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Understanding wild dog reporting behaviour of rural landholders: identifying options for behaviour change

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ABSTRACT

Purpose: As effective management of biosecurity risks such as wild dogs, relies on landholder reporting, we investigated how landholders can be encouraged to report wild dog presence or damage.

Design/Methodology/Approach: We identified potential drivers and barriers to wild dog reporting and organised these factors using the Behaviour change Wheel (BCW) framework and associated Capability, Opportunity, Motivation (COM) Behavioural model. We then surveyed 186 landholders to determine the importance of these factors, along with other demographic and situational variables, in predicting current reporting of wild dogs and their impacts.

Findings: Landholders' willingness to report was found to be influenced primarily by their personal experience of wild dog problems and motivational factors. They were particularly dissuaded from reporting by perceived negative consequences and loss of autonomy. Segmentation using latent profile analysis highlighted that landholders were not a homogenous group, with each identified segment exhibiting their own unique COM barrier profile.

Practical Implications: Use of the BCW framework and associated COM behaviour model allowed us to recommend the most appropriate type of interventions to improve the biosecurity reporting behaviour of rural landholders.

Theoretical Implications: We contribute to refining the use of psychological theory in the development of agricultural education strategies.

Originality/Value: Our study is the first to demonstrate the usefulness of the COM behaviour model and BCW framework to improve rural landholder reporting of biosecurity risks.

Introduction

Australia is known for its unique and fragile ecosystems, so managing and mitigating the risks associated with the introduction, establishment, and spread of pests, diseases, and other biological threats that could harm animal, plant or human health is of upmost

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importance (CSIRO 2020). Biosecurity in Australia encompasses a range of practices and regulations aimed at preventing, detecting, and responding to these threats to protect the nation's biodiversity, agricultural industry, and public health (DAFF 2022). Biosecurity risks, which include plant, animal and zoonotic diseases and invasive species can devastate crops and livestock, resulting in significant economic losses, as well as disrupt ecosystems and harm native flora and fauna. Some biosecurity risks, such as zoonotic diseases (diseases that can be transmitted between animals and humans), pose a direct threat to public health. An outbreak of a major pest or disease can impact international trade and tourism, as countries may impose restrictions on the import of Australian goods or travellers (DAFF 2022).

In Australia, various agencies, and mechanisms (such as legislation and quarantine zones) are in place to identify, manage, and report biosecurity risks (DAFF 2022). Public surveillance and reporting play an important role, with citizens encouraged to report potential biosecurity concerns using websites and hotlines set up by federal and state agencies. To minimise economic and ecological damage, the agricultural sector is especially reliant on the early detection and prompt reporting of biosecurity risks as associated with pest animals, weeds and diseases (Hester and Cacho 2017; Kruger et al. 2020; Wright, Jorgensen, and Smith 2018). Although effective responses to biosecurity incursions requires strong relationships between government, industry and the community, the responsibility of agricultural biosecurity surveillance falls predominantly to individual producers and rural landholders[1] given their proximity, their personal interest in limiting negative impacts, and the cost-effectiveness of the arrangement for government and agricultural sector (Doherr and Audigé 2001; Kruger et al. 2020).

As a result, management strategies for agricultural biosecurity in Australia depend heavily upon private rural landholders and producers being willing and able to conduct surveillance for these risks and report in a timely manner to authorities. This is further supported in current biosecurity legislation, with most Australian states and territories requiring rural landholders to manage their land in a manner that limits the spread of pest animals, weeds, and diseases, with the expectation that they actively engage in the prevention, as well as surveillance, detection, and reporting of biosecurity threats on their property (Curnock et al. 2017; Sinclair, Curtis, and Freeman 2020). Critical to these strategies are engagement and support programmes to ensure rural landholders are aware of and able to fulfil their legislated responsibilities (Kruger 2011; Sinclair, Curtis, and Freeman 2020).

Engaging rural landholders can be challenging (Kruger et al. 2012; Vanclay and Leach 2011). Landholders are not a homogenous group, varying in their levels of commitment and capacity to understand and perform their biosecurity responsibilities. This heterogeneity stems from the increasing mixture of land ownership and uses in rural areas (e.g. lifestyle blocks, absentee owners as well as working farms), variance in individual values, beliefs, knowledge, skills and motivations, as well as the decline in traditional rural social norms, shared experiences, neighbour relationships and trust (Buckley et al. 2006; Klepeis, Gill, and Chisholm 2009; Minato, Curtis, and Allan 2012; Pannell et al. 2006). Effective engagement programmes for biosecurity not only need to build and reinforce individual landholders' capacity for surveillance, detection and reporting, but also foster relationships, mutual learning and a sense of reciprocity within rural communities (Hall, Marzano, and O'Brien 2020; Kruger et al. 2012).

From a behavioural perspective, surveillance, detection and reporting are separate complex behaviours. The capacity and resources required to tackle property surveillance are conceptually and practically independent to those required to identify the signs of biosecurity risk, which in turn differ to those required engage with a reporting system (Wright, Jorgensen, and Smith 2018). In this paper, we focus only on the reporting behaviour of rural landholders, using the biosecurity threat of wild dogs within the state of New South Wales (NSW) as a case study.

Determinants of reporting behaviour

A primary goal of this article is to understand which factors encourage or discourage landholder biosecurity reporting behaviours. Rural landholders' awareness of the biosecurity risks and policies, along with the belief that reporting is their responsibility, have been found to be important drivers for reporting (Curnock et al. 2017; Sinclair, Curtis, and Freeman 2020; Wright, Jorgensen, and Smith 2018). Other personal characteristics such as age, property size, land tenure, capability, knowledge and resource access have also been shown to be influential (Bronner et al. 2014; Ellis-Iversen et al. 2010; Sinclair, Curtis, and Freeman 2020; Wright, Jorgensen, and Smith 2018). Social networks play an important role in driving landholder reporting behaviour by increasing the knowledge of members and improving the social acceptance of the behaviour (Curnock et al. 2017; Vergne et al. 2016). The willingness of landholders to report may be influenced by their perceived risk to their enterprise, along with trust in government agencies, their confidence in the agency's ability to act, as well as the agency's approachability, helpfulness, and accessibility (Bronner et al. 2014; Palmer, Fozdar, and Sully 2009; Sobels, Curtis, and Lockie 2001; Wright, Jorgensen, and Smith 2018).

Behaviour change framework

In recent decades, there has been increased interest in the application of human behavioural models and behaviour change theories to improve the services and outcomes across many areas, such as health, education and environmental protection. As noted by Michie and her coauthors (Michie et al. 2014a), the behavioural science literature has produced over 83 behaviour change theories, with an overwhelming number of determinants, making it difficult for practitioners to select which theory is most relevant in their context. The Behaviour Change Wheel (BCW) is a behaviour change framework, initially developed in the health area, which offers a comprehensive and systematic approach to understanding behaviour change (Michie, Atkins, and West 2014b; Michie, van Stralen, and West 2011). It combines insights from multiple behaviour change theories and models, providing a well-rounded perspective on the psychological, environmental, and social factors influencing human behaviour. This framework emphasises the importance of considering three essential components of behaviour – Capability, Opportunity, and Motivation (COM) – to pinpoint the specific areas that need to be addressed to bring about behaviour change:

(1) *Capability*. An individual's physical and psychological ability to perform a behaviour. For example, does the rural landholder have the physical skills or knowledge

and cognitive skills to use the reporting tool. Interventions tackling these types of factors should incorporate techniques that educate, train and provide personal support.

(2) *Opportunity*. The physical and social factors external to an individual that prompt or enable a behaviour to occur. For example, does the landholder have access to the relevant reporting tool, do they have the support from the family, neighbours and community to report wild dog sightings. Interventions tackling these types of factors should aim to provide access, enable, facilitate, prompt or constrain.

(3) *Motivation*. Factors internal to an individual that energise or direct behaviour. These factors can be either reflective (incorporating conscious deliberation and reasoning) or automatic (usually outside conscious control e.g. impulse, habitual or emotional) (Kahneman 2013). For example, a landholders' decision to report wild dogs may occur after careful cost–benefit deliberation, after witnessing the mauling of their livestock or because that is what they have always done. Interventions tackling these types of factors should be designed to inform, persuade, discuss, demonstrate, incentivise or coerce.

Although behaviour change research dates back over 40 years, there has been less research on which strategies work best in which circumstances (Schultz 2014). A key strength of the BCW is that it provides a useful framework for linking identified causes of behaviour (from the COM-Behaviour analysis) to the best behaviour change tool for the job, thus avoiding the 'it seemed like a good idea at the time' notion (Michie, Atkins, and West 2014b). By identifying which elements of COM-B are most relevant, practitioners can make informed decisions about which behaviour change techniques are likely to be effective in each context so that interventions can be tailored to target the root causes of a behaviour and lead to lasting and meaningful behaviour change in individuals and communities. This framework has been used successfully to assist in the identification of factors influencing reporting behaviour and the design of effective intervention and policy solutions in the peri-urban context (Hine, McLeod, and Please 2020; McLeod et al. 2015).

Matching the content to specific audience needs can improve the behavioural impact of any identified behavioural intervention. Not everyone views wild dogs, their impacts and management approaches in the same way, reflecting a complex interplay of cultural, ecological, and personal factors. For example, although many livestock producers perceive them as a nuisance, causing damage to property or livestock, many conservationists and wildlife enthusiasts perceive them as a keystone species that help regulate prey populations and maintain ecological balance so advocate for the protection of these animals (Newsome et al. 2015). Tourists and nature watchers are captivated and enthused when they encounter dogs in natural settings (Thompson, Shirreffs, and McPhail 2003), and people concerned with animal welfare outcomes may not support the lethal methods commonly used to manage wild dogs such as baiting with toxins such as 1080, trapping and shooting (Fleming et al. 2006; NSW Government 2022). Due to these varied perceptions, the patterns of drivers and barriers influencing the reporting of wild dogs are likely to vary across individuals. Interventions can be designed or targeted to best match the characteristics of segments with specific driver / barrier

profiles (e.g. Emtage, Herbohn, and Harrison 2007; Hine, Sharp, and Driver 2019; Kaine et al. 2005; Morrison et al. 2012). Messages can also be crafted for specific individuals, as opposed to larger segments. This is referred to as message tailoring and is becoming increasingly common with advances in Internet marketing (e.g. Hine et al. 2017; Morrison et al. 2017).

Wild dog case study

Wild dogs (*Canis familiaris*), which include feral domestic dogs, dingoes and their hybrids (Jackson et al. 2017) pose significant livestock biosecurity and welfare risks (Bryce 2021; Fleming et al. 2014). Not only do these animals inflict an estimated $89 million in damage to cattle, sheep and goat production nationwide (McLeod 2016), but they also act as a reservoir for parasites and diseases that effect livestock, wildlife, domestic pets and humans, including sheep measles, hydatids, mange, distemper, hepatitis, parvovirus, *Neospora caninum* and toxoplasmosis (Brown and Copeman 2003; Harriott et al. 2019; Jenkins 2006; Kelman et al. 2020; King et al. 2011), and will potentially pose a huge problem if rabies breaches Australian borders (Sparkes et al. 2015).

In NSW, as is the case in many states across Australia, current legislation (*Biosecurity Act 2015*) imposes a general biosecurity duty requiring landholders to control wild dogs on their land and prevent them from causing problems on neighbouring lands (NSW Government 2022). However, given that these animals are highly mobile and can cause problems across multiple properties, management programmes often focus on coordinated landscape action to maximise effectiveness (National Wild Dog Action Plan 2020), and are generally coordinated by local wild dog management groups (e.g. wild dog associations) with financial and governance assistance from state government agencies (NSW Government 2022). Many of these government agencies and local wild dog groups rely on rural landholder reports of wild dog sightings and damage to assist with the planning of management programmes and targeting of their funds. Landholders are encouraged to report to either the local wild dog management groups or relevant agencies (such as the Local Lands Services or Department of Primary Industries) either in person, by phone or emails or, more recently, using the online website / smart phone app WildDogScan (https://feralscan.org.au/wilddogscan/default.aspx).

The objectives of this study are:

(1) Identify potential drivers and barriers to wild dog reporting by rural landholders from the literature and interviews with key informants, then organise these factors according to the COM Behavioural model.
(2) Determine the relative importance of these COM items, along with other demographic and situational variables in predicting current reporting and future intentions of reporting of wild dogs and their impacts.
(3) Segment the rural landholders using these COM factors and identify key points of leverage to inform the development of behaviour change interventions to increase wild dog reporting amongst rural landholders.

Methods

Study design

This study was conducted in three steps. The first step was to identify a list of potential driver and barrier factors to landholder reporting of wild dogs, using key informant interviews and the literature. The identified factors were grouped according to the COM Behavioural model (i.e. capabilities, physical opportunities, social opportunities and motivations). The second step involved surveying landholders to measure their current reporting behaviour and determine the importance of the identified COM factors to this behaviour. The final step was to segment the landholders using the COM factors and identify the key leverage points for behaviour change interventions.

Identification of potential driver and barrier factors

To identify a list of potential drivers and barriers to wild dog reporting, we interviewed 14 key wild dog management informants as well as conducted a literature search. The key informants were recruited from members of the National Wild Dog Coordinator Network, along with their suggested recommendations, which included rural landholders who are impacted by wild dogs, and representatives from non-government, research, and government organisations whose duties were related to wild dog management. The interviews followed a semi-structured format, to allow for the exploration of their knowledge in their specific areas of expertise (Barriball and While 1994) and were conducted either by phone or face-to-face. All interviews, which lasted between 30–60 min, were recorded (by consent) and later transcribed and summarised. The interviews were analysed based on the guidelines for thematic analysis recommended by (Braun and Clarke 2006). Content was coded using shorthand descriptive labels. Using these labels, emerging patterns or 'themes' were generated around the identified driver and barrier factors to landholder reporting. The search of the literature was not a formal literature review but was undertaken to supplement the information collected in the interviews. A combination of the keywords 'biosecurity OR agricultural' AND 'reporting' and involved a range of information sources, including Web of Science, CAB Abstracts, Science Direct and Google Scholar. In addition, we searched the websites of key government organisations (e.g. Department of Agriculture, Forestry and Fisheries, New South Wales Department of Primary Industries) for unpublished reports and extension material.

Rural landholder survey

A random digit phone survey of 186 rural landholders within areas of NSW reported to have problems with wild dog (NSW Government 2022) and with properties greater than 10 hectares was completed to assess the potential drivers of and barriers to reporting wild dog sightings and impacts. Information about the landholders' awareness of wild dog problems in their local area, their personal experience with wild dogs on their property, participation in reporting in the past five years and future intentions of reporting was collected. Basic demographic and situational information, including age, property size,

main property uses, years of residence and main income source was also captured. Respondents were asked to rate their agreement (on a 5-point Likert scale) to the 15 identified COM driver and barrier items that had been identified from the key informant interviews and literature search (Table 1).

Quantitative data analysis

Data was initially tested for compliance to the assumptions for parametric statistical analyses: normality (frequency distribution plots, Sharpiro-Wilk test), outliers (boxplots for univariate and Mahalandas Stat for multivariate), homogeneity (Box M test) and multicollinearity (collinearity diagnostics in SPSS) (Thode 2002). To determine the degree to which all collected variables predicted current reporting behaviour and future intentions to report we conducted two multiple regressions. All COM variables were simultaneously entered into the models. Other landholder variables included age, years of residence, property area, awareness of local wild dog problems (binomial where $0 =$ not aware, $1 =$ aware), landholder's rating of their current wild dog

Table 1. The fifteen identified potential driver and barrier factors, categorised using the Capability, Opportunity, Motivation (COM) framework, their sources and their means and standard deviations (SD).

COM barrier / driver variable	Mean (SD)	Source
Landholder capabilities to report		
I am unable to tell the difference between a wild dog and a domestic dog	2.31 (1.39)	Hine, McLeod, and Please (2020), Sinclair, Curtis, and Freeman (2020), Wright, Jorgensen, and Smith (2018)
I do not know who to contact to report wild dogs	2.11 (1.40)	Informant interview, Vergne et al. (2016); Ellis-Iversen et al. 2010
Landholder physical opportunity to report		
Current reporting methods are too time consuming	2.41 (1.12)	Informant interview, Bronner et al. (2014)
Current reporting methods are not convenient	2.29 (1.03)	Informant interview, Ellis-Iversen et al. 2010
Landholder social opportunity to report		
No-one I know reports wild dogs	2.48 (1.30)	Curnock et al. (2017); Ellis-Iversen et al. 2010
Landholder motivation to report		
Wild dogs are not a serious problem on my property	3.78 (1.46)	Informant interview, Sinclair, Curtis, and Freeman (2020)
It is not my responsibility to report wild dogs	1.79 (1.02)	Curnock et al. (2017), Sinclair, Curtis, and Freeman (2020), Wright, Jorgensen, and Smith (2018)
Reporting wild dogs will reflect that I'm a poor land manager	1.55 (.74)	Informant interview, Vergne et al. (2016)
No need to report as I handle the problem myself	2.71 (1.43)	Informant interview, Vergne et al. (2016), Wright, Jorgensen, and Smith (2018)
No point reporting as the authorities do not act anyway	2.53 (1.27)	Informant interview, Bronner et al. (2014)
Don't want authorities interfering on my property	2.28 (1.29)	Informant interview, Palmer, Fozdar, and Sully (2009), Wright, Jorgensen, and Smith (2018)
Reluctant to report as don't want to harm wild dogs	1.46 (.71)	Informant interview, Hine, McLeod, and Please (2020)
If I report, I will be required to do expensive control	2.51 (1.18)	Informant interview, Palmer, Fozdar, and Sully (2009)
If I report, I will be forced to implement control methods I don't like	2.08 (1.14)	Informant interview, Palmer, Fozdar, and Sully (2009)
If I report I'm worried that resulting control will harm working dogs	2.69 (1.43)	Informant interview, Palmer, Fozdar, and Sully (2009)

problem (0 = no problem, 1 = minor problem, 2 = moderate problem, 3 = severe problem), presence of livestock (binomial where 0 = no livestock, 1 = livestock present), property run as enterprise or not (binomial where 0 = no / hobby/lifestyle block, 1 = yes) and main source of income (binomial where 0 = off property, 1 = on property).

We then conducted a Latent Profile Analysis (LPA) to classify landholders into homogenous profiles based on their responses to the COM variables. Relative model fit was assessed using the Bayesian information criteria (BIC; Schwartz 1978) relative entropy (Ramaswamy et al. 1993) and the Lo–Mendell–Rubin likelihood ratio test (LMR; Lo, Mendell, and Rubin 2001). A significant p value from the LMR test ($p \leq 0.05$) indicated that the given profile solution fit the data significantly better than the solution with one fewer profile groups. Differences between identified landholder profiles and situational and demographic variables were tested using either a MANOVA, one-way ANOVA or Pearson's chi-squared test. All analyses were conducted in IBM SPSS Version 29, except the LPA which was conducted in MPlus 8.9 (Muthén and Muthén 2019). Following the common practice in medical and psychological studies data from Likert scales was analysed as interval data (Sullivan and Artino Jr 2013).

Results

Potential COM driver and barrier factors (Objective 1)

Thirteen important COM variables for reporting of wild dogs and their impacts were identified from the literature and key informant interviews (Table 1). These were:

Landholder capabilities (2 items) – 'I am aware of wild dog problems in my local area' (reversed scored for analysis) and 'I do not know who to contact'.

Landholder physical opportunities (2 items) – 'Current reporting methods are too time consuming' and 'Current reporting methods are not convenient'.

Landholder social opportunity (1 item) – 'No-one I know reports wild dogs'.

Landholder motivations (8 items) – 'Wild dogs are not a problem on my property', 'It is not my responsibility to report wild dogs', 'No point reporting as the authorities do not act anyway', 'Reluctant as will be forced to implement disagreeable control', 'Worried that resulting control will harm working dogs', 'Don't want authorities coming on to my property', 'If I report I will be required to do expensive control', and 'No need to report as I handle the problem myself'.

Landholder survey participants

The average age of the 186 survey respondents (58% male) was 58 years (range 18–85), which is slightly older than the average age (54 years) recorded for the NSW Regional adult population (Australian Bureau of Statistics 2018). The average property size of respondents was 1381 Ha (range 2–60,000), and the average years of residence was 28 years (range 1–82 years).

Over half of the respondents (97, 52%) earned their main income from their property. Over three quarters of the respondents (141, 76%) had some type of livestock enterprise on their property, mainly cattle, small livestock (such as sheep or goats), or horses.

Thirty-one (17%) respondents categorised their property as lifestyle or hobby, and the remaining 14 (7%) ran enterprises that did not involve livestock, such as cropping, horticulture, and timber.

Half of the respondents (94, 50%) were not aware of wild dogs in their local area. A further 18% (33) reported being aware of wild dogs in their area but had not experienced any problems on their properties. The remaining respondents (39%) reported wild dog problems on their property. Of these, 12 (7%) rated their problem as serious, 29 (16%) as moderate, and 29 (16%) as minor.

Forty-four respondents (24%) indicated they had reported wild dog sightings and impacts in the past five years. These reports were mostly made to either the Local Land Services (the main state government agency associated with wild dog management) (26 respondents), or neighbours (15 respondents). Other organisations or people that respondents mentioned included the local Council (4), Regional wild dog coordinator (4), local Wild Dog Associations (4), and other government departments (4). Respondents preferred to make a phone call (36) or report in-person (20). Two respondents indicated they would ring, followed up by an email, and one respondent texted. Only one respondent indicated they had used the online app Wild Dog Scan.

Predicting reporting behaviour (Objective 2)

Multiple regression was used to investigate the extent to which the 15 COM variables and other landholder variables predicted current reporting behaviour and future intentions to report. The results from the multiple regression analyses for Current reporting behaviour and Future intentions are summarised in Table 2. The two COM variables 'Wild dogs are not a serious problem on my property' and 'If I report I'm worried that resulting control will harm working dogs' were the only significant predictors of landholder's current reporting behaviour. Overall, the model explained 41% of the variance, with 'Wild dogs are not a serious problem on my property'uniquely explaining 5% and 'If I report I'm worried that resulting control will harm working dogs' 3%. The two COM variables 'No need to report as I handle the problem myself' and 'Don't want authorities interfering on my property' were the only significant predictors of Future intentions to report. Overall, the model explained 35% of the variance, with 'No need to report as I handle the problem myself' uniquely explaining 6% and 'Don't want authorities interfering on my property' 2%.

Landholder segmentation based on COM variables (Objective 3)

To develop the most effective policies and engagement interventions, practitioners not only need to understand why landholders are willing or not to report, but also if these reasons are similar across all landholders. Latent profile analysis using the fifteen COM variables indicated that respondents could be classified into three profiles (BIC = 8558.38, Entropy = 0.94). Although the 4-profile solution produced the lowest BIC value (8534.17), and the highest entropy value (0.96), the LMR test indicated that the 3-profile solution fitted the data significantly better than 4-profile solution, and that retaining an additional fourth profile did not significantly improve fit.

Table 2. Summary of regression analysis: Variables predicting current reporting behaviour and future intentions to report.

Predictors	Current reporting[1]					Future intentions to report[2]				
	B	95% CI for B		sr²	r	B	95% CI for B		sr²	r
		LB	UB				LB	UB		
Age	-.01	-.02	.00	.01	-.03	.01	-.01	.02	.00	.21
Property area	.00	.00	.00	.00	.17	.00	.00	.00	.00	.08
Years of residence	.00	-.01	.01	.00	.13	.00	-.01	.02	.00	.18
Property as enterprise	-.04	-.73	.64	.00	.09	-.14	-1.13	.85	.00	-.02
Presence of livestock	-.06	-.51	.62	.00	.17	.04	-.76	.85	.00	.06
Main income source	.12	-.20	.44	.00	.10	.17	-.29	.62	.00	.01
Aware of local wd problem	.28	-.33	.90	.00	.47	.28	-.61	1.16	.00	-.06
Own property wd problem	.32	-.01	.65	.01	.54	-.28	-.75	.20	.00	-.07
Unable to identify a wild dog	-.03	-.15	.10	.00	-.14	-.18	-.36	.01	.01	-.40
Don't know who to contact to report	.04	-.06	.14	.00	-.13	.07	-.08	.21	.00	-.03
Reporting methods time consuming	.00	-.16	.17	.00	-.19	.15	-.08	.39	.00	-.18
Reporting methods not convenient	-.06	-.24	.13	.00	-.20	-.20	-.46	.07	.01	-.31
No-one I know reports wild dogs	-.12	-.24	.01	.01	-.27	-.09	-.27	.09	.00	-.33
Wd not a problem on my property	-.22	-.33	-.10	.05	-.52	-.07	-.24	.10	.00	.01
Not my responsibility to report wd	.01	-.16	.18	.00	-.16	-.23	-.48	.01	.01	-.40
Reporting wd reflects poor manager	.07	-.14	.28	.00	-.02	.18	-.13	.48	.00	.05
No need as handle problem myself	-.09	-.20	.02	.01	-.23	-.31	-.46	-.15	.06	-.47
Authorities do not act anyway	-.02	-.14	.11	.00	-.08	-.05	-.23	.13	.00	-.34
Don't want authorities on my property	-.05	-.17	.07	.00	-.16	-.18	-.35	-.01	.02	-.30
Don't want to harm wild dogs	-.05	-.26	.17	.00	-.07	.24	-.06	.54	.01	.02
Will be required to do costly control	-.07	-.20	.07	.00	-.23	-.03	-.23	.17	.00	-.27
Required to use methods I don't like	.12	-.03	.28	.01	-.13	.07	-.15	.29	.00	-.27
Worried control harming my own dogs	-.16	-.27	-.05	.03	-.12	-.14	-.29	.02	.01	-.28

Notes: [1]model R = .70, R^2 = .48, Adjusted R^2 = .41, F = 6.42, p<.001; [2]model R = .66, R^2 = .43, Adjusted R^2 = .35, F = 5.22, p<.001; B unstandardised beta coefficient, CI confidence interval, LB lower bound, UB upper bound, sr^2 squared semi-partial correlation, r Pearson correlation; wd = wild dogs.

The landholder profiles are shown in Figure 1, and the characteristics for each profile are described below. There were no statistical differences between property area, years of residence, awareness of local wild dog problems, whether the property was run as an enterprise or not, and main income source between the profiles (refer to Table 3 for more detail).

Landholders in the *Supportive* profile (n = 49, 26%) were the most likely to have reported previously in the past five years and likely to report in the future. These landholders had the lowest agreement on all COM variables, i.e. they were capable of reporting, had the opportunity to report, were motivated to report and were not dissuaded by perceived negative consequences of reporting. Compared to the other profiles they were older and more likely to have livestock present on their properties (24 had small livestock, 19 cattle, five had hobby farms). Along with the *Reluctant* profile they were more likely to have experienced wild dog problems (6 serious, 7 moderate and 6 minor) compared to the *Receptive* profile.

Landholders in the *Receptive* profile (n = 97, 52%), which contains over half of the respondents, were the least likely to have reported in the past five years however, along with the *Supportive* profile, they were likely to report in the future. The main barrier to reporting for these landholders was that wild dogs were not causing a problem on their property. Members of this profile agreed that they would reasonably capable and somewhat motivated to report, however along with the *Reluctant profile*
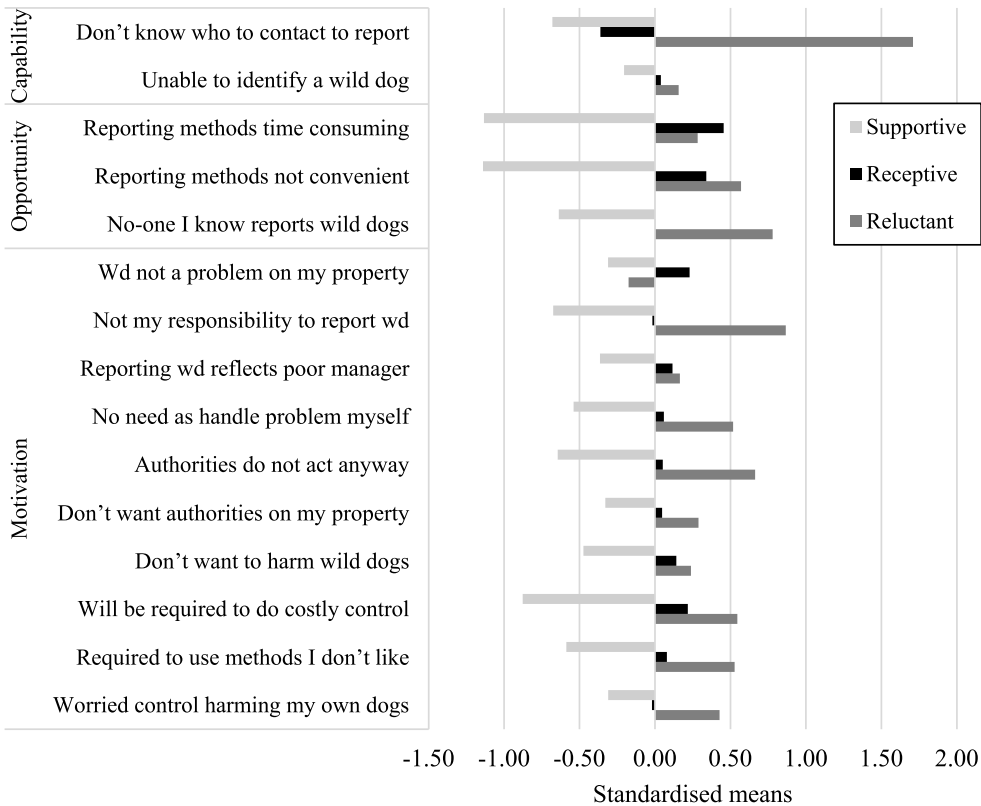
Figure 1. Standardised means of the Capability, Opportunity, and Motivation (COM) barrier items across the three landholder profiles (*Supportive*, *n* = 49. *Receptive*, *n* = 97. *Reluctant*, *n* = 40).

they lacked the opportunity to report, did not want to conduct expensive control and many did not wish to cause any harm to wild dogs.

Landholders in the *Reluctant* profile (n = 40, 22%) were unlikely to have reported in the past five years or to report in the future, despite many members experiencing problems with wild dogs (5 serious, 5 moderate and 2 minor). They tended to be younger than the other profile groups. Knowing whom they needed to report the wild dogs was a major barrier, as well as not knowing any-one else that reported wild dogs, not feeling it was their responsibility, believing the authorities didn't act anyway and being dissuaded by the perception that they would be forced to use control methods that were costly, they didn't like and that would harm their own working dogs. Many landholders in this profile did not want authorities interfering with their property, preferring to handle the problem themselves. Along with the Receptive profile, members also lacked the opportunity to report and many did not wish to cause any harm to wild dogs.

Discussion

In Australia the agricultural sector is reliant on rural landholders' reporting of biosecurity risks such as pest animals to support an effective response and limit the damage and cost to their industry. The aim of this study was to better understand the reporting of wild dog

Table 3. Comparison of reporting behaviours, demographic and situational characteristics across the three landholder profiles.

	Supportive (n = 49)		Unaware but Receptive (n = 97)		Reluctant (n = 40)		Segment differences		
	Mean	SD	Mean	SD	Mean	SD	F	p	η²
Reporting behaviours									
Reporting in past 5 years	2.16[b]	1.45	1.37[a]	.92	1.23[a]	.77	11.54	< .001	.11
Intention to report in future	4.15[b]	1.17	4.05[b]	1.33	2.63[a]	1.71	21.30	< .001	.19
Demographic & situational									
Age	62.80[b]	12.19	59.05[ab]	16.03	54.25[a]	17.25	3.39	.04	.04
Property size (ha)	2436.59	8721.44	1287.85	4460.94	312.65	472.62	1.66	.19	.02
Years of residence	31.90	22.58	27.32	20.27	24.60	15.68	1.56	.21	.02
Current wild dog problem	.78[b]	1.10	.68[b]	.65	.37[a]	1.12	3.84	.02	.04
	N (%)	Z$_{Resid}$	N (%)	Z$_{Resid}$	N (%)	Z$_{Resid}$	χ2 (df)	p	r
Aware local problems:							1.54 (2)	.46	.09
Yes	19	1.2	28	-.9	12	.3			
No	(39%)	−1.2	(29%)	.9	(30%)	-.3			
	30 (61%)		69 (71%)		28 (70%)				
Presence of livestock:							69.29 (2)	<.001	.49
Yes	43	2.3	73	-.2	25	−2.2			
No	(88%)	−2.3	(75%)	.2	(63%)	2.2			
	6 (12%)		24 (25%)		15 (37%)				
Property as enterprise:							3.48 (2)	.18	.05
Yes	44	1.4	81	.1	30	−1.6			
No (Hobby/lifestyle)	(90%)	−1.4	(84%)	-.1	(75%)	1.6			
	5 (10%)		16 (16%)		10 (25%)				
Main income source:							3.52 (2)	.17	.10
From property	31	1.8	48	-.8	18	−1.0			
Other (off property)	(63%)	−1.8	(49%)	.8	(45%)	1.0			
	18 (37%)		49 (51%)		22 (55%)				

Notes: SD = standard deviation, η2 (partial eta squared) = effect size, Means with different subscripts (in rows) differ significantly at p < .05 Tukey HSD, ZResid = Adjusted standardised residual, where ZResid > |2| is significant at p < .05. r = Pearson's correlation coefficient.

sightings and damage by landholders, who live in rural areas where wild dog problems occur. After identifying a suite of driver and barrier factors, which we organised according to the capability, opportunity and motivation (COM) Behavioural model (Michie, Atkins, and West 2014b), we were able to determine the importance of these COM factors in influencing current reporting behaviour and future intentions to report. In addition, we also identified three landholder segments with differing COM profiles. Our main findings are summarised in the next sections, along with a discussion of the practical implications using the Behaviour Change Wheel (BCW) framework to identify the main leverage points useful for targeting interventions to encourage participation.

Factors influencing reporting behaviour of rural landholders

Many of the factors predicting rural landholders' current and future wild dog reporting that we identified in this study were like those described for other biosecurity risks from across Australia, as well as wild dog reporting by peri-urban residents. These included

awareness of a particular biosecurity risk, their knowledge about who to contact, their social network and their motivation, particularly their belief that it is their responsibility and their confidence that the government agency will act (Bronner et al. 2014; Curnock et al. 2017; Ellis-Iversen et al. 2010; Hine, McLeod, and Please 2020; Palmer, Fozdar, and Sully 2009; Sinclair, Curtis, and Freeman 2020; Sobels, Curtis, and Lockie 2001; Vergne et al. 2016; Wright, Jorgensen, and Smith 2018). However, we also identified some factors relating to the perceived consequences of reporting wild dogs not yet described in the biosecurity literature.

Many landholders were dissuaded from reporting, perceiving it would lead to outsiders gaining access to their property and forcing them to conduct unwanted and costly control activities that could potentially harm their own working dogs. Many felt it was a problem they could handle themselves. In our study area, local wild dog associations and affiliated government agencies primarily depend on rural landholders to report wild dogs. This reporting aids in planning management programmes, allocating funds, and, when necessary, offering support to landholders for control measures. Unfortunately, these organisations are associated with primarily promoting lethal control of wild dogs (Fleming et al. 2006; NSW Government 2022), often using controversial methods such as 1080 toxin and aerial baiting (Fitzgerald 2009; Green and Rohan 2012; Hahner 2018; Sherley 2007). The same government agencies are also the main regulators of biosecurity legislation within the state, making it difficult to foster the trust and relationships required for an effective reporting culture (Hall, Marzano, and O'Brien 2020; Kruger et al. 2012; Sinclair, Curtis, and Freeman 2020).

Audience segmentation of landholders

We identified three distinct landholder profiles based on the COM themes and reporting behaviour – Supportive, Receptive and Reluctant. Similarities in our landholder profiles are reflected in the segments from other studies across different biosecurity contexts. In their study of wild dog reporting by peri-urban residents Hine, McLeod, and Please (2020) identified two segments based around residents' intentions to report wild dog sightings and damage to local authorities – Receptive and Reluctant. Receptive residents understood the benefits of reporting, knew who to contact, felt it was their responsibility, trusted the authorities to act and were likely to report in the future. Reluctant residents did not intend to report in the future because of their positive attitudes to wild dogs and negative attitudes to their management and / or felt it was too much effort, there were no benefits, it wasn't their responsibility and the authorities would not act anyway. In our current study both the Supportive and Receptive segments showed high intentions to report in the future, with the main difference separating the two being their experience of wild dog problems and understanding of the needs and benefits of reporting. Like the Reluctant peri-urban segment, this study's Reluctant rural landholder segments also had low intentions to report in the future, prevented by a range of barriers including opportunity and perception of negative consequences towards the animals.

The study by Wright, Jorgensen, and Smith (2018) identified three rural landholder segments for monitoring and reporting of exotic livestock diseases – Supportive, Monitor but Not Report and Not my Problem. Members in their Supportive segment had beliefs supporting their biosecurity responsibility and showed strong intentions to

monitor and report, like our Supportive profile, and also our Receptive profile. Members in their Monitor but Not Report segment were willing to monitor and manage disease in their own livestock but less likely to report to authorities, traits that were very similar to our study's Reluctant segment. Members in the Not my Problem exotic disease segment had the lowest capability to detect exotic diseases and felt the least personal responsibility for monitoring and reporting, characteristics also evident in our own Reluctant segment.

The study of Curnock et al. (2017) explored the role of community gardeners monitoring and reporting of plant pests and diseases. They identified three segments – Engaged, Unengaged and Disengaged. Unengaged gardeners were typically unaware of the biosecurity risks posed by plant pests and diseases but expressed an interest in learning and participating in monitoring and reporting like this study's Receptive segment. Disengaged gardeners were more knowledgeable of the biosecurity risks but expressed a low interest in or willingness to report a potential biosecurity threat due to a lack of interest or cynicism about plant biosecurity management processes, traits that were mirrored by our study's Reluctant segment.

These segmentation results illustrate that the patterns of barriers influencing biosecurity reporting vary across rural landholders depending on their behavioural dispositions. Matching behaviour change tools and crafting messages to specific landholder needs will improve the behavioural impact of any intervention (Hine, Sharp, and Driver 2019; Morrison et al. 2012; Morrison et al. 2017). The practical implications for intervention design, guided by the Behaviour Change Wheel (BCW) framework, are discussed below. We initially focus on our context of wild dogs then conclude with a broader discussion of the usefulness of our results for developing targeted interventions for similar biosecurity issues in other contexts.

Practical implications

The main factor influencing reporting behaviour in our largest profile, Receptive, was the lack of experience of wild dogs and their negative impacts on their property. Personal experience of these negative impacts of invasive animal such as wild dogs has been shown to be a strong motivator for participation in coordinated control activities with neighbouring landowners and local authorities (Binks, Kancans, and Stenekes 2015; Ecker et al. 2015; Fenton 2009; McLeod and Hine 2019). However not all landholders have first-hand experience of these impacts, while many are not aware of the problems experienced by others in their local community. According to the BCW, an effective way to increase awareness in this segment would be increasing knowledge through an education-style intervention (Michie, Atkins, and West 2014b). Relating personal experiences and using a narrative-style approach could enhance this type of intervention by emotionally engaging its audience (Hine et al. 2015). Recent neuroscience research indicates that people's brains react similarly when reading about an experience and actually living the experience (Mar 2011), suggesting that stories can engage audiences in a fundamentally deeper way than more traditional fact and statistics-based approaches.

Low motivation to report was an important barrier to members of our Reluctant profile that expressed low intentions of future reporting. Legislation is an important tool used by government agencies to coerce compliance and motivate adoption of desired behaviours. Current biosecurity legislation in NSW, and indeed for most states

across Australia, has shifted to the concept of 'shared responsibility' between landholders and the government. However instead of solely relying on legislation, government agencies should also develop and support institutional reforms and interventions that build the social and human capital of all landholders, not only to enhance their levels of responsibility for biosecurity issues but also to promote trust and cooperation to facilitate improved social actions such as reporting (Howard 2018; Sinclair, Curtis, and Freeman 2020). Examples of these reforms could include investing in capacity building programmes for agency officials, extension workers, and community leaders to ensure continuity of service and effective implementation of rural development initiatives. Also practising more inclusive engagement strategies, moving beyond just informing and consulting to collaborating and empowering local landholders will foster relationships, mutual learning and a sense of reciprocity within rural communities (Hall, Marzano, and O'Brien 2020; Kruger et al. 2012).

Interventions aiming to enhance landholder's personal sense of responsibility for biosecurity should highlight the positive aspects of reporting to not only themselves but also their neighbours and their community as well as emphasize the benefits of cooperation to handle the risk. Recognising individual's contributions and the use of incentives, either financial or social can be beneficial (Hine, McLeod, and Driver 2022). Messaging should be framed around landholder's perceived social role in their community and be delivered by credible sources that landholders associate with and trust. The provision of feedback from 'important others' on their experiences with reporting and the benefits achieved may also be helpful (Hine et al. 2015).

Landholder's perceptions of the lack of action by authorities on managing biosecurity risks was another important barrier to reporting. Regardless of whether these perceptions are accurate or not the authorities need to promote awareness of how they are acting, as well as provide feedback from other people's experiences and the benefits achieved would be appropriate. Care should be taken when attempting to dispel misconceptions and misinformation as it can be very easy to inadvertently reinforce the myths you are trying to correct (Cook and Lewandowsky 2011). To debunk effectively, you must understand how people process new information, how existing knowledge is modified, and how current worldviews and beliefs can undermine rational, clear thinking.

Many landholders, particularly from the Reluctant segment, where dissuaded from reporting owing to perceived negative consequences such as having outsiders on their property and being forced to conduct unwanted control activities. This reflects a perceived attack on their autonomy leading to reduced autonomous motivation to report (Deci and Ryan 1985; Marshall, Hine, and East 2017). Interventions to tackle this barrier should aim to persuade landholders that reporting will produce positive outcomes for them and their community, dispel misinformation and develop trust between reporters and authorities. Persuasive messages choosing a frame that matches the targeted landholder's values and concerns and delivered by credible sources whom landholders associate and trust will maximise impact (Hine et al. 2015; Kahneman and Tversky 1984). Providing feedback from other landholders about their experiences would also be important (Hine, McLeod, and Driver 2022). Developing trust between landholders and government agencies is a more challenging proposition. Long term-commitment and institutional change to improving landholder engagement, relationship

building, transparency and staff retention is required (Davenport et al. 2007; Howard 2018).

The results of our study on the factors influencing landholder reporting behaviour of wild dogs in Australia, along with the BCW for designing interventions, holds significant promise for addressing similar biosecurity risks not only in Australia but also in other countries facing analogous challenges. As many of the factors we found influencing rural landholders reporting and the identified audience segments were like those described for other biosecurity risks across Australia, our practical recommendations can serve as a starting point for other biosecurity issues which face similar barriers or other regions facing comparable biosecurity issues. The versatility of the BCW means it can be adapted to suit specific needs and cultural contexts, helping to develop context-specific strategies to protect agriculture, ecosystems, and public health in the face of diverse threats.

Limitations of this research

Although we assessed a wide range of behavioural predictors of landholder reporting, practical limitations associated with the length of phone surveys prevented us from assessing a more comprehensive list. The research described in this study represents a starting point for further work aimed at developing more targeted communication and behaviour change interventions to encourage landholder reporting behaviour.

The COM-B model and BCW framework provide a practical, intuitive method to understand human behaviour in context and design interventions that are most likely to be effective. However, using these methods are not a 'quick fix', and a large amount of effort is still required to organise and evaluate potential COM factors and understand how these factors vary across context. Developed interventions still need to be rigorously evaluated. Changing human behaviour can be complex, and it is all too often the case that scientifically credible evidence about the effectiveness of a particular intervention is lacking. Knowledge about what works in what contexts will only be gained iteratively through a continuous loop of learning and improvement (Hine, McLeod, and Driver 2022).

Conclusion

The research described in this study adds to the literature for understanding landholder reporting of biosecurity risks. We identified drivers and barriers to reporting of the wild dog biosecurity risk, organised them according to the COM Behavioural model, and found that landholders' willingness to participate to report was influenced by their personal experience of wild dog problems and motivational factors to do so. However, segmentation using behavioural factors highlighted that landholders were not a homogenous group, with each of the segments identified exhibiting their own unique COM profile. Using the BCW framework we were able to recommend the most appropriate type of intervention that would connect and engage with the targeted audience. The use of the BCW and its underlying COM Behavioural model (Michie, Atkins, and West 2014b) provides a practical, easy-to-employ tool for practitioners to increase their understanding of landholder behaviour and assist them in developing improved interventions to target and boost participation biosecurity reporting rates.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the Human Research Ethics Committee of the University of New England (Approval Nos HE18-182 & HE19-241), and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Note

1. For this paper a landholder refers to a person who is the owner of land or has lawful management or control of land and is rateable under the NSW *Local Land Services Act 2013* (generally a property size of 10 hectares, although this can be larger in more remote regions of the state).

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Notes on contributors

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