustainability orientation of the global animal health industry.

For business and management research, our study provides the foundation for sustainability research in animal health, a sector where there is a need for more in-depth and longitudinal research. By incorporating a quantitative methodology (i.e., survey), future studies could gather data from a larger sample of participants to assess the extent of sustainability initiatives and their corresponding outcomes. What we did is to build here the evidence base for the animal health industry, which will ultimately contribute to a better understanding of how the industry can support the achievement of the SDGs.

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Appendix 1: semi-structure interview protocol:

Set 1:

Stakeholder: Veterinary pharmaceuticals

Semi structure questions	RQ	Relevant literature
Your company wants to become carbon neutral.	RQ1	Milanesi et al. 2020; Onken et al. (2019) Veleva and Cue (2017) Sreenivasan and Reddy, 2019
Why does your company want to become co2 neutral?		
2) Is your company's sustainability approach only focused on CO2 emissions? Does YOUR COMPANY consider other GHGs and footprints?		
3) What are the new initiatives YOUR COMPANY has taken? What are the challenges, barriers, and opportunities these initiatives bring?		
4) How will the transition from current practice to co2 neutral occur? What are the challenges of these transitions?		
5) How will your up and downstream supply chain react to such a strategy?		

Supply chain-Upstream	RQ1	Hosseini-Motlagh et al., 2021; Rao and Holt, 2005; Saeed et al., 2019; Zaid et al., 2018
6. What are your upstream supply chain's most environmentally sensitive issues?		
7. What are the key challenges of managing/transforming the current supply chain (upstream suppliers) into a carbon-neutral one?		
8. How are you supporting the transformation?		
9. Are you going to procure only from carbon-neutral suppliers?		
R&D	RQ1	Debaveye et al., 2019; 2016;
10. How is environmental sustainability embedded in your R&D?		
Manufacturing	RQ1	McGain and Naylor, 2014; Jabbarzadeh et al., 2019; Bouchery and Fransoo, 2015; Roschangar et al., 2015
11. What key steps have you undertaken to reduce your environmental footprint in manufacturing?		
a) GHGs		
b) Water footprint		
c) Other chemicals		
d) Radioactive		
12. Do you conduct LCAs? If yes, do you communicate these with your stakeholders? How? Why not?		
13. Is green chemistry a part of your practice?		
14. How do you use the green manufacturing ethos?		
15. Do you have environmental criteria for reducing the consumption of raw materials, water, or energy usage in production?		
16. Do you use biodegradable materials in our product design, production processes, and packaging?		
17. Is there a link between sustainability and efficacy?		
Distribution/Marketing	RQ2; RQ3	Krieger et al., 2020; Sinclair et al, 2017 ;
18. Do you inform your market and users about your green practice?		
19. If yes? Do you think the communication is effective?		
20. What are the incentives for your market to use sustainable products?		
21. How do you promote the sustainable efficacy of your products?		
22. What customer demands, if any, are there for more environmentally sustainable products?		
Competitive advantage (CA)	RQ1; RQ3	Chaturvedi et al., 2017; Dzomonda, 2021; López-Toro et al., 2021;
23. How do you intend to use sustainability as your CA?		
24. Is there a sustainability-focused brand strategy?		
25. How do you influence the industry towards sustainability?		
26. How does your current HR embed environmental sustainability in human resource strategy?		
CE /Reverse Logistics	RQ1	

27. Is there a reverse logistics practice to reclaim, reuse, recycle/upcycle packaging materials?		Menzel et al.,2010; Mihaiu et al., 2021
28. Is the circular economy a practice you might want to adopt?		
29. What collaboration do you have with your industry on sustainability?		
Regulation	RQ2	Wernet et al., 2010; De Soete et al., 2014
30. Does the current regulation facilitate or impede sustainability practice within Vet pharma?		
31. How do you influence the regulation towards more sustainability?		

Stakeholders: Veterinary professionals, farmers and the research community

Set 2:

	Semi structure questions	RQ	Relevant literature
1	Name and location		
2	Role within the vet or farming industry	RQ2	
3	Are you responsible for business buying decisions or have the capacity to influence buying decisions? This includes medicines, but also equipment and other items.	RQ1 ; RQ2	
4	Not considering this study at all, what are your primary considerations when purchasing or advising on purchasing medicines or similarly technical products that will be used regularly?	RQ2	
4a	On a scale of 0 (no importance) to 10 (most important), how important now is environmental sustainability concerning purchasing decisions?	RQ2	Bouchery and Fransoo, 2015; McGain and Naylor, 2014.
4bi	The carbon footprint of manufacturing?	RQ2	
4bii	The impact of production on waterways?	RQ2	
4biii	What is the impact of production on resource depletion?	RQ2	
4biv	What is the carbon footprint of the transport of the product?	RQ2	
4bv	Disposal of the product packaging?	RQ2	
4bvi	Product residues in the environment?	RQ2	
4bvii	Use in animals and impact in humans, e.g., antimicrobials?	RQ2	
4bviii	Not Applicable / Are there any other concerns?	RQ2	
4c	Are you and or the business primarily interested in the environmental sustainability of individual products, or would you choose to buy from a company that has strong sustainability credentials even if the individual product in question had not been assessed yet?	RQ2	BCG, 2020 Saha et al., 2021
4d	What specific information would you expect to receive from a company regarding its sustainability policy and the environmental impact of the product?	RQ2	Sinclair et al, 2017
4e	Is there anything else you'd like to add to your response concerning environmental sustainability?	RQ2	
5	Can you describe a time when you made a purchasing decision, in a work or outside of a work setting, based on environmental sustainability considerations?	RQ2	
5a	What were the main factors that influenced your decision?	RQ2	Dzomonda, 2021; López-Toro et al., 2021.
5b	What were the main obstacles you had to overcome to make it, and what helped you overcome these?	RQ2	
5c	What was the financial impact of your decision?	RQ2 / RQ3	
6	What changes, if any, are coming in your immediate industry and country of work concerning environmental sustainability?	RQ1	Krieger et al., 2020; McCelland, 2016
6a	Who or what is driving those changes?	RQ1	
6b	Over what time frame do you see changes coming?	RQ1	
6c	What are the obstacles to these changes?	RQ1	

7	What type and scale of environmental benefits would prompt you to change your buying, prescribing or advisory decisions?	RQ2	
8	Product x and product y are functionally identical, but product y has undergone an analysis of its environmental impact from production to use, also known as a life cycle analysis. As a result, improvements have been identified that result in a 20% lower carbon footprint per item. What % price difference would you be prepared to pay for product y, if any?	RQ3	Chaturvedi et al., 2017; Vogus and McCelland, 2016; Breidert et al., 2006; .
9	Product x and product y are functionally identical, but product y provides a more environmentally responsible product disposal scheme. What % price difference would you be prepared to pay for product y, if any?	RQ3	
10	Product x and product y are functionally identical, but product y has undergone a health economics analysis, to understand the cost benefits of use of the product. As a result, it has been shown it provides a 5% increase in efficiency of growth or production in the animal, therefore a proven return on investment, to the end user following use, what % price difference would you be prepared to pay for product y, if any?	RQ3	
11	If product x was assumed to have the same benefit of return on investment, but no evidence was presented for this, would this change your decision on paying a price difference?	RQ3	
12	How confident do you feel that you understand the environmental sustainability impact of products within the animal health industry?	RQ3	Demir and Min, 2019; Schneider et al., 2010
13	Where do you or would you go for further information on this topic?	RQ3	

Appendix 2: Initial coding

Concepts (in bold) and codes	Referenced by the number of interviewees	Number of references
animal productivity	8	8
buyer pressure	8	6
change culture	8	5
clinical efficacy	18	19
clinical benefits	10	6
efficacy	14	11
indication or licence	6	4
communication	6	4
recommendation	2	2

Lack of information	13	24
social media	4	2
conflicting demands	14	12
complexity	2	2
conflicting demands	14	11
convenience and ease of use	12	9
convenience	6	3
case of use	10	6
corporatisation	2	3
cost considerations	22	22
cost	20	16
cost benefit consideration	12	9
emissions, energy and carbon footprint	14	14
carbon footprint	8	6
energy consumption	8	6
global warming potential	4	2
greenhouse gas emissions	2	3
evidence	12	12
future changes	12	15
change is coming	8	7
future plans	6	8
government and regulations	12	12
government	14	11
regulations	6	3
increasing awareness of ES	10	9
farm vets more aware than other vets	2	1
increasing awareness of environmental issues	10	8
lack of urgency or need	12	13
current lack of urgency or need	8	11
medicines minimal impact	4	2
locally sourced	10	10
market forces	8	7
TCFD	2	2
personal sustainability interest	4	5
pharma responsibilities or opportunities	18	22
pharma responsibilities	8	5
pharma support	4	2
plastic	12	8
service	4	2
trust	6	5
plant medicine	2	1
product disposal	16	17
disposal	4	2
packaging	12	10

recycling	8	5
resource use	4	4
public pressure	20	17
small difference with commodity product	6	4
society and governance	2	4
employee welfare	2	2
governance	2	1
society	2	1
soya	4	2
specific not vague commitments	4	3
supply chain and its reliability	10	10
reliability of supply	4	2
supply chain	8	8
sustainability premium	4	3
technology or availability	6	4
novelty	2	1
technology	4	3
transparency and availability of ES info	8	6
current lack of ES info	8	5
greenwashing	2	1
transparency	6	4
treatments and residues	20	31
environmental residues	20	19
human and animal health	6	5
treatments	18	18
unpredictable catalyst	2	1
veganism	2	1
veterinary upskilling	4	2