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To promote behavioural change among farmers for compliance with zoonoses preparedness, a literature review and assessment of preventive interventions were conducted. Using the Theory of Planned Behaviour, different behavioural drivers were looked at: a farmer's attitude, subjective norms, perceived behavioural control, intention, and the effectiveness of various preventive interventions on these drivers. These interventions were classified in four categories: awareness and knowledge, social influence, economic incentives, and regulatory measures. From these learnings, guidelines for designing successful intervention strategies were shared. They involve collaboration with stakeholders, considering past experiences, understanding local contexts, involving farmers in interventions, emphasising shared responsibility, and strategic communication.

Key words: zoonoses, behavioural change, interventions, prevention of outbreaks, compliance, farmers, theory of planned behaviour

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Preface

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Summary

S.1 Key findings

Zoonotic diseases pose a significant threat to human and animal health, to the animal agriculture sector and consequently food safety and security, with the emergence of unpredictable pathogens. Preventive interventions such as education, international regulations, financial incentives, or vaccination programmes, aim to prepare farmers for such challenges given their pivotal role in disease management. But for these interventions to be relevant and efficiently lead to farmers adopting preparedness measures such as tight biosecurity on their farm and strict hygiene practices, it is essential to identify the behavioural factors that define the success of preventive interventions and drive stakeholder compliance.

Among these factors, the attitude of farmers emerges as a primary determinant of their intentions, with subjective norms and perceived behavioural control also playing significant roles in shaping their responses to zoonotic threats and to preventive interventions.

To ensure the efficacy of preventive measures in ensuring compliance, a comprehensive approach is recommended. This approach includes engaging key stakeholders through collaboration with farmers as well as with their main social influences such as fellow farmers, friends, family, and veterinarians, acknowledging potential past experiences with zoonoses outbreaks, understanding the local cultural, economic, and environmental contexts, adopting participative approaches through involvement of farmers in the framing of interventions, emphasising shared responsibility, and framing communications strategically.

S.2 Methodology

Main research question: How can behavioural theory provide insights into the effectiveness of preventive interventions related to zoonotic disease outbreaks and how can these insights be used to ensure compliance among farmers for preparedness to zoonotic outbreaks in a veterinary-public health setting?

A literature review and analysis were conducted to assess important behavioural drivers of compliance in farmers, harnessing the knowledge provided by psychological behaviour change theories and farmers' behaviour in contexts of zoonotic threat and other contingencies. The Theory of Planned Behaviour (Ajzen, 1991) was used as a theoretical framework.

The insights from the literature review were used to assess preventive interventions aimed at fostering behavioural change among farmers and ensuring compliance with zoonoses preparedness measures. These interventions were categorised into four groups: awareness and knowledge interventions, social influence and collaboration interventions, economic incentives and resources interventions, and regulatory and policy frameworks.

The TPB framework was applied to examples of interventions from each category to assess their effectiveness. This analysis helped in determining guidelines for compliance of farmers to zoonotic threat preparedness.

1 Introduction

1.1 Background

Zoonotic diseases or zoonoses are infectious diseases that are naturally transferable from vertebrate animals to humans and vice versa (World Health Organisation, 2020). The vulnerability of food production, processing, and distribution chains to the emergence of Disease X, a term used to represent the potential for a pathogen not currently known to cause a severe global epidemic (WHO, 2022), has becoming increasingly apparent. The unpredictability of Disease X is particularly important as zoonoses can lead to foodborne illnesses when pathogenic microorganisms such as bacteria, viruses and parasites contaminate food or water. The risk of contamination exists at every stage of the food supply chain, from farm to fork (European Food Safety Authority, 2023). Besides food-borne transmission, emerging pathogens can transmit through direct contact, air, and contaminated environments. Consequently, the agricultural sector, particularly animal farming, can be a source of zoonotic diseases and a platform for its spread. Since 1940, agriculture has been thought to be responsible for 50% of the development of zoonotic diseases (Hayek, 2022). Moreover, the emergence of future zoonotic diseases is strongly influenced by the interconnected relationship between agriculture and the surrounding environments and ecosystems. Interactions between humans, livestock, peri-domestic wildlife, and the biosphere's wildlife led to increased risks in pathogen flows. As agriculture production intensifies and expands into wildlife habitats, greater opportunities for spill over arise and put at risk global health and biodiversity (Jones et al., 2013).

The far-reaching consequences of disease outbreaks on global food systems and agricultural productivity are flagrant, highlighting the need for proactive measures in safeguarding agricultural systems against future threats such as global pandemics.

In preparation for such occurrences, it is crucial to prioritise readiness for zoonotic outbreaks. This aspect is an integral component of Pandemic Preparedness and Response (PPR). Zoonoses preparedness comes through five subsystems and core elements:

Quotation 1: The five subsystems and core elements of PPR

- Surveillance, collaborative intelligence and early warning
- Public health and social measures & engaged, resilient communities
- Prioritised research, equitable access to medical countermeasures & essential supplies
- Lifesaving, safe & scalable health interventions & resilient health systems
- Pandemic preparedness and response strategy, coordination, and emergency operations

[WHO and the World Bank, 2022]

The different zoonoses preparedness elements are interconnected and require coordination of efforts of all stakeholders involved and rely on the capabilities of nations, frameworks provided by governance, norms and standards, and when necessary, long-term and emergency financing (WHO and The World Bank, 2022).

The entry points for enhancing zoonoses preparedness present clear opportunities should it be through agricultural practices, policy implementation and using a systemic approach to look at the issue.

Farmers, as active stakeholders, play a crucial role in the first line of defence, across all five subsystems of PPR, and in shaping food safety policies (Garcia et al., 2020). Should it be through biosecurity practices, disease monitoring and surveillance, diversification of farming systems or training and education, farmers' actions play a significant role in outbreak prevention, control, and response. This underscores the importance

of their participation in a One Health approach to disease prevention, their willingness to adopt specific behaviours being an opportunity to significantly minimise the threats to both animal and human health.

One key entry point in these preparedness subsystems is the implementation of preventive interventions aimed at farmers. Preventive interventions within the context of zoonotic outbreaks encompass a range of strategic objectives aimed at mitigating the impact of such crises, helping to save lives and reduce the cost of medicine and supportive care in the events of an outbreak. These interventions aspire to achieve several outcomes. Key objectives include enhancing education and communication, particularly by fostering collaboration with relevant food and health authorities to facilitate information exchange, referral mechanisms, and assistance during outbreaks. Additionally, preventive efforts target the limitation of interactions between humans and wildlife, safeguarding both populations. Another desired result of these interventions is that robust biosecurity measures are implemented on farms to prevent disease transmission within livestock populations and from wildlife. Vaccination programmes for livestock serve as a pivotal component to curtail disease transmission. Moreover, community engagement is actively promoted, fostering a sense of shared responsibility. Strong surveillance and disease control measures are paramount, supported by well-motivated and well-supported personnel who are equipped to oversee the increased workload during crisis periods.

While government recommendations and legislation play a significant role in implementing control measures for ensuring the safety of animal products, it is important to recognise that their influence does not reach every farmer's decision-making process. Indeed, social and financial responsibility can be shared with various stakeholders, such as among the private sector, including with other farmers, retailers, and consumers, rather than solely resting on the government (Ellis-Iversen et al., 2010). This underscores the necessity for adopting a diversified approach to effectively encourage farmers' compliance with zoonotic threat mitigation, acknowledging the need to collaborate with a range of stakeholders beyond governmental bodies.

The effectiveness of preparedness and response measures as well as interventions is influenced by numerous factors at play, including but not limited to technical solutions that are optimal from an epidemiological and economic standpoint. These technical solutions include different zoonoses preparedness measures, for example, prevention strategies such as disease surveillance, vaccination of livestock, and early warning and cooperative intelligence. Epidemiological modelling can be used to predict the effectiveness of these measures. However, for an epidemiological model to accurately predict the course of an epidemic and the effect of interventions, varied factors need to be identified and combined. The efficacy of these ideal technical solutions relies on the compliance and capability of those who are responsible for implementing them and carrying out the necessary actions, such as farmers.

Compliance is defined as an individual following diverse kinds of expectations, such as rules, standards, requests, or orders (Etienne, 2010). Compliance is closely related to decision-making as it involves the choice to follow certain recommendations or requirements. For example, in a healthcare setting, compliance is defined as the degree to which a patient's actions align with the recommendations made by their healthcare provider (Chakrabarti, 2014).

In the context of this study focusing on farmers' decision-making in zoonotic disease prevention, compliance refers to their actions regarding recommended preventive measures. Therefore, it becomes essential to delve into the factors shaping farmers' decisions to either adopt or disregard recommendations, whether from a veterinarian, health authority, or other sources of guidance. Employing a theoretical framework such as the Theory of Planned Behaviour allows for a comprehensive and structured examination of the different factors leading to compliance or non-compliance, including potential response such as reactance (a tendency to frequently say 'no' and to resist conformity) (Orbell and Hagger, 2006).

In epidemiology, attempts are made to measure individuals' compliance (Dairo et al., 2018; Jeong et al., 2023). The degree of compliance of stakeholders plays a pivotal role in explaining courses of events such as zoonotic outbreaks, thus leading to more accurate representations of reality. This relationship between interventions and accurate modelling is reciprocal: model output can inform intervention strategies, allowing for them to be prioritised at certain times in certain areas and to allocate resources efficiently, while interventions, in turn, contribute to refining and enhancing the accuracy of modelling.

However, epidemiological modelling insights on compliance levels are not sufficient for fully effective containment and prevention measures. It is necessary to design interventions that can help reach this level of compliance through rigorous intervention planning that adopts a comprehensive approach and considers the logistical, economic, environmental, epidemiological and behavioural factors that influence the outcome of these interventions.

Current veterinary epidemiological infectious disease transmission models frequently exclude behavioural elements and assume farmers' behaviour as homogeneous. However, understanding behavioural determinants, behavioural change processes, and intervention implementation are crucial for changing farmers' behaviour (Biesheuvel et al., 2021). To fully understand how prevailing social, cultural, legal, political, and economic variables affect disease categorisation and diagnosis, epidemiology and public health techniques must work in interactions with these anthropological perspectives (Wood et al., 2012).

1.2 Objectives

In this research, we aim to give a comprehensive overview of the state of the art of behavioural determinants, processes of behavioural change, and intervention implementation within farmers' decision-making context of zoonotic diseases. An underlying goal of this review is to identify the main behavioural factors to take into account in the design of preparedness interventions for farmers in relation to zoonotic threats.

Indeed, given potential constraints such as limited time and resources to prevent the spread of zoonotic disease, it remains important to prioritise the examination of key predictors of behavioural change in the context of zoonotic preparedness. This would hypothetically facilitate quicker action to enhance farmers' preparedness and response to emerging threats, contributing to the overall safeguarding of public health.

This report also aims to integrate and build upon the existing knowledge on how to foster compliance to zoonotic control measures, contributing to a novel approach to prevention from zoonotic threats using behavioural theory.

1.3 Research question

How can behavioural theory provide insights into the effectiveness of preventive interventions related to zoonotic disease outbreaks and how can these insights be used to ensure compliance among farmers for preparedness to zoonotic outbreaks in a veterinary-public health setting?

1.4 Methodological approach

This report addresses this research question by comprehensively examining the behaviours, underlying motivations, beliefs, and interactions of farmers and other relevant stakeholders. The methodological approach will allow to gain a deeper understanding of these behavioural dynamics and their role in shaping decisions related to reinforcing zoonoses preparedness practices within the context of outbreak preparedness.

Indeed, behaviour analysis is used as a framework to understand the values and sentiments of stakeholders and influence their compliance in acting and improving their preparedness and response. From such analysis, evidence-based input on the prediction of sentiment in an outbreak setting will be provided. Emphasis is placed on understanding the behaviour of farmers in the context of zoonotic threats. Considering their behaviour helps in developing tailored interventions that are more likely to be accepted, adopted, and effectively implemented by farmers.

To reach the objectives of this report, a literature review followed by synthesis and assessment was conducted with a focus on psychological theories of behaviour change, farmers' behavioural process in the context of animal disease control (both zoonotic and non-zoonotic diseases, due to an insufficient amount of literature on the subject of behaviour of farmers facing zoonotic threats specifically), as well as literature on the efficiency of biosecurity strategies, and on other long-term-oriented entrepreneurial actions (such as pro-biodiversity actions). Grey literature, such as reports and working papers, alongside peer-reviewed academic articles, was identified. Details on the scoping protocol of this literature review can be found in Appendix 2.

Theoretical framework: Theory of planned behaviour

The Theory of Planned Behaviour (TPB) (Ajzen, 1991), a widely applied and key framework for studying the psychological factors behind farmers' decisions and behaviours (Senger et al., 2017) was used as a theoretical framework. Among the various theories aimed at explaining behaviour, including health-relevant behaviour (Conner and Norman, 2005), the Theory of Planned Behaviour has been extensively applied in agricultural research to understand different behaviours such as encouraging pro-biodiversity actions on-farm (Small and Maseyk, 2022), the diversification of small farmers' agricultural production (Senger et al., 2017), the acceptance of water policy options (Mahdavi, 2021), cultivated-land-abandonment (Chen, 2022), engagement in sustainable agricultural practices (Fielding et al., 2008), antimicrobial usage in dairy farms (Vasquez et al., 2019), or improvement of animal welfare (Winkel et al., 2020).

In the TPB, model represented in Figure 1.1, intention of an individual to perform a behaviour is explained by three main constructs: attitude of the individual towards the behaviour, subjective norms, and perceived behavioural control. Attitude corresponds to how positively or negatively a person views the behaviour, subjective norms relate to the social pressure associated with particular behaviours and thirdly, perceived behavioural control refers to whether a behaviour is regarded to be easy or difficult to accomplish (Biesheuvel et al., 2021).

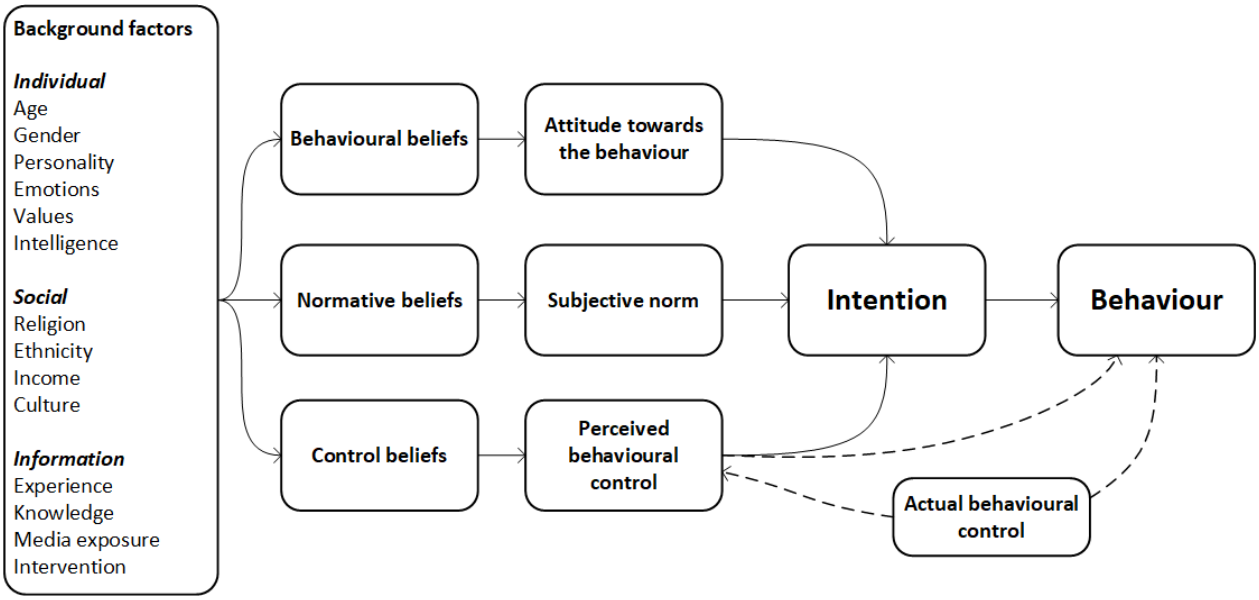

Figure 1.1 *The Theory of Planned Behaviour of Ajzen*

The choice to use this framework was made due to the Theory of Planned Behaviour's versatility, simplicity, and ease of application (Bergevoet, 2005). A farmer safeguarding their farm against zoonoses is an example of entrepreneurial activity: farmers seeking safer practises, more production, improved animal care and better farm organisation (Kahan, 2013). Entrepreneurial activity being planned behaviour and involving cognitive thinking, the TPB is deemed to be a suitable model for shedding light on the thought process related to entrepreneurial actions of farmers (Bergevoet, 2005). The TPB can account for the complexity and diversity of health behaviours and contexts. The TPB considers the motivational (the reasons that drive people to act in a certain way) and volitional (the process that lead people from intention to action) aspects

of human behaviour (Conner et al., 2005). Capturing both these aspects helps in understanding why individuals comply or not with certain behaviours, justifying TPB has the chosen model for understanding compliance. Moreover, the constructs of the model are assumed to efficiently mediate the impacts on behaviour of external factors such as demographics (Elliott et al., 2003).

This choice of theoretical framework is done keeping in mind the gap between a theoretical model and practical reality and the limited amount of literature. In response to this, it is common for studies looking at behaviour to include other constructs alongside the TPB's elements (de Lauwere, 2020).

A list of zoonoses preparedness interventions was identified and organised into four categories: awareness and knowledge, social influence and collaboration, economic incentives and resources, and finally regulatory and policy framework. This categorisation is based on the interactions of different types of interventions with the elements of the TPB:

- Awareness and knowledge interventions mainly appeal to the attitudinal components of the theory as well as perceived behavioural control.
- Social influence and collaboration relate to subjective norms and perceived behavioural control.
- Economic incentives interact with attitude and perceived behavioural control.
- The last category, regulatory and policy frameworks, interacts with all components of the TPB, and includes both voluntary and mandatory interventions. While mandatory interventions may be less aligned with a farmer's own motivations as they are imposed by an authority, they are included in this categorisation. Indeed, the TPB has been applied to study the effect of laws on intention (Macy et al, 2011), and has been found to place emphasis on external factors that influence an actors' behaviour-related beliefs (Tzeng et al., 2022) which shows the relevancy of taking into account external sources of decision-making.

Examples of each of these categories of preventive interventions were then analysed in juxtaposition with the Theory of Planned Behaviour's constructs, to conclude on the effective design of preventive interventions taking into account social drivers of compliance.

A representation of the conceptual framework of this report can be found in Appendix 1, Figure 2 which illustrates the methodological approach of the research and sets it in the context of farmers' compliance facing zoonotic threats.

2 Theoretical framework

Psychological theory and rural sociology are both extensively used domains that have helped to understand behaviour in agricultural and health-related sectors, notably farmers' behaviour. In sociological approaches to behaviour, there is a focus on the context within which the individual lives and their associated interactions. Behaviour is the result of widespread social norms and intricate relationships, which vary across individuals and thus the homogeneity of farmers' decision-making process should not be assumed. Social aspects are key factors in regional and international variations of disease dynamics and burden (Biesheuvel et al., 2021).

Decisions encompass numerous factors, including objective characteristics of the farm and farmer, the social-institutional environment (legal and institutional frameworks), economic constraints, decision characteristics and behavioural characteristics (Bartkowski and Bartke, 2018). As a starting point, we assume that farmers' decisions are influenced by several factors: farming objectives and goals, risk-taking, personality, quality and quantity of information, other individuals involved in the decision-making process, the individual's problem-solving ability, attitudes towards legislation, autonomy, management skills, and stress management skills (OECD, 2012). The purpose of using a theoretical framework is to delve deeper into the connection between preventive interventions and these factors, pinpointing the stage at which they become relevant. Taking a closer look at these elements that make up decision making, we will then analyse farmers' behaviour relating to zoonotic threats and attempt to determine which predictor has the largest effect on behaviours and is the best indicator of effort being exerted for a behaviour to be performed.

Given the complex interactions between individual decision-making and the social environments in which farmers operate, the Theory of Planned Behaviour offers a valuable framework for examining their compliance behaviours in the context of zoonotic threats. The TPB allows for exploration of the interplay between individual motivations, social dynamics, and contextual factors and emerges as a fitting lens to shed light on the mechanisms guiding farmers' responses to preventive interventions. It provides a structured framework for the dissection of the decision-making of farmers in zoonotic disease prevention, and for the identification of key predictors and elucidating the pathways to compliance.

The Theory of Planned Behaviour

The TPB (depicted in Figure 1.1) was developed in the second half of 1980s by Icek Ajzen to enhance the predictive capability of his Theory of Reasoned Action (TRA) first proposed in 1980 (Conner et al., 2005). The TPB bases itself on the idea that individuals consider both benefits and drawbacks of a new behaviour before engaging in it and conceptualises behaviour as a result of a key determinant: intention, which reflects the motivational factors that influence behaviour. Motivational factors are indications of the degree of effort an individual is willing to exert to enact a behaviour (Nancy and Dongre, 2021). The TPB emphasises this motivational (reasons that drive people to act in a certain way) but also considers volitional (the process that leads people from intention to action) aspects of human behaviour (Conner et al., 2005). Capturing these two aspects helps in understanding why individuals comply or not with certain behaviours.

Moreover, an individual's motivation is caused either by intrinsic reasons or extrinsic reasons. Both intrinsic and extrinsic motivations are highly relevant in entrepreneurship, as individuals may initiate changes or improvements within their establishment driven by internal (personal choices) or external (obligation, control) factors (Al-Jubari et al., 2019). This is relevant to keep in mind looking at a farmers' decision-making and their compliance to interventions.

At the basis of the theory, are the external variables and background factors. These include demographic variables (gender, age, education level, occupation, socioeconomic status, religion), personality traits (openness, conscientiousness, agreeableness, extraversion, neuroticism) and environmental influences such as physical environment and access. They will influence all other components of this behavioural model, being unconscious parts of the decision maker's environment (Conner et al., 2005).

Transitioning from the examination of background factors, we now proceed to delve into the subsequent steps of our model. According to Ajzen, three distinct types of beliefs that are influenced each in their own manner by the external variables, will shape their own constructs, ultimately contributing to the formation of intention to comply.

The first type of belief is *behavioural beliefs*. Behavioural beliefs represent the perceived consequences or additional characteristics of a behaviour. These beliefs shape the construct of attitude towards a behaviour: attitude refers to an individual's perception of if a certain behaviour makes a positive or negative contribution to their life. Attitudes are learned and determine how a person consistently responds to a behaviour (Conner et al., 2005).

Attitude encompasses a farmer's judgment about complying to a particular behaviour. Study of a farmer's opinion towards zoonoses preparedness measures is then relevant in understanding their attitude and shifting it to a positive feeling and to more perceived advantages than disadvantages. Concrete examples of perceived advantages or disadvantages to zoonoses preparedness improvement are financial incentives and motivations such as the avoidance of periods of financial stress, or on the other hand clear financial benefits and the generational pass-over of the business (Hayden et al., 2021).

In this context, it is valuable to define incentives as rewards or penalties that serve as encouragements for individuals to engage in a particular activity and dictate how they approach it. These incentives, whether positive or negative, tangible or intangible, can be applied to either promote desirable behaviour or deter negative actions (Gneezy et al., 2020).

Second, *normative beliefs* reflect an individual's perception of the preferences held by specific influential individuals. Normative beliefs will then shape the construct of subjective norms, a construct that is taken into account by an individual in their decision-making process. These norms allow to understand how social pressures articulate themselves and how others influence an individual's decisions (Conner et al., 2005). The literature robustly supports the positive correlation between social norms and compliance (Cooper, 2016).

In the context of preparedness to zoonotic diseases in animal husbandry, subjective norms would then refer to a farmer's beliefs of significant others' opinions on what behaviours the farmer should follow when it comes to improving their farm's ability to resist such outbreaks.

At a farmer's level, it is then interesting to look at the relevant stakeholders that might exert a social pressure that would benefit zoonoses preparedness. An example of such key actors are veterinarians, the farmer's family, friends, and neighbours.

The third and final set of beliefs are *control beliefs*, explained as the perception of elements that are likely to promote or impede the performance of the conduct, shape the construct that is perceived behavioural control. This construct refers to the level of control of an individual on goals and behaviours that depend themselves on the performance of a complex chain of other behaviours. A term that is commonly found in psychological theory and that is similar to perceived behavioural control in its meaning is self-efficacy: the confidence in one's capacity to carry out the advised courses of action (Conner et al., 2005). Control is a significant determinant of behaviour as people tend to perform actions over which they have actual control instead of little to no control. And since control is hard to measure, perceived behavioural control is presumed to forecast behaviours quite faithfully and is thus employed to predict behaviours (Conner et al., 2005).

Based on this reasoning, the importance of the farmer's perception of how easily a behaviour can be accomplished is underlined. The farmer's perceived behavioural control over improving their zoonoses preparedness affects its performance and the actual making of decisions and concrete behaviours to improve their preparedness. When an individual perceives a lack of control over a behaviour, it weakens the relationship between their intentions and the actual behaviour. Even if a farmer intends to engage in a measure for increased zoonoses preparedness, the difficulty in conducting the multiple steps involved can make it harder to translate that intention into action. Examples of such barriers constraining a farmer's perception of control over the behaviour are the lack of ability to invest in a transition towards a farm that

fulfils zoonoses preparedness measure, the time that it requires in the farmer's schedule, or the lack of skills and knowledge on how to implement these measures. These factors can significantly impact a farmer's ability to comply with the necessary steps for zoonoses preparedness.

Psychological theories, like any models, have their limitations, as they simplify the complex realities they aim to explain. Since its creation, researchers have been exploring the TPB's omissions, as well as potential alterations to the model aiming to increase the fidelity of its depiction of reality.

It has been observed that the theory assumes that a change in attitude will also result in altering one's behaviour. In actual circumstances, people seem to alter their behaviour and then progressively change their attitudes (Nancy and Dongre, 2021).

Additional predictors such as self-identity, fear, mood, past behaviours, anticipated regret, or moral norms are disregarded or not given due importance in Ajzen's model. The influence of past behaviour on future behaviour seems however to be a competent predictor of future behaviour (Conner et al., 2005).

The TPB predicts behaviour better in the near term compared to the long term and is more helpful for predicting self-assessed behaviour than objective assessment of behaviour. Moreover, the TPB seems to be more helpful in identifying what people believe and think about a behaviour, rather than providing specific suggestions on how to change these beliefs (Conner et al., 2005). This however does not have to be a limit, if we aim to adapt the interventions to the farmer's behaviour rather than the other way around, changing their behaviour to fit current interventions.

3 Identification of important drivers of compliance

This section delves into the assessment of drivers of farmers' compliance and their significance based on a comprehensive review of various scientific articles. This review was done with a focus on studies on behavioural analysis of farmers in similar contexts, while using the TPB and/or constructs closely related to attitude, subjective norms and perceived behavioural control and their sets of beliefs. It is important to note that the found significance of the different drivers on farmers' compliance may vary depending on the study, with different authors highlighting distinct factors as the most influential.

De Lauwere et al. (2020) studied the participation of farmers in a dairy health programme that could help in the prevention of Bovine Virus Diarrhoea outbreaks. The enrolment of dairy farmers in this hypothetical health program showed the diversity in farmers' choices, underscoring varying sensitivities to rewards or fines, along with differences in intentions, attitudes, beliefs, and perceptions. However, it did shed light on potential drivers in a farmer's decision-making process. Attitude came out as one of the main drivers of their choice to join or not the voluntary programme. In this study, other notable drivers of decisions were control belief strength (the degree to which they anticipate being able to spend little time on disease prevention), the farmers' aversion to ambiguity (the degree to which the individual avoids uncertainty about the probabilities of various outcomes) and the degree to which they perceive problems with the health of their livestock. The study also pointed out that when creating interventions tailored to the unique contexts of farmers, having a comprehensive understanding of farmers' adoption of practices meant to reduce health risks is essential (de Lauwere et al., 2020). Hence, behavioural change is more likely to occur when a comprehensive approach considers and addresses the various elements and influences affecting an individual's behaviour concurrently.

In a study looking at encouraging pro-biodiversity actions on-farm using the Theory of Planned Behaviour, attitude is the greatest predictor, accounting for 49% of the variation in behavioural intention (Small and Maseyk, 2022).

In 2008–2009, a survey was conducted in the Netherlands to investigate the motivations of both commercial livestock farmers and hobby holders for vaccinating their animals against the Bluetongue virus (BTV). Prevention of production losses and subsidisation of vaccinations were thought to be the major reasons for vaccinating livestock against BTV. These incentives can be related to one's attitude, as financial rewards have been observed to influence shifts in farmers' attitudes toward a specific behaviour. Three other significant motives were observed: practitioners' recommendations which contributes to normative beliefs, as well as welfare concerns and contribution to the eradication campaign. These two last motives were classified as 'idealistic motives' in the study, not allowing for a direct correlation to the TPB model but indirectly contributing to all three types of beliefs (Elbers et al., 2010).

In a study focused on the management of zoonotic diseases on English and Welsh cattle farms, the authors sought to examine farmers' decision-making processes using a theoretical framework derived from the TPB. The results state that despite a generally positive attitude towards zoonotic control, more than half of the farmers showed no intent to implement control measures. Indeed, those with an intention to implement measures, cited non-supportive social norms and a lack of belief in self-efficacy as inhibiting factors. This shows that having a positive attitude towards the behaviour as well as an intention to implement change, can be downplayed by the effects of the other constructs. However, farmers with an intent to implement control measures, were said to be the most motivated by financial incentives, which relate to one's attitude. Farmers with no intent to implement measures saw their veterinarian as the preferred motivator, relating to subjective norms (Ellis-Iversen et al., 2010).

In another study aiming to analyse the factors that influence farmers' decision to take part in a fictitious reactive vaccination programme (a vaccination strategy implemented in response to the presence or emergence of a disease in a population) for BTV, attitude is seen to outweigh social norms and perceived

behavioural control considerations. While results show that attitude is the main determinant of farmers holding a positive intention towards vaccination, social pressure is also seen to influence decisions significantly. Indeed, farmers were seen to be impacted by influential figures' opinions as well as other farmers' anticipated action (Sok et al., 2016).

Most research on farmers' opinion towards biosecurity, as reviewed by Mankad (2016), shows the prevalence of a moral struggle between investment and individual costs of biosecurity implementation, and the collective advantages of increased biosecurity involvement. This indicates a conflict between attitudes and subjective norms as the primary drivers of farmers' decision-making. Ultimately, it is contextual factors that determine which of these two factors takes precedence as the main driver in a given situation (Mankad, 2016).

In their review, Mankad (2016) examines how psychological, social, and cognitive aspects may affect management strategies and behaviour linked to biosecurity. They discuss social norms and their impact on farmers' decision making. Social norms can be defined as two main elements: injunctive norms (or beliefs about what is commonly approved), and descriptive norms (or perception of the individual on what is often done in a particular context). Subjective norms mentioned in the TPB are said to be remarkably similar to injunctive norms in their definition (Mankad, 2016). According to Mankad, norms play a key role in shaping farmer behaviours, particularly through the mechanism of diffusion. As described by the diffusion of innovation theory (Rogers, 2004), diffusion represents a process of social change where innovative practices are gradually communicated within a social structure or system over time. In early agricultural research, it was observed that the diffusion process placed normative pressures on farmers with similar socioeconomic backgrounds, compelling them to adopt innovative farming methods advocated by early adopters in their local community.

The main takeaway from looking at such social norms is that biosecurity measures are more likely to be adopted by farmers if they perceive that their peers are also doing so, and that there would be social consequences to them not adopting said measures (Mankad, 2016). Subjective norms can thus be seen as a major indicator of desirable behaviour for zoonoses preparedness.

It is good to note that across the agricultural sectors, different industries respond differently to pandemic preparedness. In farming sectors that imply cooperation between the farmers for the good production of their product (such as rice farming, irrigation networks flowing through fields), it has been observed that farmers low in relational mobility (relational mobility being defined as the degree of opportunities individuals possess within a social context to choose and change their interpersonal connections) and with fewer new acquaintances in the last 30 days share tight social norms. These tight social norms lead to the efficient monitoring of the contribution of all individuals in these relationship networks, as well as the sanctioning of stakeholders that are not owning up to their responsibilities. In event of pandemics, sanitary measures are then easier to implement (Talhelm, 2023). This implies that if a binding relationship, sense of responsibility and of dependence on each other's actions is reached in such a setting of low-relational mobility, implementation of measures against outbreaks would be more feasible.

When it comes to the third set of beliefs defined above, perceived behavioural control, it holds its own power of prediction on farmers' compliance. Aiming to understand farmers' decision-making drivers, several studies of decision-influencing factors were reviewed by Bartkowski et al., (2018). What came out of the analysis is that economic constraints and incentives are key contributors. Aside from that, 'goodness of fit' and past behaviours are additional major determinants (Bartkowski et al., 2018).

In this particular context, the concept of 'goodness of fit' can be explained as how well the measure fits in with existing farm management practices and legal restrictions. Farmers have been observed to choose simple solutions since they require little work and do not conflict too much with their activities (Bartkowski et al., 2018). This can be linked to their perception of the control that they have over the implementation of new measures. If an intervention is less time consuming and requires less implementation efforts and shifting around of other activities, then it might consequently be more easily adopted. This can be linked to the perceived behavioural control construct of the TPB framework.

Several prerequisites must be in place to facilitate substantial change of behaviour, including the requirement that the intended beneficiaries are adequately motivated, possess a belief in their own capacity and influence to bring about change, and have access to the essential resources. This underlines the importance of self-efficacy as a driver of change. In Bandura's self-efficacy theory, self-efficacy comes from four main sources: verbal persuasion from others, performance successes from personal experiences, vicarious experience from seeing others execute the activity, and physiological and affective states (worry, tension, or other emotional states can affect an individual's assessment of their efficacy) (Hamilton et al., 2022). According to Ajzen, self-efficacy is a component of perceived behavioural control along with perceived controllability (Conner et al., 2005).

Other variables are still worth mentioning as drivers of behavioural change in the agricultural context. Studies have described past behaviour as the best predictor of future behaviour, with large correlations between past behaviour and future behaviour, past behaviour and intention, past behaviour and attitude, and past behaviour and perceived behavioural control. Ajzen suggests that past behaviour is a way to assess if the TPB is enough to predict behaviour, and that its impacts are mediated by perceived behavioural control. In simpler terms, doing something repeatedly makes the individual feel more in control of it. Based on this idea, past behaviour should be related to perceived behavioural control (Conner et al., 2005).

With that logic, one might argue that how well a farmer protects their livestock or responds to a new outbreak, depends on their past experiences with outbreaks. In the context of the Dutch animal husbandry sector, which is prone to (zoonotic) outbreaks due to the large number of farms and animals within a relatively small area, several epidemics were faced in the two last decades (see Table 3.1). However, it is uncommon that the same farmer is confronted multiple times with an outbreak.

Table 3.1 *Major outbreaks of zoonoses and animal diseases with zoonotic potential affecting the Netherlands' animal agriculture from 2000 to 2022*

Disease	Year(s)	Animal husbandry sector impacted
Avian influenza (H7N7)	2003	Poultry sector
Avian influenza (H5N1)	2005-2006	Poultry sector
Q fever	2007-2010	Dairy goat farming
Swine influenza (H1N1)	2009-2010	Pig farming
Covid-19	2019-2020	Mink farming
Avian influenza (H5N1)	2021-2022	Poultry sector

Note. From Hubalek and Rudolf (2010); RIVM, 2004, 2021, 2022.

The major Chinese outbreaks of African Swine Fever (ASF) in 2018 and 2019, causing the culling of more than 1,200,000 pigs by mid-2019 to stop the spread of the virus (Suning et al., 2021), has allowed to study the recovery of farmers that were confronted to an epidemic. It was observed that the farmer's self-efficacy was improved by the experience, with increased confidence in recovering their production after an epidemic. Hazards associated with an outbreak are better understood by the farmer and there is more motivation to invest in prevention to future epidemics. Moreover, in this context, correlations with age were found, young farmers being more willing to accept changes and adopt new technologies while older farmers were more risk-adverse and tending to reduce their farming volume as a result of an epidemic (Ge et al., 2022).

On the other hand, a study (Indrawan, 2019) done in the poultry sector of the Indonesian region of Western Java showed that prior disease outbreak experience did not correlate with improved biosecurity practices among farmers. It appeared that farmers either accepted the economic consequences of outbreaks or found these consequences to be minor due to factors like contractual agreements or an existing market for sick chickens. Paradoxically, this lower level of biosecurity increased the risk of disease outbreaks, leading to more experience with outbreaks (Indrawan, 2019). This specific turn of events might however change depending on the farming sector and country legislations surrounding handling of epidemics. Nonetheless, past experience should be taken into account as a variable to explain behaviour, while being dealt with carefully.

To conclude on this section, looking at the literature, while all three constructs of attitude, subjective norms and perceived behavioural control have strong effects on behaviour, in this context, attitude emerged as the predominant predictor. However, other variables such as past experiences must also be taken into account.

4 Evaluation of preventive interventions to reinforce the zoonoses preparedness of farmers

Next, based on the elements of the TPB framework, we evaluated the anticipated effectiveness of preventive interventions. We hereunder classified preventive interventions into four main categories: awareness and knowledge interventions; social influence and collaboration interventions; economic incentives and resources; regulatory and policy frameworks. As stated in the methodological approach, interventions were classified based on their interactions with the TPB model. Using examples from each category, the beliefs of each TPB construct were put in the contextual setting of the intervention of the factor, showing the possibilities of using the TPB as a framework during intervention strategy design.

Solid evidence of behavioural change interventions or strategies that successfully alter farmers' behaviour is still lacking. In designing these interventions and in aiming for lasting behavioural change, one should consider components at the individual, interpersonal and environmental levels (Biesheuvel et al., 2021). An example of preventive measures to zoonoses outbreaks are biosecurity interventions. Their implementation is an intricate process and should strive for effectiveness at different levels: from farmers (both small holders and commercial farmers), village-level practises, commercial operation efforts in other parts of the value chain, to national and international programmes. Biosecurity measures must be in line with the goals of everyone engaged in the supply chain for animal production, ideally by providing advantages for short-term risk management and encourage interest, investment, and implementation (Windsor, 2017). That is why it is pertinent to evaluate intervention so that they can fulfil such criteria.

As we are seeking to act at a farmers' level, we will base our scope of analysis on interventions that are aimed at farmers and in improving their zoonoses preparedness.

One must note that this classification of interventions does not exclude the fact that they might intertwine and influence each other, be delivered jointly and that farmers can go through a combination of them before improving their zoonoses preparedness. Some are designed for a specific context and scope, while some others are more generally targeted, at a larger scale. The tools that are mentioned here aspire to act at the preliminary stage, informing, guiding, or mandating farmers in the increase of their pandemic preparedness and response abilities.

Below, we list advantages and disadvantages of each category of intervention, based on our previous analysis of behavioural drivers of compliance and adherence.

Using the Theory of Planned Behaviour as our framework and looking at the main elements that make up intention, we will look at farmers' behaviour relating to zoonotic threats in the context of different preventive interventions. If one attempts to allocate the benefits and disadvantages of a particular intervention to the different constructs that make up TPB, one can understand the effectiveness of the chosen intervention. This method can also be used to create an impactful combination of interventions to reach zoonoses preparedness compliance.

4.1 Awareness and knowledge interventions

To establish a solid foundation for effective preparedness and response to zoonotic outbreaks among farmers, awareness and knowledge interventions are important to alter behaviour and foster compliance. Equipping farmers with knowledge serves as a fundamental basis, enabling them to make informed decisions and facilitating subsequent actions such as implementation of preparedness measures.

Circling back to the TPB framework and to significant behavioural drivers, a farmer making better informed decisions would make it more likely that they form a positive attitude towards complying to safeguarding their farm against zoonotic threats. Their perceived behavioural control can also be improved through these interventions, with an improved knowledge on what their control is in these situations of zoonotic threats, ultimately leading to compliance and desirable behaviour.

These interventions operate through a spectrum of informational instruments encompassing communication campaigns, information dissemination, training and courses, capacity building, technical assistance and advisory services. Farmers are given skills, knowledge, and important updates through diverse channels, including workshops, webinars, and awareness campaigns, delivered via radio, television, mail, social media and/or extension services.

The desirable outcome to these preventive interventions is the enhancement of farmers' understanding and skills in their zoonoses preparedness strategies, with subjects such as disease surveillance, vaccination, biosecurity protocols, risk assessment, emergency response planning, and safe handling of agricultural products during pandemics.

Moreover, technical assistance and advisory services provide crucial guidance on disease prevention, animal health management, and vaccination programs. Information dissemination mechanisms, such as newsletters, websites, mobile apps, and SMS alerts, keep farmers updated on outbreaks, preventive measures, market conditions, and relevant policies.

A key element is training and capacity building, which can be either voluntary or mandatory. Aside from farmers, other relevant stakeholders such as veterinaries can benefit from trainings on zoonoses outbreak preparedness. This continuous training is necessary as veterinarians have a crucial role in recognising and controlling the transmission of zoonotic illnesses and their education can be complementary to farmers' knowledge (Ablah et al., 2008).

For example, as the 2022 Netherlands' National Action Plan for the Strengthening of the Zoonotic Disease Policy states, several measures are taken to insure that professionals involved in this field maintain a substantial level of knowledge on zoonotic outbreaks. The Signalling Forum Zoonoses (Signaleringsoverleg Zoönosen, SOZ) sends out a newsletter every month with updates on pertinent warning indications, refresher veterinary school courses on One Health are taught, and websites such as the National Institute for Public Health and the Environment's (Rijksinsituut voor volksgezondheid en Milieu, RIVM) or knowledge networks messaging services on infectious illnesses such as Vetinf@ct may be used to find information for professionals.

Such interventions have the major advantage or creating accessibility of information. Taking the example of vaccination, a farmer's beliefs in the effectiveness of vaccinations plays a major role in their willingness to carry it out on their own livestock (Win et al., 2021).

These interventions give the opportunity of framing communications in a particular way, adaptable to the context and where lessons from behavioural change can be applied. With this framing, comes the possibility of choosing who will communicate the information to the farmers.

Behaviour Change Communications (BCC) help in preventing emergence and re-emergence of diseases, through an attempt at developing behavioural immunity through the design of efficient BCC strategies. Through a multifaceted approach involving mass media, interpersonal communication, and community mobilisation, positive behavioural changes can be fostered (Nancy et al., 2021).

Hands-on learning is another type of intervention relating to the awareness and knowledge of the farmer. It was found efficient both for offering experiential learning to the farmer, while improving human capital via knowledge, which consequently boosts an individual's perceived behavioural control (Hamilton et al., 2022).

When it comes to the main pitfalls of such preventive interventions, voluntary education programmes depend on the farmers' participation. Even with financial incentives offered and information on the programme given, farmers may perceive too many constraints (such as time investment). A change in attitude is required for farmers to take part in these voluntary education programmes and go beyond the constraints that they impose (OECD, 2012).

Educational campaigns often focus on providing accurate general information, with the expectation that individuals will adopt desired behaviours once they grasp the underlying issues. However, this approach often fails, and people continue to take risks or engage in undesirable behaviour. This implies that instead of focusing solely on accurate information, we should assess the information people already possess and how it influences their intentions and actions, regardless of accuracy. One must also focus on specific beliefs about the behaviour of interest rather than general knowledge. By identifying accessible beliefs for the target population, one can provide information that challenges contrary beliefs, strengthens existing supportive beliefs, or helps form new beliefs that support the desired behaviour (Ajzen and Joyce, 2011).

These interventions, to successfully work, require that the information conveyed is not only accurate, but also well understood by those receiving it. Moreover, these communications should be planned according to literacy rates, cultural sensitivities, and pre-existing knowledge of scientific concepts surrounding transmission of diseases (Madhav et al., 2017).

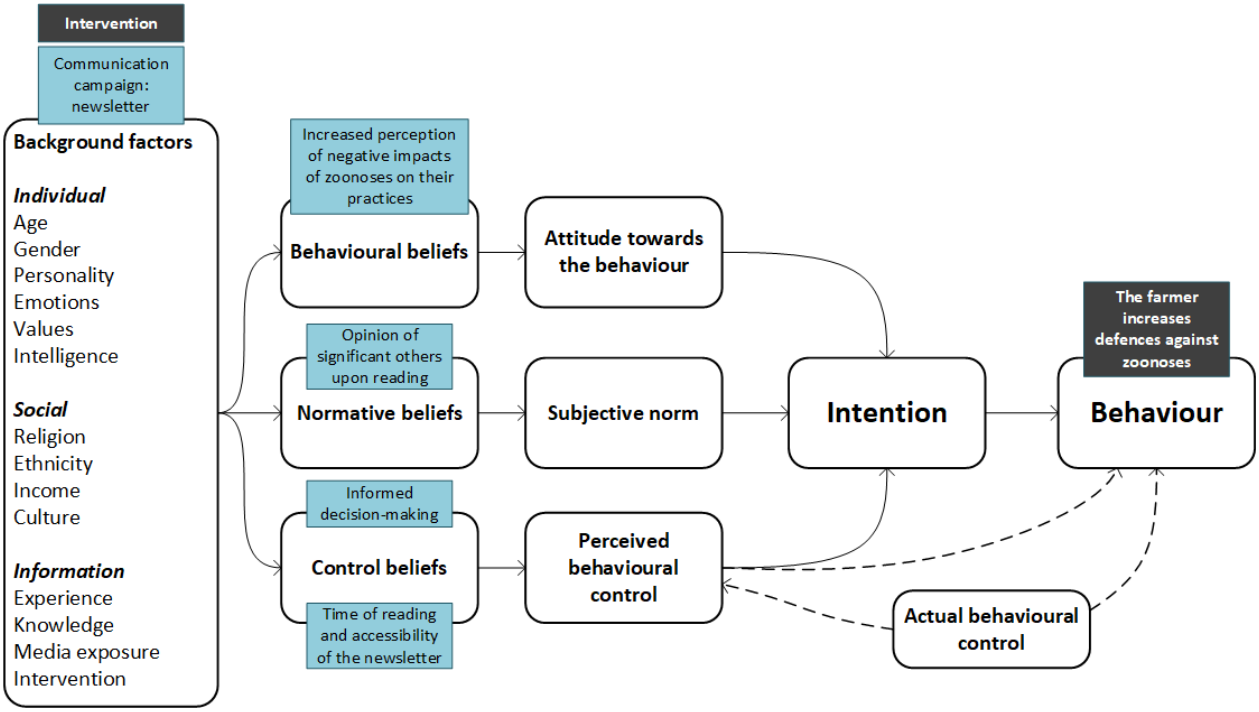

Figure 4.1 *Evaluation of a communication campaign in the shape of a newsletter*

As seen in Figure 4.1, using the example of a hypothetical communication campaign disseminated in the shape of a newsletter, several elements are observed and aligned with the constructs of the TPB. The newsletter might influence the farmer's attitude through informing them on negative impacts of a zoonoses outbreak on their practice, appealing to their wish to avoid periods of financial stress. Second, the newsletter can be read by one of the farmer's significant others, who can then share their opinion on what they have read and what they deem important to act upon. Finally, appealing to a farmer's control beliefs, a newsletter has the advantage of providing the farmer with more informed decision-making and potentially increasing their self-efficacy, but does occupy some of the time in the farmer's tight schedule in order to be read. The newsletter should also be physically and financially accessible to the farmer.

4.2 Social influence, collaboration interventions

The second category revolves around harnessing social influence and fostering collaboration among farmers and their peers. Building upon the knowledge gained from awareness and knowledge initiatives, these interventions emphasise the dissemination of best practices through organic channels. Collaboration takes centre stage, with initiatives such as farmer networks, platforms, and collaborative research and innovation endeavours. These partnerships collectively strive to enhance the farm's capacity to prevent and respond to zoonotic outbreaks.

This category links back to the TPB in its contributions to behaviour change within the constructs of subjective norms and perceived behavioural control. Indeed, social influence initiatives will allow for the farmers to interact with peers and other actors, influencing their normative beliefs. Collaboration, in particular, can enhance their perceived behavioural control, providing farmers with a new sense of agency. This can ultimately drive farmers' compliance, strengthening their defences against zoonoses.

This collaborative paradigm finds resonance in concrete initiatives like Netherland's National Action Plan for the Strengthening of the Zoonotic Disease Policy. Here, the Zoonotic Disease Quality Mark serves as a checklist for animal owners and veterinarians, facilitating annual discussions and actionable steps to mitigate disease risks. Similarly, the Central Netherlands Zoonotic Disease Knowledge Network functions as a conduit for knowledge exchange, uniting relevant professionals such as general practitioners (GPs), veterinarians, and municipal health services in a collective effort to enhance understanding and detection of zoonotic risks.

Drawing inspiration from successful models such as the farmer field school (FFS) concept in Denmark, peer learning and study groups are prevalent in Dutch agriculture, facilitating experiential learning and knowledge exchange among farmers. Such dynamic exchanges have demonstrated positive outcomes, notably seen in Denmark's reduction of antibiotic use through FFS implementations (WUR et al., 2010). Collectively, these interventions under the social influence and collaboration category exemplify the power of shared learning and collaborative networks in strengthening the preparedness and response of farmers to zoonotic threats. They have an active role in supporting or changing the normative beliefs of farmers by discussing various subjects, and farmers engaged in such activities see their actual and perceived behavioural control improved by learning from each other's best practices (WUR et al., 2010).

This type of intervention proves its potential through the possibility of involving other key stakeholders such as veterinarians, being the first source of information on disease control and animal health for farmers. Indeed, in a study on sources of information of broiler farmers when it comes to reduction of their AMU, the principal way that farmers collect knowledge about biosecurity and improving disease prevention comes from individual advice. Information provided by their veterinarian, their feed supplier, other farmers from the sector, customers, animal health services and partners are seen as most significant, in that order (de Lauwere and Bokma, 2019). Veterinarians' perspectives and interactions with farmers should thus be considered into the design process of interventions and regulations, as veterinarian behaviour and beliefs are intricately linked to farmers' decision-making processes. They help in defining positively or negatively the barriers to disease control. This means that they have responsibilities in farmers' adoption of vet-public health measures and should understand completely the determinants of disease control of farmers (Biesheuvel et al., 2021). Veterinarians thus have the potential to influence farmers' intention through the element of subjective norms and perceived behavioural control.

Other relevant stakeholders include advisory systems, key agents in determining attitudes and motives (OECD, 2012), as well as additional feed and health advisors, family and friends, farmer organisations, agricultural extension services, farming press, local communities, nearby farms, early adopters and 'peer champions' (fellow farmers whose testimonials and experiences are utilised to provide relatable and influential advice) (Rose, Keating, Morris, 2018).

Due to the previously seen importance of social norms in the decision-making process of farmers, working together or organising themselves into networks may be greatly beneficial. It has been observed that farmers' choices are a balance between their own and the community's needs (OECD, 2012).

These interventions have the opportunity of establishing a close connection between zoonotic preparedness and public benefits, appealing to the subjective norms of farmers. Social norms have the potential to influence collective action, strengthening the relationship between zoonoses preparedness and public benefits and creating a shared value for being able to face zoonoses outbreaks through various group activities. Indeed, individuals tend to exhibit a more positive attitude towards cooperative behaviour when they perceive others are participating as well (OECD, 2012).

Moreover, a community-wide biosecurity response is more about social and psychological elements that influence how danger is perceived and how motivated people are to act than it is about an expert-led scientific eradication approach. This indicates that when discussing biosecurity emergencies in policy documents, it is important to emphasise the concept of shared responsibility (Mankad, 2016).

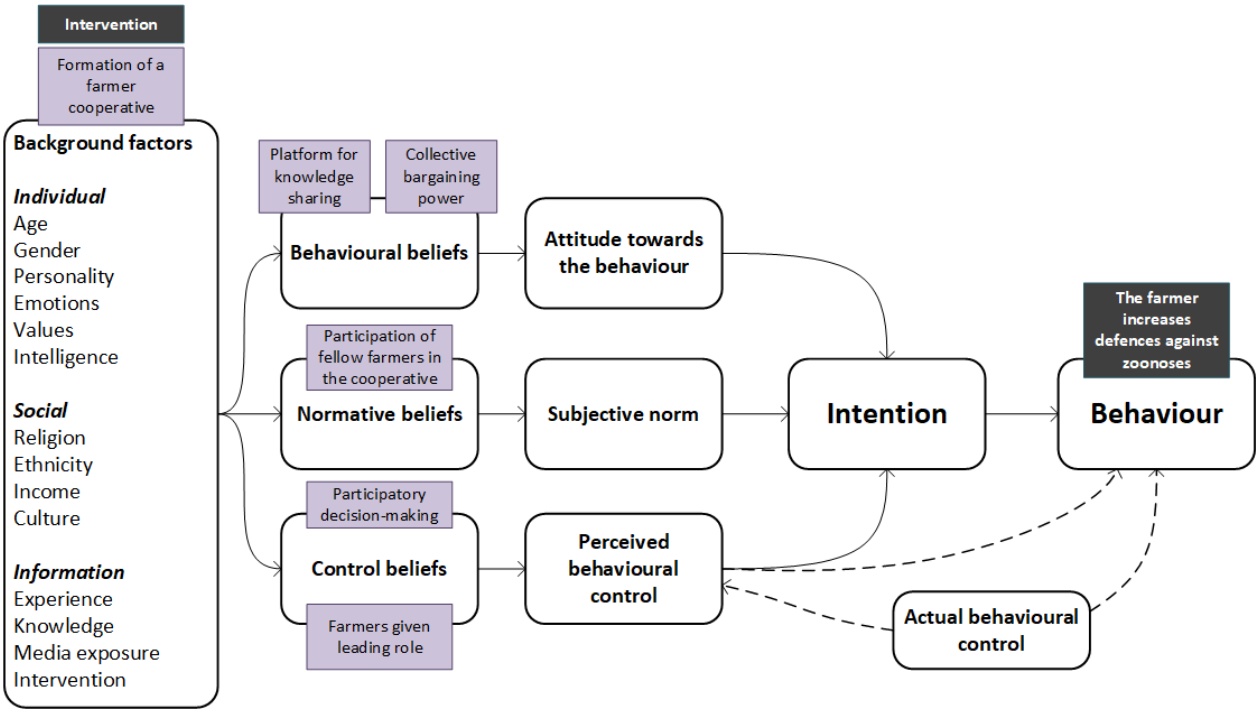

Figure 4.2 *Evaluation of the formation of a farmer cooperative*

If we choose the example of the creation of a farmer cooperative and link it to the increasing of a farmer's defences against zoonoses (see Figure 4.2), participatory decision-making is instigated, elevating the farmer from a passive receiver of information to active stakeholder, appealing to their self-efficacy. The success stories are then propagated within social spheres, creating a network effect that empowers other farmers with proven strategies coming from trusted agents, engaging with their perceived behavioural control and subjective norms. Farmer networks provide a fertile ground for shared learning, fostering an environment where best practices are shared.

4.3 Economic incentives and resources interventions

This third category of preventive intervention is closely related to attitudes in the behavioural process, particularly concerning compliance-based and market-based rewards. Financial incentives and support, which encompass direct payments, monetary rewards, relative advantages, market incentives, compliance-based rewards, grants, subsidies, low-interest loans, insurance schemes, and revenue protection programmes, are instrumental in bolstering farmers' commitment to zoonoses preparedness measures. These incentives, often facilitated by government entities or other organisations, serve as supplementary elements that promote adherence to regulatory requirements. Importantly, the provision of financial resources becomes increasingly relevant once farmers have acquired the necessary knowledge and skills.

These resources play a pivotal role in alleviating barriers for farmers and facilitating the effective implementation of zoonoses preparedness measures within the agricultural sector, thus bettering their perceived behavourial control. Additionally, it has been observed that the perceived impact of diseases on a farmer's sales will influence his willingness to vaccinate livestock (Win et al., 2021), showing the remaining importance of economic factors on attitude.

Financial incentives can however serve as a disincentive for cooperative action through their interactions with moral motivations: intrinsic motivation might be 'crowded out' when these external incentives are introduced. Indeed, price incentives might cause the perception of the responsibility to be shifted from the person to the enforcing body (OECD, 2012).

The moral conflict here revolves around finding the right balance between the advantages biosecurity brings to society as a whole, and the personal costs it may impose on individuals. Early studies in sociology related to biosecurity show that people's willingness to get involved in biosecurity activities often depends on whether they think it makes economic sense for them personally (Mankad, 2016).

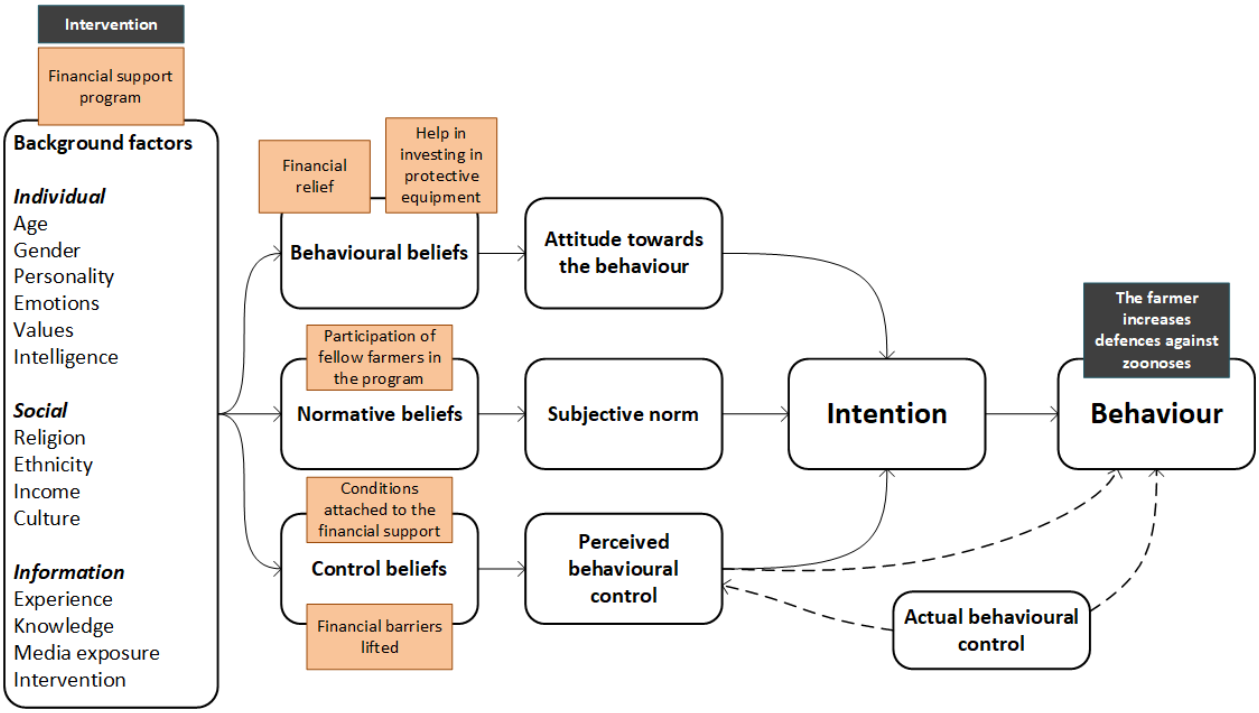

Figure 4.3 *Evaluation of a financial support program, applying the TPB framework*

If a financial support program intervention is applied to the TPB framework (see Figure 4.3), several elements can be discussed. Appealing to the list of advantages and disadvantages that the farmer makes when confronted with such a programme (behavioural beliefs), one can deduce that this programme will help in providing with financial relief and with investment in protective equipment, leading to an increased resilience. If other farmers such as neighbouring farms take part in the program, the individual might me more inclined to take part. Finally, some financial barriers being lifted, the individual's sense of control improves. However, the conditions to be fulfilled in order to benefit from such a programme should be stated clearly and should not seem too complicated for the farmer not to be discouraged in applying.

4.4 Regulatory and policy frameworks

Governments and agricultural authorities employ a diverse set of regulatory tools to ensure both compliance with specific procedures and the promotion of zoonoses preparedness and response practices among farmers. These tools encompass policies, laws, guidelines, standards, and regulations, all orchestrated by the appropriate authorities. To strike a balance between encouraging desired behaviours and enforcing necessary standards, a combination of voluntary and mandatory measures is typically deployed. Mandatory frameworks play a crucial role in maintaining consistency and accountability in zoonoses preparedness efforts, particularly for farmers who may evaluate participation in, for example, voluntary training sessions, as too many constraints. The aim is to provide guidance through voluntary guidelines or standards and, when necessary, enact laws that modify various aspects of a farmer's environment to promote safer behaviour (Gostin, 2000).

Examples of regulation strengthening the response to zoonoses outbreak are the private Integrated Chain Management (ICM) systems ensuring compliance with biosecurity measure in the livestock sector and checking for compliance through an independent certification body, European regulations and health requirements for international trade in live animals and WOAH's Animal Health Regulation. At the national level, the Netherlands put in place the Animals Act (Wet Dieren), prevention rules aiming to hinder the spread of diseases from farm to farm (Dutch Government, 2022).

Examining both voluntary and mandatory interventions through the TPB provides insight into how governments and other regulating bodies may influence a farmer's compliance. When it comes to mandatory interventions, the TPB has been applied to the study of intention regarding the implementation of laws (Macy et al., 2011) and tax policy (Bellová and Špírková, 2021). For instance, regulations can shape subjective norms: when something is prohibited, it can be perceived as socially unacceptable, creating a sense of normative pressure (Macy et al., 2011). In research looking at compliance and tax policy, where economics and legislation meet, tax compliance is heavily influenced by subjective norms through social and legal pressures of law enforcement authorities. Attitude also positively influences tax compliance through personal honour and morals, while it was necessary that sufficient sanctions exist. Perceived behavioural control is another significant factor affecting a taxpayer's intention to comply. The study found that taxpayers' perceptions of control on the likelihood of being audited, facing fines and sanctions, and being reported by a third party significantly influence their intention to comply (Bellová and Špírková, 2021).

These interventions also have added value when it comes to dealing with individuals exhibiting signs of reactance (excessive propensity to say 'no', and a negative correlation with conformity) (Orbell and Hagger, 2006). A paper looking at attitudes towards taxes and more particularly reactance to taxation (Kirchler, 1999), points out that reactance can be understood as a motivation to regain freedom, which can lead to the development of negative attitudes towards the state and taxation. Moreover, the intensity of reactance towards tax compliance appears to be proportional to a person's motivation to be in control of their decisions, linking back to the constructs of perceived behavioural control (Kirchler, 1999).

These elements make it relevant to apply the TPB's framework to both voluntary and mandatory regulations, to better understand and predict individuals' compliance behaviour taking into account their attitude, subjective norms, perceived behavioural control, and potential reactance.

Acting on zoonoses outbreaks through regulation and policy is an important piece of the puzzle. The interventions have the power to disseminate information on a large scale, to function as an authority figure and to implement measures that can lead to protection of animal, human and environment health.

Through their impact on motivation, policy tools may have an indirect impact on conduct. In addition to having direct effects on relative costs and budgets or via regulatory restraints, public policy also has an impact on how individuals perceive what is ethically right or wrong. The extension, dispersion, and training of innovation, as well as advisory systems, are key factors in determining attitudes and motives. Moreover, policy can allow for guidance through nudging with 'visualisation' policies such as labelling. Nudging can be defined as a behaviourally informed intervention that reshapes how choices are presented to individuals, predictably changing their behaviour (Murayama et al., 2023). Labelling has the potential to convey efforts of

the farmer's compliance and active participation in increasing their preparedness to zoonoses, directly to the consumer (OECD, 2012).

However, policies show some limits. For example, market-based policy tools have been developed under the presumption that farmers make informed decisions. Moreover, some policy instruments function differently for certain farms. Small-scale farms are likely to exhibit traits different from large-scale oriented farms (OECD, 2012).

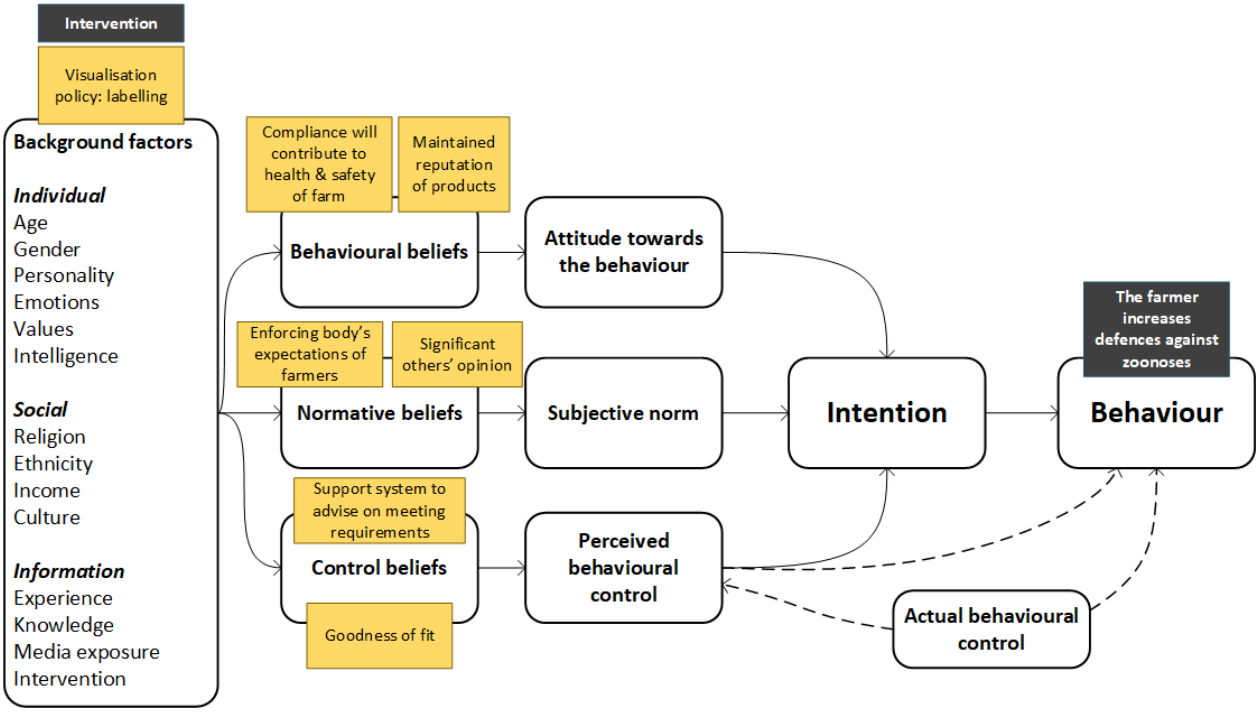

Figure 4.4 *Evaluation of a labelling visualisation policy applying the TPB framework*

Using the example of a hypothetical labelling policy that would convey to the consumer that the farmer did put into place zoonoses preparedness measures in his farm and regularly monitors their livestock, one can observe the different interactions with the TPB's constructs (see Figure 4.4). Such a policy would help in maintaining the reputation of the farmer's products and thus lead to sustained income, all while contributing to the health and safety of the livestock and farm employees. This helps in shaping a positive attitude towards the visualisation policy. When it comes to normative beliefs, complexity lies in the relationship between the enforcing body and the farmers. The opinion of the farmers' circle would also impact their final decision. Finally, a support system to advise on meeting requirements for the label would help lifting some barriers, and reducing the time that might be perceived as necessary to obtain rights to label the products.

5 Discussion and recommendations

5.1 Statement of principal findings

This literature review centres on the Theory of Planned Behaviour and its constructs, aiming to explain the behavioural process of farmers in the context of compliance to zoonotic threats prevention in their establishments. The studies that were examined highlight the importance of comprehending farmers' beliefs and perceptions in their decision-making processes concerning animal health programs, biosecurity measures, and other preventive interventions to zoonoses.

Attitude emerged as a significant predictor of compliance in farmers from the reviewed literature. A dilemma was also observed between the individual costs and collective benefits of implementing protective measures, indicating a clash between attitudes and subjective norms. Indeed, the role of social norms was emphasised, demonstrating their impact on farmers' behaviours. The context ultimately dictates which factor predominates. Perceived behavioural control was also seen to sway farmers' intentions: economic constraints, "goodness of fit" with existing practices, and past behaviours are crucial determinants of compliance. Understanding these factors is important for measuring behaviour and designing effective interventions strategies.

In line with this reasoning, the TPB was employed as a theoretical framework to elucidate the drivers behind a behaviour. By utilising examples of preventive interventions, we catalogued the various mechanisms that could influence a farmer's decision-making process.

5.2 Guidelines and possible mechanisms for stakeholders

In light of the insights from preceding sections, key elements for designing effective preventive interventions and accurately measuring behaviour concerning zoonotic threats have been identified. Stakeholders, categorised into policy makers, researchers, and veterinarians, can derive unique learnings associated with the different constructs of the TPB. For policy makers, guidelines include leveraging TPB constructs when designing interventions, prioritising attitude when no prior behavioural measurement exists, and considering objective characteristics of farmers. In the implementation stage of interventions, communication must be clear and highlighting the public benefits of pathogen outbreak preparedness. Farmer cooperatives are emphasised as accessible points of contact and reliable messengers. Researchers, as neutral stakeholders, can engage with farmers to assess behaviour and validate hypotheses. Designing research methodologies can be done adopting the TPB constructs, with attitude identified as a primary predictor. Past experiences, objective characteristics, and the role of significant social influences such as families and friends should be considered. Finally, veterinarians, seen as influential stakeholders, can directly impact farmers' subjective norms, attitude, and perceived behavioural control. Farm visits and staying informed about zoonotic developments are crucial for effective communication and advocating for enhanced zoonoses defenses.

These guidelines can be found further detailed in Appendix 3.

5.3 Strengths and weaknesses

When it comes to the strengths of the Theory of Planned Behaviour, it offers several advantages when used to understand behaviour. Its visual representation serves as a practical tool for anticipating the potential impacts that an intervention might have on a farmer and allows to fill the divide between social and natural sciences, contributing to the creation of a common language (Miller, 2017).

The available literature on the application of the TPB in the context of zoonotic threats and livestock diseases demonstrates its effectiveness (Ellis-Iversen et al., 2010; Mucinhato et al., 2022; Mingolla et al., 2019; Bannor et al., 2021). The TPB's background elements allow for the consideration of a farm and farmer's characteristics: The influence of an individual's environment can be reflected in the TPB, helping to identify the effects of environment on the formation of intention. Moreover, the TPB can be used as a foundation and expanded with additional constructs when certain aspects are not adequately addressed.

Beyond its use as a framework, the TPB can be utilised in the creation of questionnaires (Ajzen, 2006). The collected data can be analysed to assess the relation between the TPB constructs and intention, using psychometrics.

However, it is crucial to recognise the limitations of using the Theory of Planned Behaviour in understanding behaviour. When it comes to its suitability in designing interventions, the TPB does efficiently help in understanding the thoughts and attitudes that need to be addressed but does not provide concrete guidance on how to change them (Conner et al., 2005). Additionally, critics point out that the TPB has limited ability to predict behaviour accurately. One known challenge to the TPB that hasn't been resolved are 'inclined abstainers' (people who intend to act but don't follow through) (Sniehotta et al., 2014).

The decision to utilise the TPB as the analytical framework for examining compliance behaviour was driven by its capacity to provide a structured understanding of the many factors influencing the following of recommendations to preventive measures within farm settings. A pertinent example highlighting the applicability of the TPB to understanding compliance is found in a study by Langham et al. (2012), which explored tax compliance. It demonstrated that intention to comply, as measured by the TPB, may not consistently translate into actions. Indeed, a significant proportion of taxpayers was observed to failing in fulfilling their intended compliance despite expressing the intention to do so. For an individual to go further than intention to comply in paying their taxes, the tax system has to establish an optimal environment for the taxpayer to adhere successfully. This example shows the applicability of the TPB to attempt at explaining compliance in interventions, including mandatory procedures such as tax obligations, allowing for a nuanced approach to the assessment of compliance.

However, the suitability of the TPB to study compliance in actors is to be carefully assessed, particularly in this work's context. While the TPB still allows for a comprehensive investigation into the different factors at play in compliance of farmers to regulations to putting protective measures in place, the model has been deemed constrained in its consideration of affective influences on behaviour (Cho and Walton, 2011), as cognitive beliefs shape the constructs of attitude, subjective norm, and perceived control. Not taking into account the affective or emotional aspects of decision-making proves to be a limitation, as emotions can strongly influence compliance behaviours in a high-stress environment such as those associated with zoonotic threats.

The TPB 'simplifies' decision making, and makes the assumption that behaviour is the result of a linear decision-making process. However, often, individuals first alter their behaviour, gradually adapting their attitudes afterward. For example, in the context of a law newly implemented, adherence may occur before a positive attitude towards the behaviour endorsed by the law is fully developed (Nancy and Dongre, 2021). Moreover, human behaviour being highly complex, information is not always cognitively assimilated into decision-making processes, showing the importance of additional factors to TPB's constructs in understanding compliance (Miller, 2017). For example, elements such as self-identity and habit strength are shown to predict efficiently behaviour (Sniehotta et al., 2014).

The matter of habits and routine behaviour has not been mentioned in this report. In this context of preventive interventions, they are relevant to consider, as for example routine actions like frequent showering of the farmer can increase biosecurity. It is good to note that the reasoned action focus of the TPB has been contested, based on claims that human behaviour is often habitual and instinctive, meaning that the TPB could omit taking into account these types of actions. However, Ajzen (2000) wrote on the relationship between automatic actions and reasoned action, and on the compatibility of automatically-taken decisions within the theory of planned behaviour through a shift in the understanding of attitudes. Indeed, attitudes can be formed either automatically, without extensive deliberation, or through deliberate retrieval of beliefs from an individual's memory. This aligns with the core principles of the TPB, through the expansion of the definition of what an attitude is (Ajzen and Fishbein, 2000).

In recognising the limitations of the methodology employed in this report, it is essential to note that this literature review did not adopt the structured approach of a systematic review. Moreover, the review broadened its scope beyond zoonotic diseases due to limited available literature. The assumption underpinning this expansion was that farmers exhibit similar behaviour in the scenarios of facing non-zoonotic diseases on-farm and other entrepreneurial decisions such as long-term investments of farmers. Moreover, this report does not address a scenario where a desirable behaviour is performed only once but not reproduced beyond this point. Indeed, behaviour change has to be sustainable, especially in the context of zoonotic threats.

As detailed in Section 5.4, further interaction with farmers on the topic is crucial to confirm hypotheses and extend the findings beyond the confines of this literature review.

5.4 Recommendations for future research

In the continuation of this report, it is imperative to substantiate the hypothesis proposed earlier. Indeed, following this phase of theory formation, more research is needed to test the theories on most significant drivers of compliance in farmers, in the context of zoonotic threats.

We propose using the Theory of Planned Behaviour in a mixed-method approach, incorporating (semi-)quantitative methods such as surveys and case-control studies, as well as qualitative methods like in-depth interviews. This study would aim to explore drivers in farmers' decision-making and understand the impact of habit formation on behaviour, in the context of zoonotic threats. We suggest conducting in-depth interviews with farmers, considering spatial heterogeneity, to assess attitudes, subjective norms, perceived control, and intention regarding zoonoses preparedness. Additionally, we propose targeting specific groups of farmers for more effective interventions, for example classified by level of intention or of reactance. Our ultimate goal is to comprehend and amplify farmers' preparedness to zoonotic diseases, with a follow-up to rank preventive interventions and integrate findings into epidemiological modelling. We emphasise the importance of adhering to good practices when applying the TPB in our future research (Sok et al., 2020). Our recommendations for future research are further detailed in Appendix 4.

6 Conclusion

By harnessing knowledge from existing literature and employing the framework of the Theory of Planned Behaviour, we gained insights into the effectiveness of various preventive interventions to zoonoses in reaching compliance among farmers to preparedness to zoonotic threats. Using this framework provided by behavioural modelling allowed to identify behavioural drivers of compliance in farmers, and to visualise the benefits and disadvantages of different preventive actions.

We defined guidelines for different categories of stakeholders, should it be in the design and implementing of policies, in the creation of research methodologies and efficient measurement of drivers of behaviour, and in engaging with key on-the-ground actors such as veterinarian.

Moreover, following the proposed guidelines will help in identifying the most relevant interventions for reaching compliance of farmers, and in adapting intervention design to make them more likely to lead to desirable behaviours. Indeed, these guidelines encompass the necessity of engaging key stakeholders, considering past behaviours, acknowledging the local context, adopting participative approaches, emphasising shared responsibility, and framing communications strategically. A holistic strategic consisting of a mix of knowledge interventions, collaboration, economic incentives and regulatory interventions are likely to be necessary to trigger compliance. By adhering to these recommendations, the path to transforming zoonoses preparedness into a public good and enhancing its effectiveness becomes clearer.

Moreover, it is imperative to validate these findings through future research, ensuring that the behavioural drivers are substantiated and well-understood. The integration of these drivers into epidemiological models promises to significantly enhance the precision of predicting zoonotic outbreak scenarios. This integrated approach stands as a significant stride toward strengthening our preparedness and response capabilities in the face of emerging zoonotic threats, contributing to safeguarding public health.

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Appendix 1 Conceptual framework

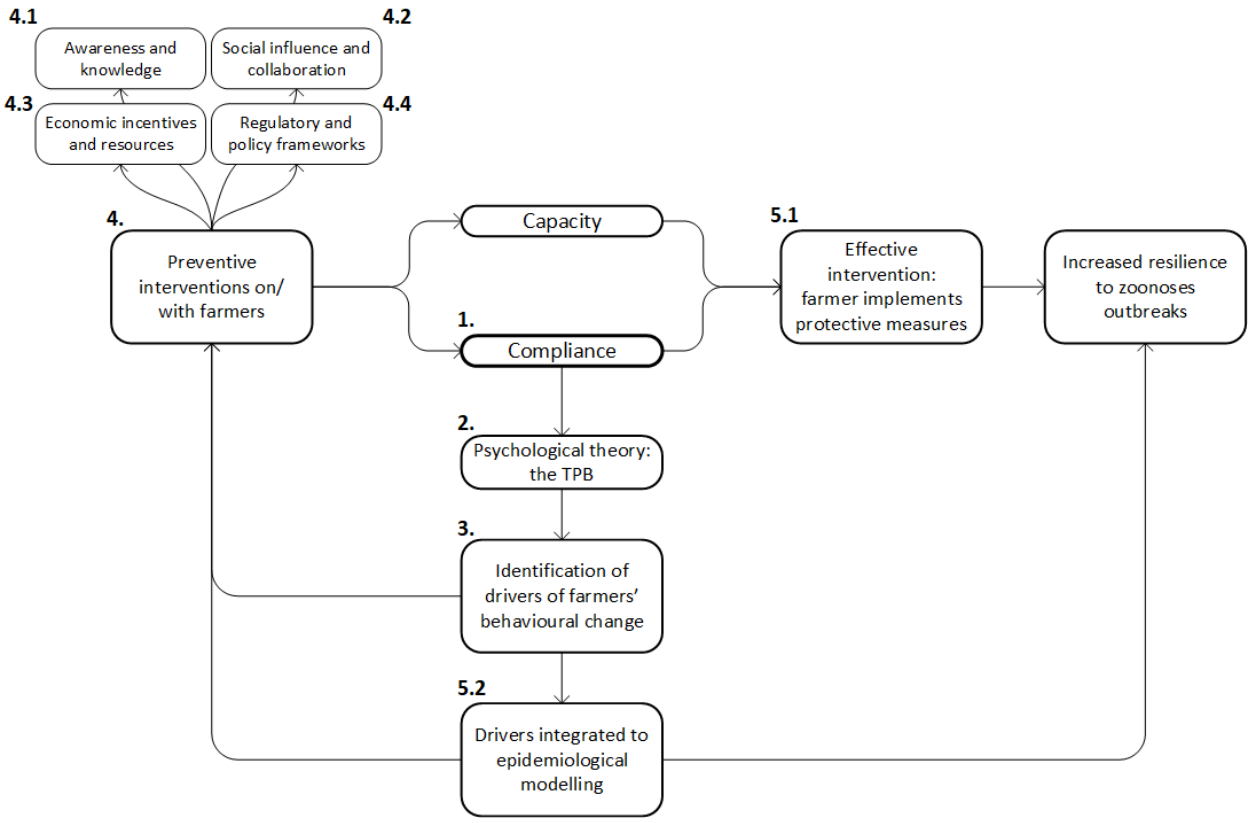

Figure A1.1 *Conceptual map: approaching zoonoses preparedness through psychological theory*

In Figure A1.1 is the conceptual framework of this report, illustrating the reasoning behind this literature review based on psychological theory, and the subsequent analysis of preventive interventions.

The relationship between preventive interventions on/with farmers and the end result that is increased resilience of farmers to zoonoses outbreaks is explored through compliance to protective measures, using psychological theory. Here, the theory of planned behaviour, was the chosen approach as a mean to understand human behaviour in the context of farmers facing zoonotic threats, to ultimately improve compliance to implementation of protective measures.

A farmer wanting to improve their defences to such threats has to be able to do so (capacity), as well as being willing to (compliance) – this is explained in the introductory part of the report (1.). In this research, a closer look is taken at compliance through our theoretical framework (2.) and through the Theory of Planned Behaviour (TPB), an example of psychological theory aiming at an individual's decision-making process. Insights gathered looking at studies on farmers' decision making in the context of zoonotic diseases and other contingencies, allow us to attempt at identifying the main drivers of a farmers' behavioural change (3.). Using the TPB's framework, we look at four different categories of preventive interventions (4.) using the different elements of the TPB. Finally, this allows us for a better design of intervention strategies, and farmers implementing protective measures (5.1). Lessons learned from this research can eventually contribute to better the integration of compliance in epidemiological modelling, with suggested follow-ups (5.2).

Appendix 2 Literature review search protocol

The focus of the review was on farmers' behaviours analysed within the framework of the Theory of Planned Behaviour. The aim was to understand behavioural mechanisms aligning with the TPB's constructs and explore diverse interventions, emphasising studies addressing compliance behaviour. Priority was given to scientific sources specifically situated in the context of animal diseases threats. Additionally, papers addressing behaviours in analogous scenarios and long-term-oriented entrepreneurial actions such as resistance to climate change and responses to natural disasters, were considered.

The literature review for this study followed a targeted process to identify relevant sources and select papers. Key terms formed the foundation of the search strategy, with consistent use of the following primary keywords: farmer; farmer behaviour; theory of planned behaviour (or its constructs: attitude, subjective norms, perceived behavioural control); compliance; zoonoses; livestock disease. Complementary keywords included: intervention; prevention; preventive intervention; outbreak.

The search initiated with these keywords was expanded through a snowballing approach, exploring studies interconnected with the research question. Sources were sought from various reputable platforms, including but not limited to Frontier, Google Scholar, ScienceDirect, ResearchGate, BioMed Central, and Taylor and Francis Online. The methodology and results sections of identified studies were examined to discern the factors influencing farmers' decision-making processes.

Appendix 3 Guidelines for improved compliance to preventive measures

Different stakeholder categories can derive unique learnings and implement them in various ways. These learnings and actions are associated with the different constructs of the TPB in the following guidelines.

Policy makers, who possess the authority to formulate both mandatory and voluntary interventions and policies, play a crucial role as discussed in Section 4.4.

In the design stage of interventions:

- When designing policies or other interventions, it is beneficial to use the constructs of the TPB as a foundation. This approach helps to consider all the interacting elements of the model and of the behavioural process and promotes compliance to the interventions.
- Working in collaboration with researchers provides an opportunity to examine and measure behavioural patterns within specific contexts, which can inform and guide the subsequent stages of the process.
- Behaviour of veterinarians as well as their interactions with farmers should be considered into the design process of interventions and regulations, as a primary source of information and having influence on farmers' self-efficacy.
- While all three constructs of attitude, subjective norms and perceived behavioural control have strong effects on behaviour and should be measured, attitude emerged as the predominant predictor in the context of zoonoses preparedness. Following that logic, in the context of short-term action and limited resources, one must prioritise the measurement of a farmer's attitude towards zoonoses preparedness to understand their behaviour. If an intervention has to be designed without prior measurement of behaviour, setting priority on acting on farmers' attitudes is advised.
- Designing interventions on attitudes, subjective norms, and perceived behavioural control all at once could potentially lead to more effective and faster results in reaching compliance, provided that the necessary resources are present.
- The objective characteristics of the farmer and their farm - the size of the farm, the surrounding environment, the availability of technology, and demographic considerations such as age and level of education - should be considered when making policies/interventions. Indeed, these background factors (see *figure one*) function as a pre influence on behaviour and remain relevant throughout the decision-making process.
- Past behaviour and experiences of farmers with zoonoses outbreaks should be considered.
- When creating suitable incentives, local behavioural effects must be taken into consideration as relationships with surrounding farms and/or farms part of a same network have a significant impact on a farmer's decision-making process. (Relates to subjective norms).
- Hands-on learning is an efficient way of both offering experiential learning and improving human capital via knowledge. (Relates to perceived behavioural control, attitude).
- Interventions can have an impact not only on farmers but also on their immediate surroundings. Therefore, it's advisable to extend the target audience to include stakeholders in close proximity to the farmers, such as veterinarians, friends, family, and fellow farmers. (Relates to subjective norms).

In the implementation stage of interventions:

- The framing of risk communications should be presented in a clear, straightforward, and timely manner. These communications should be planned according to a variety of factors, including literacy rates, cultural sensitivities, and pre-existing knowledge of scientific concepts surrounding transmission of diseases. (Relates to background factors).
- When communicating with farmers, should it be in the context of a communication campaign or communication around a policy, it is recommended to explicitly highlight the link between pathogen outbreak preparedness and public benefits, framing it as a collective good. It was observed that cooperation among farmers is often influenced by their awareness of others' actions. Therefore, establishing a shared value for effective outbreak response and fostering a collective sense of responsibility can cultivate a more positive attitude toward cooperation, especially when farmers perceive that it is the norm for others to participate as well. (Relates to subjective norm and attitude).
- The communications should be relied by reliable messengers, credible communicators, demonstrating a high degree of similarity between the communicator and the listener, with both the message and the communicator seen as trustworthy by the farmers (such as members/representatives of farmer networks). (Relates to subjective norms).
- Farmer cooperation should be promoted as it leads to the sharing of success stories and good practices, impacting positively attitude, perceived behavioural control and subjective norms.
- Ensure that farmers have a readily accessible point of contact for any clarifications they may need regarding procedures, such as applying for financial resources, or complying with biosecurity legal requirements… (relates to perceived behavioural control).

Researchers, as neutral stakeholder, can engage with farmers through interview or surveys to assess their behaviour and validate hypotheses.

Guidelines in the design of research methodologies and tools:

- Attitude has been identified as the primary predictor of intention in the context of zoonoses preparedness. This could form a hypothesis to be tested through the development of a TPB questionnaire. The questionnaire would include items designed to evaluate each of the theory's main constructs - attitude, subjective norm, perceived behavioural control, and intention.
- The role of behavioural drivers should be given greater emphasis in the field of epidemiology.
- The objective characteristics of the farmer and their farm - the size of the farm, the surrounding environment, the availability of technology, and demographic considerations such as age and level of education - should be considered when designing surveys/interviews/workshops.
- Past behaviour and experiences of farmers with zoonoses outbreaks should be considered in the design of research methodology and tools. (Relates to perceived behavioural control).
- Relevant stakeholders that might exert a social pressure on a farmer's zoonoses preparedness should be included in survey/interview/workshop (veterinarians, friends, family, and fellow farmers). (Relates to subjective norms and perceived behavioural control).
- Collaborative workshops are a stimulating way of working with the farmers, providing agency and getting insights into their beliefs. (Relates to perceived behavioural control, attitude).

Veterinarians, who are active participants in the field and a crucial source of information for farmers, make up another category of influent stakeholders for improving compliance.

- They can directly influence the subjective norms (social pressure, expectations to adhere to certain measures), attitude (through knowledge provision), and perceived behavioural control (by helping in elevating barriers) of farmers.
- They are viewed by farmers as trustworthy messengers and can advocate for enhanced zoonoses defences. (Relates to subjective norms).
- Their farm visits allow for a visual assessment of preventive measures and provide an opportunity to gather information on farmers' beliefs about the issue of zoonotic threats, in an informal setting.
- They should consistently stay informed about the latest developments in zoonoses, including disease symptoms, to ensure they communicate accurate and comprehensible information to the farmers. (Relates to attitude).

Appendix 4 Future research

This appendix defines potential follow-up research to verify whether attitude is the biggest predictor of intention. As continuation to this initial literature review, a research methodology can be designed according to the previously stated guidelines. Indeed, a meticulous data collection process is essential to ensure accuracy. An empirical model, based on the Theory of Planned Behaviour, can be developed to assess the hypothesis made in this report. This can be done in acknowledging the model's limitations and using complementary constructs in the design of quantitative and/or qualitative research.

Examples of quantitative methods helping in measuring beliefs, attitudes, behaviours, and perceptions are surveys in longitudinal and cross-sectional studies, case-control studies comparing the attitudes of two groups (such as outbreak farms and non-outbreak farms), and statements evaluated by Likert-scales. Qualitative methods are however useful in adopting a pragmatic approach, finding out about an individual's emotions, opinions, and attitudes in a complex and subjective context. Methods of information consist of focus groups, expert panels, in-depth interviews. Mixed method would nonetheless allow for analysis of convergence between qualitative and quantitative data (Biesheuvel et al., 2021).

In the context of a study on sustainable mange control in sheep and cattle farms, the TPB was extended with learnings from behavioural economics, taking into account that while making decisions, people frequently exhibit behavioural biases or reasoning errors. This helps in understanding the bias that some farmers experience towards disease control. In a similar fashion, this future research could address biases such as the bandwagon bias (the beliefs on other farmers' opinion about the preventive methods), availability bias (farmers who believe that a zoonotic threat often occurs on their farm), loss aversion bias (perceived cost related to the adoption of the control method), and default bias (wanting to retain to their default treatments of zoonoses) (Mingolla et al., 2019).

It was theorised that repetition of a behaviour leads to it becoming a habit. To test the idea, researchers can create a measure of habit by asking individuals to quickly choose between different hypothetical situations. Habits are linked to past experiences, proving that they should be incorporated into the research method (Ajzen and Fishbein, 2000).

In-depth interviews with farmers to verify and apply the guidelines of Appendix 3 could be a potential next activity to verify the findings. These in-depth interviews would aim to evaluate attitude, subjective norms, perceived behavioural control and intention of the farmer regarding zoonoses preparedness. This series of interviews can be done over a localised area, as behavioural change needs to be measured and understood at the local level to address spatial heterogeneity and the specificities of farms. This would allow to evaluate what are the farmers community's beliefs on the topic of preparedness to zoonoses outbreak in that specific region, and how these beliefs interact and influence with each other. A potential course of action can be comparing Q-fever and non-Q-fever regions in the Netherlands.

These interviews can involve people that are close and important to the farmers, should it be veterinarians or family and friends. Perception on what neighbouring farms think of zoonoses preparedness and response should be asked to the farmer, and then placed in juxtaposition with the actual opinion of neighbouring farmers to show if their beliefs are an accurate reflection. This localised approach allows to keep in view the interactions between different stakeholders and to evaluate the opinion of the farmer's peers. The objective characteristics of the farm and individual differences such as gender and age should be recorded or asked along with the interview, as well as their past experiences with zoonoses outbreaks in their farm.

Good practices and success stories shared by farmers that already engaged in preventive measures can be collected through surveys or interviews and can be shared to another farmer of the same social circle to assess the given reaction and how it influences the farmer's opinion. Their vision of another actor as "trustworthy" can also be measured accordingly through the questions. Participation to initiatives such as

farmers network can be assessed, as well as willingness to join a training course or take part in a financial support program for improved zoonoses defences. The farmer's opinion can be assessed when faced with a risk communication on zoonoses preparedness.

Furthermore, this intervention can be directed towards specific groups of individuals displaying lower aversion to ambiguity and greater reluctance to participate in an intervention due to a lack of perceived advantages or concerns about social approval or identified as having a higher level of reactance. Targeting such groups can lead to a more effective initiative and provide insights into addressing compliance limitations. This represents a pivotal initial phase in comprehending how the concept of preparedness to zoonotic diseases can be embraced and amplified by farmers, spanning from the local community level to the national scale.

An additional follow-up would be to use the results to rank the different types of preventive interventions, determining which are the most effective in changing behaviours of farmers towards increasing their capacity to prevent and contain the transmission of zoonoses. The characteristics of these interventions could be quantified and allow for integration to epidemiological modelling, where the (semi)quantitative inputs on the effectiveness of interventions influence the course of the infection dynamics.

In a systematic review of how well applied the TPB is in the context of agricultural economics, Sok et al. (2020) point out the importance of adhering to certain good practices in order to use the TPB correctly: the principle of compatibility (defining behaviour clearly in terms of target, action, context and time and ensuring compatibility of all TPB constructs with these elements and in measurement scales), the analysis of the impact of different TPB constructs on intention, the identification of influential behavioural, normative and control beliefs, taking into account the sufficiency assumption (assumption that no predictor other than attitude, subjective norm and perceived behavioural control have a direct impact on intention) and justifying the addition of predictors of intention to their model, and finally the integration of background factors to the TPB model (Sok et al., 2020). These principles should be taken into account in this future research.

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