# Application of the Five Domains model to food chain management of animal welfare: opportunities and constraints

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For businesses involved in animal production, ensuring high animal welfare standards has become the cornerstone of corporate social responsibility practices. Since animal welfare cannot be verified by consumers at the point of purchase, industry-led audits provide important assurance that animals used to produce food lived an acceptable quality of life and experienced a humane death. The Five Freedoms offer a simple tool to conceptualize the complex, multi-dimensional concept of animal welfare, and they have been widely adopted as a basic operational framework for compliance. However, the Five Freedoms are problematic in that they focus on the absence of negative welfare states, underemphasize the importance of positive experiences, are absolute, and represent a (mostly unattainable) ideal. The Five Domains model represents inter-related aspects of an animal's welfare state, with four physical/functional domains used to infer likely mental experiences in the fifth domain. This model allows for consideration of both positive and negative affective experiences, recognizes degrees of welfare compromise, acknowledges that animals cannot be free from all negative experiences (and that indeed, some are essential for survival). Thus, the model better reflects current scientific understanding of animal welfare and – that ultimately, we are interested in how animals experience their lives. Nevertheless, caution is needed when inferring mental states, which can never be directly observed or measured, and hence the ultimate outcomes of the model's application should be qualitative. Operationalization of the Five Domains offers several opportunities to improve the breadth and quality of welfare audits for production animals. The model can incorporate both resource/management- based and animal-based measures of welfare; the former reflect risks to animals' welfare while the latter often provide direct information on the animal's welfare state at the time of assessment. Existing welfare indicators may be linked to relevant mental states and evaluated accordingly, and new metrics may be scientifically identified. Importantly, the Five Domains structure demands scrutiny of the affective state

consequences to animals of housing, handling, and husbandry procedures, and could improve the effectiveness of animal welfare training for auditors and stockpersons. Adoption of the Five Domains framework could facilitate improved communication about animal welfare in the food chain with customers and consumers.

# 1 Introduction

As consumer preferences shift toward purchasing products they perceive to do more public good and less harm, corporations are increasingly challenged to ensure their business practices and values align with these changing expectations. One means by which companies can demonstrate their values is through their corporate social responsibility (CSR) practices. Such practices typically have a core focus on social and environmental stewardship (Maloni and Brown, 2006; Costanigro et al., 2016). How different businesses manifest their commitment in these domains may vary, but for those involved in animal production and processing, ensuring high animal welfare standards has become a cornerstone of CSR. Not only is animal welfare in itself important to consumers and other members of the public, it is often used as a proxy indicator of product attributes that people value, such as food safety, quality, and the general sustainability of food production (Harper and Makatouni, 2002; Croney and Anthony, 2014). Thus, animal welfare has become an even stronger focal point for consideration within agri-food businesses' CSR initiatives (Morgan et al., 2018). Unsurprisingly, various stakeholders, including consumers, consumer and animal advocacy non-governmental organizations, and others are increasingly holding companies accountable for animal welfare across the various food chain sectors.

In North America, voluntary strategies, including implementation of codes of practice and guidelines, are employed for guiding farmers and ranchers in their implementation of best animal care, handling, and management practices, whereas other countries and jurisdictions, like the European Union, primarily use laws or directives to protect farm animal welfare (Croney and Millman, 2007). In the U.S., federal law primarily covers specific aspects of food animal production and slaughter that include acts of cruelty committed during the offloading and handling of livestock prior to and during slaughter, road transport, the marketing of labeled products, feed additives, antibiotic use, and growth promoters. Food safety mandates and other practices that pose a risk to human health are also covered (CAST, 2018). Industry level quality assurance programs (e.g., Beef Quality Assurance) and private guidelines or standards fill the gap for covering the day-to-day management, care, and handling practices of livestock at the farm level. Laws concerning farm level production practices have been implemented at the state level in less than half of US states but have predominantly focused on housing practices for veal, gestating sows, and laying hens. Therefore, an incomplete and sometimes conflicting patchwork of state laws have led to an inconsistent approach to addressing farm animal welfare at the national level. Canada engages a national stakeholder-driven process that includes government, scientists, the animal industries, animal protection groups and other stakeholders in setting evidence-based codes of practices (see NFACC https://www.nfacc.ca/codes-of-practice). These Codes of practice cover the on-farm care, transportation, and slaughter for nearly all species of farm animals. Although the codes of practice are considered voluntary, except where regulatory requirements exist, they are given considerable weight when legal or public issues arise concerning farm animal welfare. Furthermore, the World Organization for Animal Health (OIE, 2021) has set global animal welfare standards for the care, slaughter, and transport of farmed terrestrial and aquatic animals; while these standards are not legally binding, member states commit to translating them into their national animal welfare-related legislation (WOAH, 2022).

In the late 1990s, a major shift occurred in how farm animal welfare was addressed, especially in countries where related legislation was deemed too minimal by members of the public and special interest groups. Rather than relying on legislative initiatives to advance their animal welfare objectives, special interest groups began to publicly issue directives to corporate supply chain sectors, thus leveraging consumers' perceptions of brands and related purchasing to influence market changes (Schweikhardt and Browne, 2001). In the United States (US), well-known fast food retailers, including McDonald's and Burger King established animal welfare advisory councils to help develop and implement welfare standards aimed at addressing consumer concerns. Fast casual chain restaurants, supermarket chains, and major food processors and distributors followed suit (Maloni and Brown, 2006). As a result, there was rapid growth in animal welfare science research and the development of public or proprietary animal welfare assessment and auditing programs. Competitive marketing of 'humane' or 'higher welfare' labeling and certification programs also emerged, many of which incorporated incentives for producers to comply with standards that are generally higher than the legal minimum (Thompson et al., 2007; Lundmark et al., 2018). Central to these activities was the intent to provide

public assurance that animals used to produce food lived an acceptable quality of life and experienced a humane death.

In several cases, unfunded animal welfare mandates were created for farmers (Norwood et al., 2019) resulting in inconsistent compliance with new welfare standards and varying outcomes for animals. Challenges began to emerge relating to the accuracy of using terms such as 'humane' in animal production (Spain et al., 2018; Browning and Veit, 2020). Demands also increased for proof that the conditions under which farmed livestock and poultry were raised, transported, and processed were consistent with the high welfare standards promised by private corporations (Smith, 2022). Since animal welfare, like food quality, is a credence attribute that cannot be verified by a consumer at the point of purchase (Croney and Anthony, 2014) animal welfare audits have become an increasingly important means of verification for food corporations.

For a majority of North American corporate animal welfare assessment and assurance programs, the Five Freedoms have provided a basic operational framework. However, practically translating the Five Freedoms into on-site practices and corresponding audits creates certain difficulties that may spur some companies to seek an alternative framework. Here, we outline the merits and challenges of operationalizing the Five Freedoms into animal welfare assessment and auditing. The potential benefits and difficulties associated with incorporating the newer Five Domains model into animal food corporation practices and policies are discussed, with special attention to the implications for auditing in the production animal sector.

## 2 The Five Freedoms: benefits and challenges in the context of farm animal welfare assurance

The Five Freedoms grew from the initial work of a UK government committee (chaired by Roger Brambell) in 1965, tasked with examining the welfare of intensively reared farm animals (FAWC, 2009). The Freedoms were intended to represent a set of "ideal states" rather than explicit standards by which to evaluate the welfare of animals. They scope wide dimensions of welfare, incorporate both the physical and mental well-being of animals, and users are encouraged toward continuous improvement in these areas. The Five Freedoms were later refined to their current format (Figure 1) by the United Kingdom's Farm Animal Welfare Council (now Animal Welfare Committee). In their full form (Figure 1), they include provisions which constitute practical advice on how each Freedom may be achieved, for example "Freedom from hunger and thirst – by ready access to fresh water and diet to maintain health and vigor". The Five Freedoms also consecrate the important notion that behavioral restriction causes welfare harm. Most of all, the Five Freedoms have represented a route to conceptualize the complex, multidimensional phenomenon of animal welfare into a memorably simple list – a highly attractive quality for regulators and corporations, which should not be underestimated. Unsurprisingly, adoption of the Five Freedoms, as a 'checklist' for considering animal welfare, has burgeoned and now ranges from assessments of insects (van Huis, 2021) to whales (King et al., 2021).

Increasingly, though, questions arise as to how well corporate and private industry programs and organizations are fulfilling their pledges to the ideals laid out by the Five Freedoms. How might an interested stakeholder know when those ideals are met and with what level of confidence? A commitment to the Five Freedoms brings an immense responsibility to meaningfully demonstrate how these five "ideal states" of animal welfare are being met. Herein lies the problem. Within any organization that undertakes a commitment to the improvement of farm animal welfare, there must be a meaningful, realistic, and common understanding of the fundamental framework utilized to assess the welfare of animals against a set of clearly delineated goals. Particularly in this regard, the Five Freedoms model has been criticized (McCulloch, 2013). A



1. **FREEDOM FROM HUNGER AND THIRST**
   by ready access to fresh water and diet to maintain health and vigour.

2. **FREEDOM FROM DISCOMFORT**
   by providing an appropriate environment including shelter and a comfortable resting area.

3. **FREEDOM FROM PAIN, INJURY OR DISEASE**
   by prevention or rapid diagnosis and treatment.

4. **FREEDOM TO EXPRESS NORMAL BEHAVIOUR**
   by providing sufficient space, proper facilities and company of the animal's own kind.

5. **FREEDOM FROM FEAR AND DISTRESS**
   by ensuring conditions and treatment which avoid mental suffering.

FIGURE 1
The Five Freedoms (FAWC, 2009).

key theoretical deficiency is that conceptualizing welfare as "freedom from…" as described by most of the Five Freedoms quickly begins to create scientific and logistical difficulties for those who must provide evidence of meeting these goals, which in most cases are not actually achievable. This is problematic for animal producers and processors who already face contentious public discourse and legal challenges relative to their animal welfare claims. Another limitation of the Five Freedoms is that the absence of negative affective states alone does not generate positive experiences and is thus not sufficient to ensure what is now considered by most to be 'good' or acceptable welfare for animals (Yeates and Main, 2008). For example, the absence of fear or pain alone does not ensure that an animal is experiencing a good mental state.

In short, although the Five Freedoms model was instrumental in facilitating wider recognition of welfare harms and movement towards improving the welfare of a variety of species, including companion, farm, lab, and zoo animals, it was arguably never a tool designed to underpin detailed assessment and assurance of acceptable welfare states. As a result, organizations and private industries that base their social policies, commitments, and animal welfare assurance programs only on the Five Freedoms may be challenged to effectively demonstrate the attainment of the ideal states they describe.

# 3 The Five Domains model: a practical alternative to the five freedoms in the context of farm animal welfare assurance?

## 3.1 Introduction to the Five Domains model for animal welfare assessment

The Five Domains model (Mellor and Beausoleil, 2015; Mellor, 2016; Mellor, 2017) was designed to provide a more pragmatic and robust framework for the assessment of animal welfare than the unattainable ideals set out by the Five Freedoms. The model was originally formulated in 1994 to facilitate identification and relative grading of the negative impacts of research, teaching, and testing procedures on animals in New Zealand (Mellor and Reid, 1994). It has since been used to assess the welfare of a range of animal taxa in a variety of situations, including working dogs (Littlewood and Mellor, 2016), horses (McGreevy et al., 2018), free-living wildlife (Harvey et al., 2020; Nicol et al., 2020; Boys et al., 2022) and pest animals (Baker et al., 2016; Beausoleil et al., 2016; Baker et al., 2022). It has also been used to assess suffering and animal cruelty leading to court prosecutions (Ledger and Mellor, 2018), to 'educate' animal caretakers (Fletcher et al., 2021), to guide development of specific assessment protocols for animal industries (e.g. Mellor and Burns, 2020), and it has been proposed as a way of structuring veterinary curricula (Littlewood and Beausoleil, 2021). Throughout its 25-year history, the model has been regularly updated to include the latest developments in animal welfare science thinking (Williams et al.,

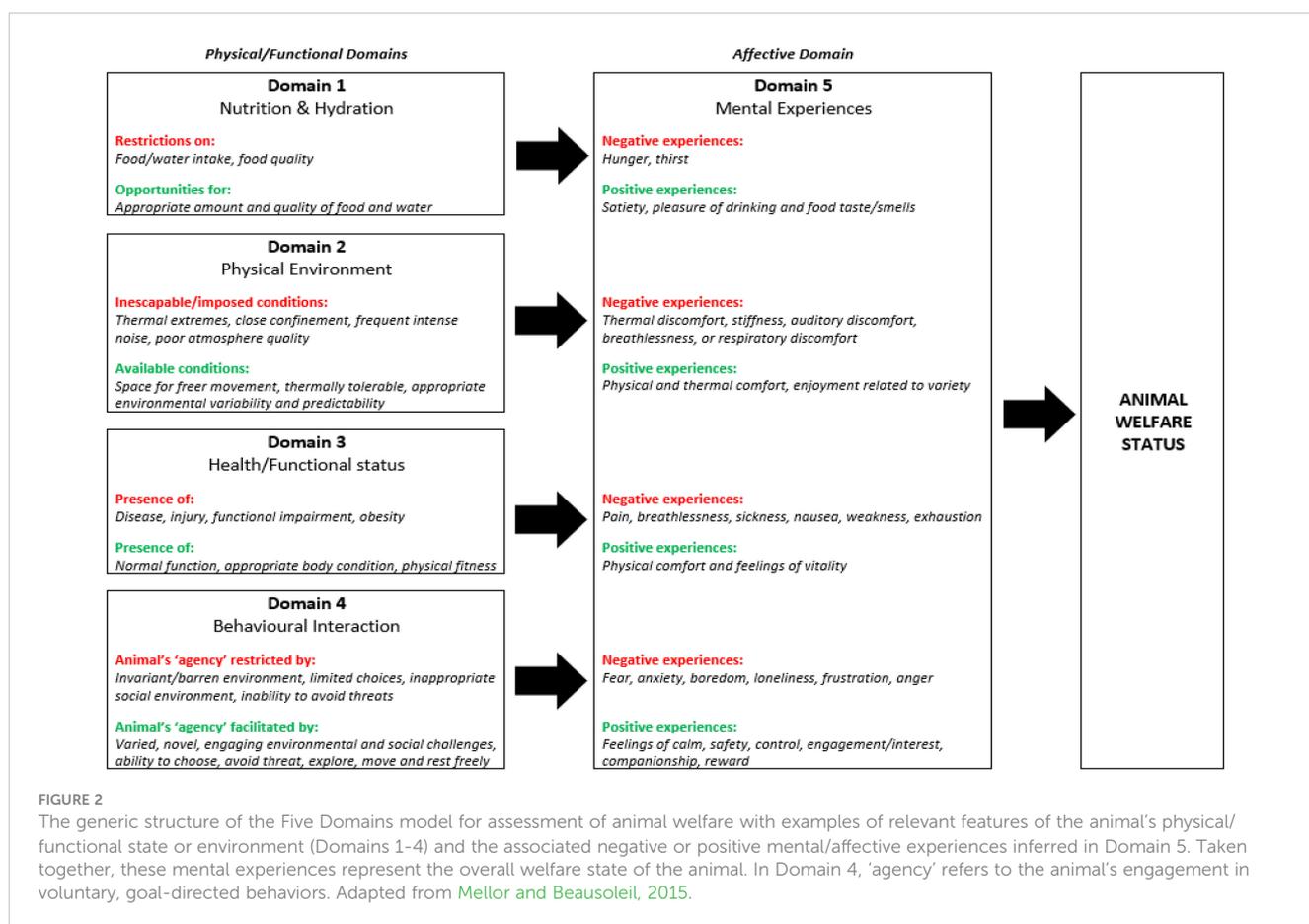2006; Mellor et al., 2009; Mellor and Beausoleil, 2015; Mellor et al., 2020).

As the name suggests and in common with the Five Freedoms, the Five Domains model is structured to represent five inter-related aspects of an animal's welfare state. As shown in Figure 2, evidence of impacts on the animal (both negative and positive) is organized into four physical/functional domains which relate to its (1) Nutrition and hydration, (2) Physical environment, (3) Health or functional status, and (4) Behavioral interactions. This evidence is provided by a range of qualitative and/or quantitative physical, physiological, pathophysiological, biochemical, immunological, neurological, and behavioral indicators. This information is then used to cautiously *infer* the animal's likely mental/affective experiences, which are most relevant to its welfare state, in Domain 5: Mental Experiences.

Negative experiences such as thirst, hunger, breathlessness, or pain may arise in Domain 5 from factors that disturb or disrupt the internal stability of the body (evidence in Domains 1-3) or when the animal is prevented from achieving strongly motivated behavioral goals to interact with the environment and other animals, e.g., fear or frustration (evidence in Domain 4) (Mellor et al., 2020). Positive experiences such as the pleasure of eating or thermal comfort may arise when the animal has opportunities to maintain or restore its internal physical stability (Domains 1-3) or when it can achieve its goals, e.g., the pleasure and safety of companionship (Domain 4).

In addition to animal-based indicators used to infer the occurrence of negative and positive mental experiences, parameters relating to the resources and conditions provided, and management practices applied to the animal (resource/management-based indicators) can also be organized in Domains 1-4 to evaluate the *likelihood* of specific negative or positive mental experiences occurring in Domain 5 (see Section 3.3.3).

While the Five Domains model is widely used to guide thinking about animal welfare and its assessment by professional organizations (e.g., SPCAs in the US, veterinary associations) and laypeople alike, the model has only been fully operationalized for practical assessment in a few situations. In the zoo community, the Five Domains has been incorporated into routine animal assessment as part of the Australasian Zoo and Aquarium Association's (ZAA) Member Accreditation Programme (https://www.zooaquarium.org.au/public/Public/Animal-Welfare/ZAA-Accreditation.aspx) and in Zoos Victoria's in-house welfare assessment program (Sherwen et al., 2018). Similarly, the Sharp and Saunders Humaneness Assessment Model is an operational version of the Five Domains model used in Australia, New Zealand, and the UK to characterize and compare the negative welfare impacts of different methods of managing pest animals (Sharp and Saunders, 2011; Baker et al., 2022; Beausoleil et al., 2022). However, the Five Domains model has not yet been fully operationalized for the purposes of routine assessment and auditing within livestock and poultry production systems.

Successfully operationalizing any theoretical model for practical welfare assessment presents a number of challenges and first requires a clear understanding of the philosophical basis of the model, its features, and any associated limits on interpreting the

FIGURE 2
The generic structure of the Five Domains model for assessment of animal welfare with examples of relevant features of the animal's physical/functional state or environment (Domains 1-4) and the associated negative or positive mental/affective experiences inferred in Domain 5. Taken together, these mental experiences represent the overall welfare state of the animal. In Domain 4, 'agency' refers to the animal's engagement in voluntary, goal-directed behaviors. Adapted from Mellor and Beausoleil, 2015.

outcomes of its application (Beausoleil and Mellor, 2015a; Harvey et al., 2020; Beausoleil et al., 2022). The Five Domains model is predicated on the understanding of animal welfare as a state within the individual animal itself that arises due to the integration of its various mental experiences at a point in time. Mental experiences that have valence (i.e., are negative or positive) are considered to *matter* to the animal and are often referred to as 'affective experiences' or 'affects' (Mellor, 2019). In other words, an animal's welfare reflects how it is experiencing its own world and life, and its overall welfare state will vary over time on a continuum from very poor to very good as those experiences vary.

This understanding of animal welfare aligns most closely with the 'affective state' approach which posits that good welfare can be achieved when animals have few, minor and/or transient negative mental experiences *and* have frequent and meaningful positive experiences (Weary and Robbins, 2019). Other approaches to welfare relate predominantly to the animal's 'biological functioning' (e.g., productivity or evolutionary fitness) or the 'naturalness' of the way the animal is kept (Fraser et al., 1997; Dwyer, 2009; Hemsworth et al., 2015). The Five Domains model emphasizes the 'affective state' orientation for several reasons. First, affective experiences most directly link the individual animal's welfare state with its own subjective perceptions and interpretations of various features of its world (Duncan and Petherick, 1991; Fraser, 2008); second, affective experiences and biological functioning are dynamically related. An animal's mental

experiences arise from the central nervous system's processing and interpretation of sensory information gathered about its physical state (internal bodily processes/biological functioning) and its external environment (Duncan and Petherick, 1991; Mellor et al., 2020). Affective experiences such as fear can, in turn, influence physical functioning and productivity (Hemsworth and Barnett, 1989; Hemsworth et al., 2002; Hemsworth and Coleman, 2011; Acharya et al., 2022). The structural link between the animal's physical state/behavioral interactions in the first four Domains and the consequent affective experiences in Domain 5 is a fundamental feature of the model and one of its key strengths for transparently justifying conclusions drawn about overall welfare state. However, the requirement to interpret 'objectively' observable or measurable variables in terms of the animal's subjective internal experiences can be challenging for some (see Section 3.3.1).

## 3.2 Key advantages of the Five Domains over the Five Freedoms for farm animal welfare auditing

The Five Freedoms model has provided an apparently straightforward, high-level framework to understand and explain important components of an animal's life and care relevant to its welfare. As such, it may still be useful as a checklist for the general public if explained in the context of current knowledge. However,

for the purposes of scientific assessments, which are required to develop and justify robust welfare auditing and assurance systems, the Five Freedoms is not sufficiently detailed nor is it accurate in the light of contemporary understanding. Further, the freedoms do not operationalize well; for example, it is not possible to capture 'freedom from' in an audit tool because an absence of evidence (i.e., indicators of negative welfare states) is not evidence of absence.

While both models comprise five dimensions of an animal's welfare state and there are obvious similarities in coverage, a key difference is the explicit requirement to show links between the animal's physical state or behavioral interactions in Domains 1-4 and the corresponding affective experiences in Domain 5. By contrast, three of the Five Freedoms are couched in terms of mental experiences that matter to the animal (hunger and thirst; discomfort; fear and distress) while one represents a mixture of physical causes (injury, disease) and one of numerous possible mental states that could be associated with such causes (pain). Another reflects behavioral expression with no mention of any experiential correlates. This list of possible experiences no longer reflects up-to-date scientific knowledge about the range of unpleasant experiences of which many animals are capable (e.g. Mellor et al., 2009; Beausoleil and Mellor, 2015b; Siniscalchi et al., 2021) and does not explicitly represent the positive experiences considered necessary for acceptable welfare states (Yeates and Main, 2008). Nor is inclusion of the nebulous and scientifically unrecognizable term 'distress' useful to encourage more holistic investigation of the broad range of specific negative experiences possible (Beausoleil, 2017).

Other theoretical benefits of the Five Domains model are as follows:

1. The Five Domains model recognizes degrees of welfare compromise (negative impacts) or enhancement (positive impacts) versus the absolute ideal states outlined in the Five Freedoms. Although not the original intent, the Five Freedoms can easily be interpreted as binary, with good welfare only achieved if an animal is completely free from all negative experiences (and free to express normal behavior) and any deviation from total freedom resulting in bad welfare. This is neither a realistic expectation of any person responsible for animals nor is it an accurate depiction of animal life in a human-managed or a wild environment. It is also feasible that animals whose 'freedoms' are in some way constrained might have acceptable or even good welfare.

2. The Five Freedoms fails to acknowledge that it is undesirable for animals to be completely free of some negative experiences. These are the 'survival-critical' experiences that drive behaviors that keep animals alive, including thirst to seek water, hunger to seek food, breathlessness to avoid/escape respiratory impairment, and fear to avoid threats like predators. What is desirable is for animals to be *free of chronic, frequent, or extreme intensities* of these survival-critical negative experiences.

3. The structure of the Five Domains model allows for and encourages a level of detailed assessment that reflects

current scientific understanding of animal welfare. The model is flexible and draws on evolving knowledge of animal behavior, physiology, and affective neuroscience to inform cautious inference of an animal's mental experiences and welfare state.

4. The latest versions of the model (Mellor et al., 2020) facilitate consideration and evaluation of both positive and negative affective experiences relevant to an animal's welfare status and how these might be integrated to gain a holistic understanding of animals' welfare states (Mellor and Beausoleil, 2015).

5. The "Freedom to express normal behavior" in the Five Freedoms may be problematic. For example, many normal behaviors indicate negative affective experiences (see discussion by Learmonth, 2019). In addition, this objective does not provide a specific mechanism for considering *how* we can provide opportunities for animals to have positive experiences.

6. The Five Domains model has wider applicability to more species of animals, both wild and domestic. The original Five Freedoms were developed specifically to address the effects of husbandry practices on the welfare of intensively produced farm animals. This limits its applicability to other situations e.g., the welfare of wild animals, which are not and cannot survive free of most of the ideal states listed in the Five Freedoms (Mellor, 2016).

While the Five Domains model provides additional opportunities and scientific advantages over the Five Freedoms as a framework for evaluating animal welfare to support auditing and assurance schemes, there are inherent risks associated with its application for practical assessment that warrant consideration. In reality, these risks are likely to apply to any theoretical model for animal welfare assessment.

## 3.3 Key considerations for operationalizing the Five Domains model for practical welfare assessment in livestock industries

The authors' collective experience of practical welfare assessment across various livestock production systems and the application of the Five Domains model in the contexts of zoo and pest animal welfare highlights key caveats and considerations for operationalizing the model. These relate to the underlying philosophy and focus of the model on affective states and the implications for interpretation of any outcomes, the validity of evidence used to infer those experiences and overall welfare state, and the identification and relative grading of impacts (leading to negative experiences) and enhancements (leading to positive experiences).

### 3.3.1 Inference of affective experiences is subjective

Mental or affective experiences are, by definition, internal and subjective, and thus, cannot be directly assessed or measured.

Consequently, application of models that put ultimate relevance on animals' affective experiences for understanding their welfare states (i.e., affective state orientation) hinges on cautious inference of such mental experiences from various indicators that are observable or measurable (Dawkins, 2001; Weary et al., 2017; Weary and Robbins, 2019; Siniscalchi et al., 2021).

For some scientists and producers, the need for subjective interpretation of evidence in terms of animals' mental experiences is uncomfortable or unnecessary for practical welfare assessment. For example, there may be concerns about anthropomorphism and the attribution of specific mental experiences to animals with no such capacity for them (Green and Mellor, 2011; Serpell, 2019). In such cases, this could lead to over-estimates of the impacts of human systems or management on animal welfare, which might make production systems impractical or impossibly costly.

However, such concerns about focusing on animals' affective experiences are inconsistent with widely accepted principles outlined in law and science-based policy around the world that state or imply that some non-human animal species *do* have the capacity for some affective experiences, i.e., that they are sentient. Examples of such documents include the European Union *via* the Treaty of Lisbon (2008), French Civil Code (2015), New Zealand Animal Welfare Act (2015), Australian Capital Territory Animal Welfare Act (2019) and OIE Global Animal Welfare Strategy (2017). Denying the significance of the animal's own experiences to its welfare raises the question: why include *only* animals considered capable of affective experiences in animal welfare legislation if we are not ultimately interested in their feelings? (Weary et al., 2017).

There is also growing scientific and legal recognition that sentient animals may be physically healthy and functional but have poor welfare nonetheless due to a predominance of negative experiences such as fear or frustration in their lives (Duncan and Petherick, 1991; Ledger and Mellor, 2018). In addition, a sole focus on measures of productive function is likely to be misleading when domestic animals have been subject to strong genetic selection for productivity (Hartcher and Lum, 2020; Littlewood and Beausoleil, 2021). In such situations, reliance on physical functioning alone to understand welfare state could lead to under-estimates of the impacts of human systems or management. Related to this, assessments that emphasize the importance of mental experiences may result in greater weight being given to welfare outcomes in some regulatory environments (Beausoleil et al., 2018).

Some concerns about the affective state orientation of the Five Domains model are warranted, and the assumptions underpinning inferences of mental experiences should be rigorously evaluated before application of the Five Domains model for any animal. Not all animals are considered capable of welfare-relevant affective experiences, and the onus is on the user to justify inferences of specific mental experiences for the taxon and/or developmental stage being assessed, as well as to demonstrate the validity of the indicators considered to reflect those experiences (Beausoleil and Mellor, 2017; Harvey et al., 2020). For example, while it would be possible to apply the Five Domains model to assess the welfare of insects, these animals are not currently considered sentient in any

legislation and the scientific evidence to support their capacity for affective experiences is not yet sufficient to support such evaluation (Lambert et al., 2021).

Even for taxa already considered to be sentient, including all mammals and birds in most jurisdictions, caution is required when inferring specific mental experiences relevant to welfare state. For example, there is still a need for research focused specifically on the neurophysiological capacity of poultry for experiences such as breathlessness to accurately understand the impacts of carbon dioxide stunning on their welfare (Steiner et al., 2019; Beausoleil et al., 2021). However, there are ways to improve confidence in the validity of inferred affective states and welfare status as they relate to observable indicators.

In humans, those indicators can be directly validated by asking the person what they are experiencing when they express the indicator or when they find themselves in conditions suspected to give rise to the affective experience of interest. In non-human animals, validation of indicators of affect and welfare state relies on various factors. These include: a) scientific understanding of the cause and effect of disease, dysfunction or disruption to the animal's internal physical state or behavior, b) consistency among a variety of different indicators, such as expression/presence of behavioral and physiological measures, in the same situation, c) understanding of the nervous system pathways leading from sensory inputs to the generation of specific mental experiences such as pleasure, pain, fear or breathlessness, and d) the effects of actions known to cure the disease, resolve the internal dysfunction or disruption, remove the external stimulus or restore normal behavior (Dawkins, 2001; Weary et al., 2017; Steiner et al., 2019). This kind of validation requires long-term investment in fundamental animal welfare research, which can be conceptually and financially challenging; as a result, systematic validation of welfare indicators used in practical assessments is still relatively rare, particularly for positive affective experiences (Beausoleil and Mellor, 2017).

Even after addressing these technical issues, concerns may remain because the process of inference requires interpretation of evidence by human observers and is thus inevitably open to personal and systematic bias. In the first instance, the type and/or intensity of experiences inferred from measurable indicators will be influenced by what the person or group believes the particular species and/or life-stage is capable of experiencing (e.g., Mellor, 2018). Further, the significance assigned to an animal's experience is entirely subjective and will vary from person to person and among groups – one person might think severe pain for a short time is worse than moderate nausea for a long time, but another may have a different view (Beausoleil and Mellor, 2015a). These are not questions that can be resolved by scientific investigations, and there is unlikely to be a universally acceptable answer.

One way to address concerns about the subjective nature of inferring affective states is to ensure that the appropriate expertise is available for developing and applying a practical assessment tool based on the model. For example, evaluations of the impacts of control tools on the welfare of pest animals using the Sharp and Saunders Humaneness Assessment Model are usually undertaken by a diverse panel of experts, including those with knowledge of

veterinary medicine, toxicology, the ethology and ecology of the species being assessed, the in-field practicalities of the control method as well as the model's philosophical basis and general principles of animal welfare science (Baker et al., 2022). General consensus is developed among panelists about the type, intensity, and duration of the animals' mental experiences through detailed discussion of the available evidence. While there is always a risk of 'group think' influencing such processes, presenting clear justification for the inferences made and the panel's confidence in the scientific support for those inferences will likely enhance confidence in the validity of the welfare outcomes of the evaluation (Beausoleil et al., 2022).

### 3.3.2 Outcomes of welfare assessments based on affective states should be qualitative

Another way to allay concerns about subjectivity is to acknowledge and ensure that the outcomes of practical assessments using models such as the Five Domains remain qualitative. For some, the inherently qualitative nature of assessments undertaken using the model is problematic. However, acknowledging the model's focus on the affective state, it becomes clear that qualitative outcomes are most appropriate; while *some* indicators can be precisely measured and/or quantified, the affective experiences considered most relevant to welfare state cannot (Beausoleil and Mellor, 2015a). One cannot, for instance, quantify pleasure or suffering experienced in animals; indeed, this remains infeasible even for humans. Reflecting this, the existing operational versions of the model deliberately use qualitative scales to evaluate the relative degree of compromise or enhancement of animal welfare state. For example, the Sharp and Saunders model uses ordinal (mild to extreme) rather than interval scales to assign impact scores in each Domain to ensure that the qualitative nature of the assessment is explicit (Beausoleil et al., 2022). Similarly, the ZAA tool grades are reported as positive, negative and neutral/ambiguous findings in each Domain. While numerical or alphabetical scoring systems can and have been used for Five Domains assessments (e.g., Beausoleil et al., 2016), it should be made clear that the grades assigned are relative only (i.e., they reflect relative ranks of the options being compared) and scoring precision should not be implied where it is not genuinely possible (Beausoleil and Mellor, 2015a).

An alternative to qualitative grading involves using expert judgement to generate numerical values representing the relative importance of various features relevant to welfare. For example, experts in one study indicated that the size of a farrowing pen was not considered to be very important for piglet welfare (score 1/5) but was very important for sow welfare (score 4.4/5) (Sandøe et al., 2020). Moreover, expert-generated values can be used to represent the relative acceptability of different versions of those features. In the same study, a farrowing pen providing 3m$^2$/sow was considered by experts to represent minimum welfare for sows (score 1/10) while a 10m$^2$ pen with outdoor access was ranked as the best possible welfare for sows of the options provided (score 8.8/10) (Sandøe et al., 2020). This approach facilitates quantitative aggregation of different resources or conditions considered to be

relevant to welfare, creation of ranks based on the overall aggregated scores, and inclusion of these numerical welfare scores into broader calculations (such as the effects of law and private initiatives on a country's overall pig welfare). Such quantification to facilitate the aggregation of the separate dimensions of welfare may be desirable for the purposes of auditing and the weighting of different features. It also allows acknowledgement that some dimensions have greater impact on welfare state than others. However, there are both ethical and practical challenges associated with aggregation (Sandøe et al., 2019). For instance, expert judgements may be systematically biased (e.g., by beliefs about feasible animal management systems) and numerical aggregation may be taken to imply precise grading of affective states, which is not possible at this time. To avoid the problems associated with the quantification of the affective state requires acknowledgement that the assessment of the animal's experience is inherently qualitative and most important. The application of qualitative scoring systems within the Five Domains model provides a more realistic picture of the welfare outcome for an animal or group of animals within a production system. The model also allows for indicators of welfare that lend themselves to quantification and thus, can contribute to a welfare assessment.

### 3.3.3 Assessment of welfare risk and actual welfare impacts rely on different indicators and provide different insights about welfare

The Five Domains model can be used for two distinct purposes: first, it can be used to assess the *risks* to welfare state associated with placing animals in specific environmental or social conditions or with applying particular management practices; second, it can be used to evaluate the *actual* welfare impacts occurring in those conditions or due to those practices (welfare status). It is important to differentiate between these and to limit the conclusions drawn to those appropriate for the type of assessment.

Welfare risk assessments rely mainly on resource/management-based indicators while assessments of actual impacts require animal-based indicators. Resource/management-based indicators include the available space, physical features of the environment, the character of human handling, familiarity of routines, noise, and presence of dominant or congenial conspecifics, to name a few. These are also called 'welfare alerting' indicators (Harvey et al., 2020) as they call our attention to conditions or practices which have the *potential* to influence the welfare state of the animals.

Risk or likelihood can be evaluated for both negative experiences (welfare impacts/compromise) and positive experiences (welfare enhancement). However, there is a real possibility of circular logic if such evaluations are not understood to be, and explicitly named as, 'risk' assessments. To illustrate – not every individual animal kept in the same environment will have or express evidence of the same experience and welfare state. The presence of a sharp corner on a pen represents increased risk/likelihood of injury to animals kept in that pen but without animal-based evidence of injury, it would be inappropriate to conclude that all animals in the pen experienced injury-related pain. This becomes particularly important when evaluating welfare at the group or

population level – for example, when trying to estimate the proportion of a population experiencing a particular welfare impact in different management systems (NAWAC, 2022). If physical features of the system (i.e., resourced-based indicators) alone are used to infer welfare impacts, the system itself becomes the definition of welfare state for all animals managed within it.

This potential problem becomes even more obvious when we consider 'risk' of positive experiences and welfare enhancement. Understandably, most evaluations of welfare enhancement to date have relied on 'provision of opportunities for positive experiences' (i.e., resource-based indicators such as space, presence of natural materials, toys, conspecific age-mates) rather than on validated animal-based indicators, which are still scarce (Edgar et al., 2013). However, the presence of opportunities alone does not indicate how many individuals in the group use them to generate positive experiences or how long-lasting and meaningful those experiences are (NAWAC, 2022). Observation of animal-based indicators such as frequency, duration, and character of behavioral interactions with resources is required to understand the degree to which welfare in the population is enhanced.

Most Five Domains evaluations published so far apparently represent welfare risk assessments (e.g., Littlewood and Mellor, 2016; McGreevy et al., 2018; Mellor and Burns, 2020), although some explicitly differentiate indicators of welfare risk and welfare status (e.g., Boys et al., 2022). Welfare risk assessments are a valuable component of improving farm animal welfare – they alert us to those features of animal management that should be investigated further. However, without further scientific justification, they are not sufficient to draw conclusions about animal welfare impacts or enhancements. To ensure that conclusions about the detrimental or enhancing effects of conditions, resources and management practices on welfare state are robust and justifiable, a body of evidence linking welfare-alerting indicators to animal-based indicators should be provided or its collection prioritized before any assessment protocol is implemented (Beausoleil and Mellor, 2017). Thus far, examples of Five Domains assessments that link welfare-alerting indicators with animal-based measures to evaluate *actual* welfare impacts have been limited to the effects of various lethal control tools for possums (Beausoleil et al., 2016) and rodents (Baker et al., 2022).

### 3.3.4 Integrating assessments of negative and positive experiences to holistically understand welfare state

As the focus on the importance of positive experiences for acceptable animal welfare and the ability to scientifically recognize positive states in animals progress (e.g., Beausoleil and Mellor, 2015a; Beausoleil and Mellor, 2015b; Rault et al., 2020; Mellor et al., 2020; Keeling et al., 2021), a remaining challenge is how to integrate information about negative and positive experiences to holistically understand and represent welfare state. To date, only a few attempts have been made to develop integrated protocols for overall welfare assessment (e.g., Edgar et al., 2013; Keeling et al., 2021). Notably, the Welfare Quality protocol aims to incorporate evidence of a positive welfare state through the inclusion of the Qualitative Behavior

Assessment (QBA) principle component 1 made at the group level. QBA involves assessors intuiting animals' current emotional state based on observation of their behavior and demeanor (Andreasen et al., 2013). While high inter-observer agreement supports the validity of QBA as a holistic reflection of animals' state, it was not found to correlate with indicators of other dimensions of welfare (Andreasen et al., 2013) and how the results are aggregated with these other dimensions to understand overall welfare state is not clear (Sandøe et al., 2019).

One attempt has been made to integrate positive and negative experiences by applying the Five Domains model. As suggested by Mellor and Beausoleil (2015), the authors of a recent Five Domains comparison of sow and piglet welfare in different management systems found it necessary to apply and report different grading systems for impacts (reflecting negative experiences) and enhancements (reflecting positive experiences) (NAWAC, 2022). Although a single integrated 'outcome' was not considered appropriate, this separate approach to grading facilitated methodical and transparent comparison of the relative likelihood of impacts and enhancements across management systems.

Key considerations for future development of integrated grading systems include: what is actually being evaluated and its significance to welfare/quality of life, e.g. short-term positive emotion or long-term positive mood (Rault et al., 2020; Keeling et al., 2021); variability in what is perceived as an opportunity for positive experience among individual animals; evaluating utilization of resources for positive experiences (animal-based measures) versus just opportunities provided for such experiences (resource-based/alerting measures – see Section 3.3.3); the inability of animals to utilize available opportunities for positive experiences if they are experiencing significant negative experiences such as fear, pain or debility (Mellor and Beausoleil, 2015); how to aggregate positive and negative affective experiences of different qualities, intensities and durations (Sandøe et al., 2019); and how much positive experience is sufficient to achieve acceptable welfare in farm animal production systems (Edgar et al., 2013; Keeling et al., 2021).

## 4 Implementation of the five domains model for supply chain management of animal welfare

As US food companies work toward continuous improvement of animal welfare practices in the supply chain, the need for comprehensiveness, scientific justification, transparency, focus on animal experience and facility for ongoing improvement in audit programs is growing. Food companies have developed and publicly announced corporate social responsibility (CSR) commitments to animal welfare and have integrated assurance and audit requirements into their specifications that must be met for doing business. CSR initiatives are marketed to stakeholders through public-facing annual reports that seek to promote a positive corporate image by demonstrating that they are upholding their commitments (Fuoli, 2018; Thottoli, 2021). One means by which food supply companies have worked to assure their stakeholders

about animal welfare is through the use of regular audits. Auditing is commonly used by corporations to demonstrate compliance with a set of recognized standards. Originally developed to assess financial integrity and accountability as part of a total quality management scheme (Karapetrovic and Willborn, 2001), audits have been adapted for other purposes including food safety, environment, and as previously noted, animal welfare.

Given public expectations of ethical treatment of animals, including those used for food (Widmar et al., 2018), robust animal welfare programs and related audits are necessary (Sun et al., 2021). Ideally, a company's animal welfare program would reflect a holistic approach to identifying and managing the myriad factors that influence animal quality of life or experience. These would include the elements captured in Domains 1-4 of the Five Domains Model (Environment, Health, Nutrition and Behavior) as well as the management practices used by the business. Audits permit measurement and management of the outcomes intended to be achieved by the welfare program. Thus, they must be carefully designed and tailored to meet the program's goals. Significant and continuous improvement of animal welfare cannot depend simply on a checklist of minimum requirements against which compliance can be gauged. This approach typically lends itself to the setting of a "lowest common denominator" threshold and pass/fail results. Karapetrovic and Willborn (2001) noted that under these audit conditions, breakdowns typically occur between the 3rd party auditor's issuance of a report to the client and what the client actually does with the report. Under this scenario, little progress is made, and improvement stagnates. Consequently, these authors have advocated for a systems approach, wherein audits are dynamic, adaptive, composed of interrelated elements that external auditors understand. Furthermore, audits that are only viewed as a compliance tool used to determine whether a standard is met, overlook the value of an audit in assessing whether the standard itself is suitable or effective. Since the publication of Karapetrovic and Willborn's (2001) paper, a systems approach has been widely implemented across most of the business world. It has also become an expectation for the conduct of agricultural, environmental, and other types of scientific research. However, farm animal welfare assurance and auditing programs are relatively new as compared to those established for the financial sectors, and in some cases, they suffer from a "check-the-box" approach to auditing and a lack of fully validated indices for animal outcomes (Krueger et al., 2020).

As scientists are increasingly involved in guiding individual corporate and broader industry efforts to set higher levels of responsibility throughout the food supply chain, their expertise has advanced understanding of how businesses can adapt audit practices to assess and assure the continuous improvement of animal welfare in the field and within a heterogeneric supply chain. Scientific collaboration is critical since animal welfare standards must be evidence-based, effective, relevant, and subject to change. The assessment and auditing practices should be efficient to avoid undue burden, easy to use, and effective in demonstrating welfare outcomes for animals (Rushen et al., 2011; Escobar and Demeritt, 2017; Grandin, 2021). These demands notwithstanding, audits must be based on what can actually be evaluated and this is likely to be somewhat limited. Therefore, the frameworks

underlying field-applicable welfare assessment tools must lend themselves to being operationalized into suitable welfare standards for which related audits can be developed.

Not only must the framework used be able to be operationalized, it ideally should facilitate welfare 'scoring'. As is the case for research-based welfare assessment tools, scoring criteria must be valid and sufficiently reliable (Meagher, 2009; Mugenda et al., 2019) as to avoid undue concerns about observer subjectivity and situational variation in animal responses (Kaufman and Rosenthal, 2009; Bauer et al., 2017).

Finally, it is the interpretation of what is measured that is of importance when considering implementing the Five Domains model. It is not necessarily just about what is measured but how it is organized (so as to be comprehensive) and interpreted, how poor scores/assessments/failures are responded to, and how much importance is given to the animals' (and the individual animal's) experiences. For example, it is possible to measure some of the same items in an audit and not ever interpret them in terms of animal welfare, but rather for productivity e.g., carcass damage, mortality, and feed intake. With these criteria in mind, the Five Domains Model has strong potential to serve as 1) a working framework that can be operationalized in the field, 2) an important training resource for field auditors and managers to understand the interrelatedness of elements within the audit system, and 3) for building effective auditing tools and standards that can demonstrate outcomes and the continuous improvement of animal welfare.

## 4.1 Animal scoring systems

There are three general categories of measures on which animal welfare audits can be comprised: resource-based, management-based, and animal-based measures (see review by Grandin, 2021). Resource and management-based measures often entail the review of documentation of protocols, procedures, and practices followed, or they require that certain specifications have been met in the case of provisioned resources. Space allotments, food and water are resources that can be specified for a given facility and correspondingly scored in an audit. Preventative health programs, the training of employees, and emergency management plans, are examples of documentable management practices. Animal-based measures focus on the outcomes for the animal while living in its environment. Such measures include the physical or behavioral characteristics of the animal. These are often categorized using scores that are taken to reflect acceptable to poor welfare. Examples of physical animal-based measures include feather cover and cleanliness, lesions and wounding, lameness, hair coat condition, and body condition. Behavioral measures may include outcomes of human approach scoring or fear testing, vocalization, slipping and falling, playing, standing, or resting quietly, huddling when cold or panting when hot, indicating thermal discomfort.

While some audits focus primarily on one or more categories (usually non-animal-based measures), ideally, a comprehensive audit would include all three types of measures. The measures chosen for welfare benchmarking may vary depending on the type of facility or food supply chain segment of focus. Animal-based

measures, such as body-condition, lameness, and evidence of comfort (e.g., resting quietly) can and should be incorporated throughout every stage of production (e.g., in the case of broilers: hatching, rearing, grow-out, catching, transport, and slaughter). However, certain resource-based measures (e.g., provision of enrichment) may be more applicable to on-farm welfare assessment than to auditing during transportation and processing, where such provision is neither practical nor likely to be used by animals. Likewise, some management-based specifications (e.g., documentation of employee training or standard operating procedures for monitoring of animals) may apply across the supply chain. Regardless of which categories of measures are chosen for auditing purposes, what is most important is that they are tied to validated metrics that can give a clear and comprehensive sense of the animals' mental experiences (positive and negative). In so doing, the audits may facilitate the client's understanding of which factors, including resources and management practices yield better or worse outcomes for animals. Subsequently, developing or re-examining existing animal welfare requirements and associated audit tools through the lens of the Five Domains model may yield important insights related to continuous improvement of animal welfare. The New Zealand SPCA Certified® Standards provide an example of an existing auditing scheme for meat chickens (free range) structured around the Five Domains, including a mixture of resource, management and animal-based measures and indicating when achieving the standard or recommendation would provide positive mental experiences for birds (available at https://www.spcacertified.nz/standards/farmed-animals/free-range-chickens).

Examining a business' animal welfare standards and developing or revising related audits with respect to the Five Domains may be daunting, especially given the model's emphasis on animals' affective experiences. Some might presume such an exercise requires entirely discarding auditing practices and measures that are well established and practical. This has been a key concern voiced by those contemplating the ramifications of changing the philosophical basis of animal welfare regulation, but it could also be viewed as an opportunity for improved clarity and justification in welfare compliance systems. In fact, the actual indicators used to assess animal welfare state (or audit systems) do not necessarily have to change from the ones used under other frameworks such as the Five Freedoms. Rather, the use of the Five Domains model demands that greater emphasis be put on what each of the indicators tells us about the animal's experience of its own life – in a sense reframing the interpretation of existing measures. This should be an explicit part of selecting/testing indicators to include in assessment protocols and when considering the priority/weight different indicators have for understanding/safeguarding overall welfare.

One area that may create foreseeable challenges for those attempting to transition to auditing based on the Five Domains Model relates to management-based specifications. While these practices certainly influence animal welfare, and thus, are typically scored in some manner, they generally do not correspond directly to any of the Five Domains. However, this does not present a problem. Each of these elements can be categorized and scored independently of the resource- and animal-based measures so that they remain properly integrated into the audit without effort to 'shoe-horn' them into domains in which they do not fit. Table 1 uses an abbreviated version of the National Chicken Council's (NCC) broiler welfare guidelines and audit checklist (NCC, 2022) to illustrate how the required audit

TABLE 1 Example of how a selection of abbreviated measures from the National Chicken Council audit (2022) for processing operations might be categorized. Audit areas are categorized according to their corresponding physical domains (Nutrition; Environment; Health; Behavior) and type of measure [(resource-based (RB); management based (MB); animal-based (AB)]. Note other parties might assign items to the respective domains differently. Justification of such categorization is what is most important, along with ensuring that items are not missed or double counted.

| Audit requirement | Domain | Measure Type |
| --- | --- | --- |
| Verify shackling area consists of adequate space, lighting, and air quality. | Environment | RB |
| Ensure shackles are well-maintained. | Environment | MB |
| *Ensure that shackles are properly-sized so that birds can be shackled w/o causing visible injury. | Health | MB & AB |
| A bird being visibly injured during shackling is a major non-conformance and an **audit failure** | Health | AB |
| Evaluate bird comfort shackling to stunning. Observe bird activity to ensure compliance. | Behavior | AB |
| *Verify that the equipment is functioning properly and birds are being rendered insensible. | Health | MB & AB |
| *Verify automatic knife is effectively cutting blood vessels to induce a rapid bleed-out. | Health | MB & AB |
| Confirm backup employee post automatic knife to bleed-out birds not killed. | Health | MB |
| Evaluate 500 birds after the picker to ensure that no live birds entered the scalder | Health | AB |
| *Ensure the company has a monitoring program in place to monitor wing and leg injuries. | Health | MB & AB |
| Evaluate 500 birds for broken or dislocated wings immediately before or after the stunner. | Health | AB |
| Evaluate 500 birds for leg injuries as outlined in the guidelines after scalding and picking | Health | AB |
| Evaluate a random sample of 100 birds (200 paws) at the plant for footpad health. | Health | AB |

*As written, these items are both management-based and animal-based measures. The requirement for equipment verification and a monitoring program are management requirements, while the direct animal observations yield animal-based outcomes.

areas might map onto each of the four physical/functional Domains that ultimately inform understanding of the animals' mental experiences.

Given the centrality of mental experiences to quality-of-life assessment, any model used as the basis for animal welfare auditing must account for animals' affective or emotional states. However, inability to quantify these states through direct indicators is likely to cause apprehension for farm and abattoir staff as well as auditors. Consequently, one of the biggest challenges for those considering the Five Domains as the basis for animal welfare assurance is likely to be how to 'calculate' the valence (positive or negative) and strengths of effects in Domains 1-4 on Domain 5 (Mental State). While theoretically it might seem feasible to assign and sum numerical scores in these areas to obtain an overall 'score' for Mental State, from a practical standpoint, the relative weightings the audit tool assigns to each area (assuming all scorable Domains are represented) are likely to complicate such calculations. Further, the basis for the weightings themselves would require a transparent scientific basis and consensus. For these reasons, a simpler and potentially more useful approach might be to visually illustrate the relative impacts of each area on the total score to gauge where there are better versus worse outcomes and identify in which domains improvement should be targeted (see Figures 3, 4). Figure 3A demonstrates how this approach might inform an organization, in this case the NCC, about the audit point distribution among the

animal welfare measure types (resource- based, management-based, animal- based), and (Figure 3B) by using the different domains (nutrition, health, environment and behavior). Figures 4A, D uses heat maps to illustrate the scores obtained in a hypothetical audit scenario based on the number of points allocated to each corresponding item of the NCC 2022 guidelines and audit for the grow-out (i.e., rearing) and catching/transport stages of the poultry chain.

## 4.2 Applying the Five Domains model to auditing: benefits and limitations

Because the Five Domains model explicitly links observable/measurable indicators of welfare to the animal's affective state, it offers opportunities to clearly visualize how the individual effects of the different domains collectively shape the animal's mental experience. For example, it may be feasible to represent the degree of qualitative negative impacts on the animal or support for positive affective states through generating heat maps based on the number of points allocated in the audit to the required areas (see Figure 3). This type of representation of the audit outcomes may permit visualization of where improvement is needed in areas of negative impact without the need for introducing detailed measurements of the affective state domain that are neither
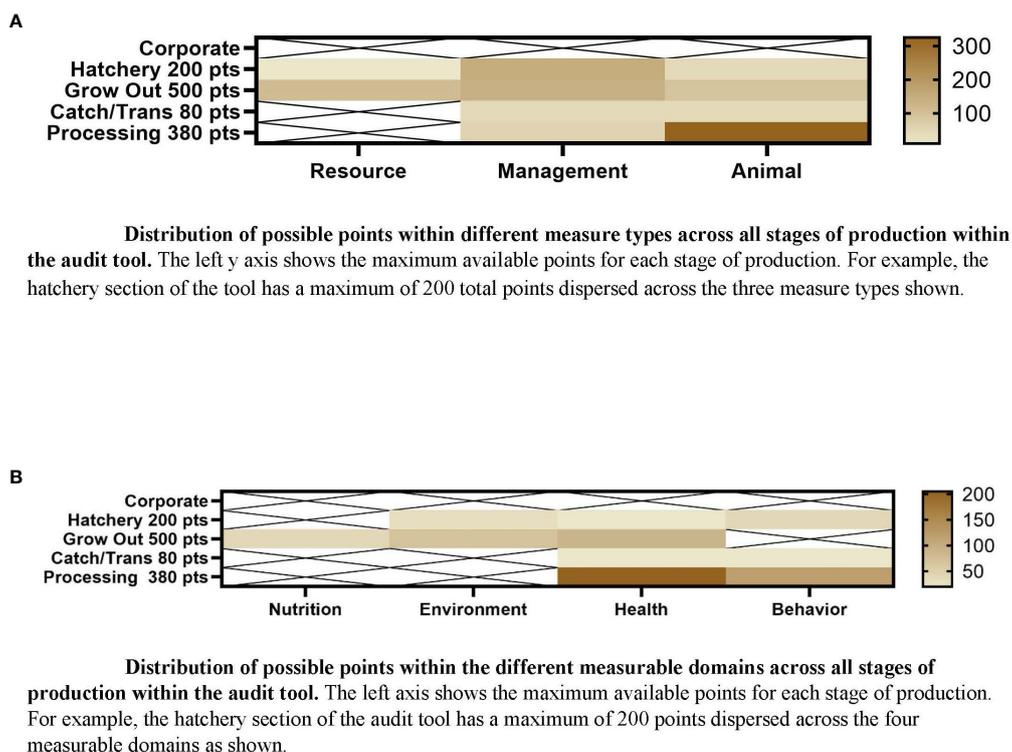


**Distribution of possible points within different measure types across all stages of production within the audit tool.** The left y axis shows the maximum available points for each stage of production. For example, the hatchery section of the tool has a maximum of 200 total points dispersed across the three measure types shown.



**Distribution of possible points within the different measurable domains across all stages of production within the audit tool.** The left axis shows the maximum available points for each stage of production. For example, the hatchery section of the audit tool has a maximum of 200 points dispersed across the four measurable domains as shown.

FIGURE 3
**(A)** Distribution of possible points within different measure types across all stages of production within the audit tool. The left y axis shows the maximum available points for each stage of production. For example, the hatchery section of the tool has a maximum of 200 total points dispersed across the three measure types shown. **(B)** Distribution of possible points within the different measurable domains across all stages of production within the audit tool. The left axis shows the maximum available points for each stage of production. For example, the hatchery section of the audit tool has a maximum of 200 points dispersed across the four measurable domains as shown.
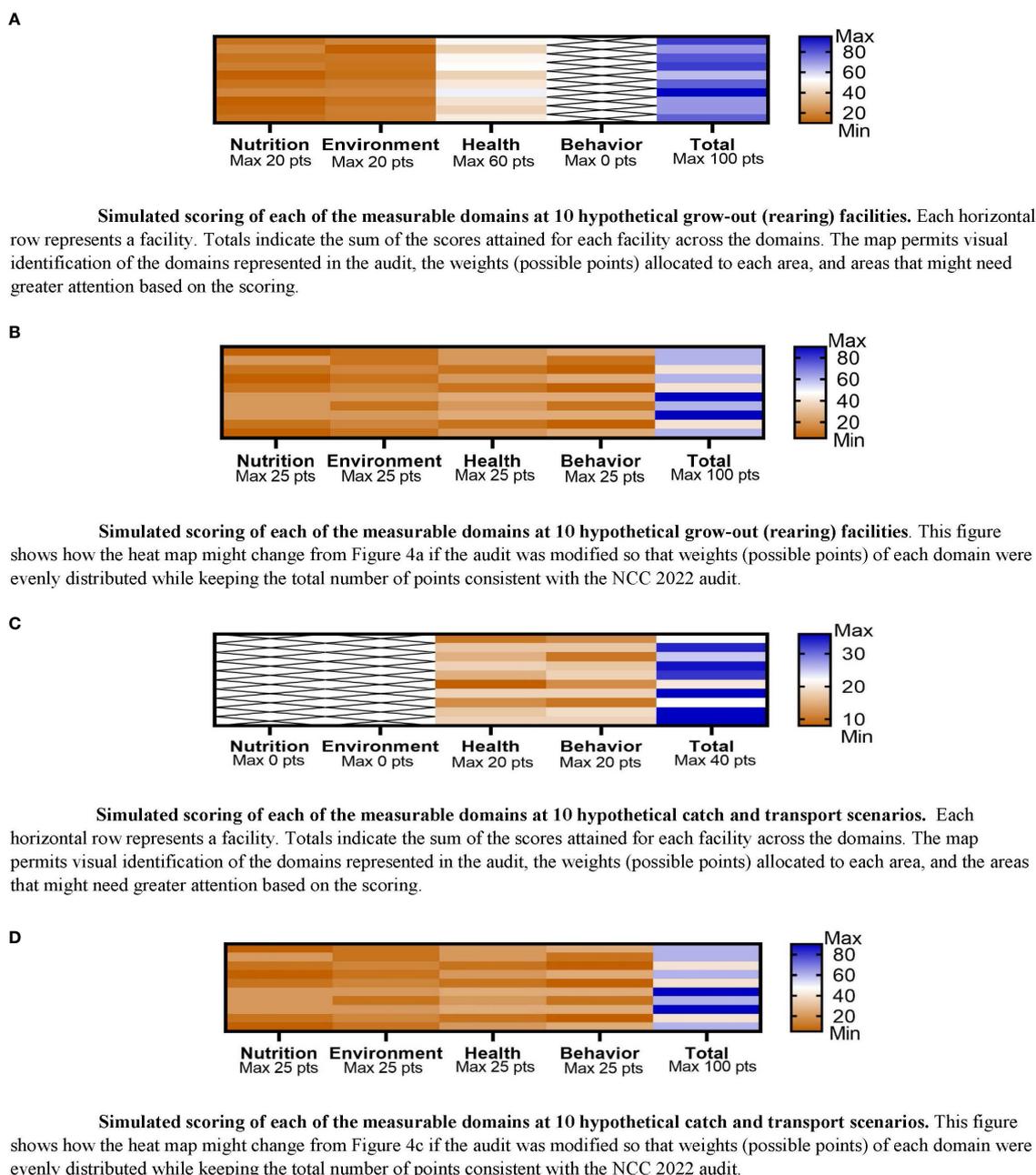
**A**



**Simulated scoring of each of the measurable domains at 10 hypothetical grow-out (rearing) facilities.** Each horizontal row represents a facility. Totals indicate the sum of the scores attained for each facility across the domains. The map permits visual identification of the domains represented in the audit, the weights (possible points) allocated to each area, and areas that might need greater attention based on the scoring.

**B**



**Simulated scoring of each of the measurable domains at 10 hypothetical grow-out (rearing) facilities**. This figure shows how the heat map might change from Figure 4a if the audit was modified so that weights (possible points) of each domain were evenly distributed while keeping the total number of points consistent with the NCC 2022 audit.

**C**



**Simulated scoring of each of the measurable domains at 10 hypothetical catch and transport scenarios.** Each horizontal row represents a facility. Totals indicate the sum of the scores attained for each facility across the domains. The map permits visual identification of the domains represented in the audit, the weights (possible points) allocated to each area, and the areas that might need greater attention based on the scoring.

**D**



**Simulated scoring of each of the measurable domains at 10 hypothetical catch and transport scenarios.** This figure shows how the heat map might change from Figure 4c if the audit was modified so that weights (possible points) of each domain were evenly distributed while keeping the total number of points consistent with the NCC 2022 audit.

FIGURE 4
**(A)** Simulated scoring of each of the measurable domains at 10 hypothetical grow-out (rearing) facilities. Each horizontal Tow represents a facility. Totals indicate the sum of the scores attained for each facility across the domains. The map permits visual identification of the domains represented in the audit, the weights (possible points) allocated to each area, and areas that might need greater attention based on the scoring. **(B)**. Simulated scoring of each of the measurable domains at 10 hypothetical grow-out (rearing) facilities. This figure shows how the heat map might change from Figure 4A if the audit was modified so that weights (possible points) of each domain were evenly distributed while keeping the total number of points consistent with the NCC 2022 audit. **(C)**. Simulated scoring of each of the measurable domains at 10 hypothetical catch and transport scenarios. Each horizontal row represents a facility. Totals indicate the sum of the scores attained for each facility across the domains. The map permits visual identification of the domains represented in the audit, the weights (possible points) allocated to each area, and the areas that might need greater attention based on the scoring. **(D)**. Simulated scoring of each of the measurable domains at 10 hypothetical catch and transport scenarios. This figure shows how the heat map might change from Figure 4C if the audit was modified so that weights (possible points) of each domain were evenly distributed while keeping the total number of points consistent with the NCC 2022 audit.

validated nor reliable. Furthermore, this approach may help to refocus attention where it needs to be - emphasizing the spirit of continuous improvement of animal welfare rather than on scores that in some cases may be subjective or arbitrarily assigned, particularly in Domain 5 (mental experience), which cannot be directly measured.

A Five Domains approach could also result in improved visualization of the interrelated nature of the domains and their

collective impacts on affective state, bringing industry understanding and approaches in line with growing scientific consensus. For instance, clear representation of the domains could be used by those designing standards and audits to enhance the quality of welfare assessment through identification of where some domains may be over- or under-represented. The corresponding weight attributed to each domain in audit scoring and related benchmarking could then be more transparent, offering greater opportunity to review and improve audit tools (and outcomes) as necessary to more equally represent each domain that is scored. For example, based on the information presented in Figures 3, 4, it would be feasible to evaluate the relative number of points allocated to each of the Five Domains to better understand how much weight each area is given. This would aid in visually representing relative progress in each area and in determining whether new or expanded criteria might be needed to achieve more balance across the different domains represented in the audit. Our intent is not to criticize the NCC broiler standards and audit. These standards and audit reflect the commendable on-going effort of an organization and scientists working together to meet public and corporate expectations for the assurance of continuous improvement in the welfare of broiler chickens in a diverse supply chain. Importantly, current deficits in scientifically validated animal-based outcomes play a role in how organizations cope with meeting these expectations through documenting and demonstrating improvements to animal welfare.

Another benefit is that the structure of the Five Domains approach allows identification of opportunities to incorporate new metrics for food producers by evaluating what can and should be measured across the various food chain sectors. Figures 3, 4 illustrate how simple visualization of the number of points allocated to items within an existing audit protocol can reveal where some types of measures may be over- or under-represented. This could lead to further discussion of ways in which more animal-based metrics, including behaviors that indicate positive and negative affective states might be incorporated to better gauge the animal's quality of experience. The more structured and transparent representation of welfare in the Five Domains may also facilitate more effective on-farm and abattoir training by enhancing staff understanding of what animal welfare is, how it is measured and why it matters, while also reinforcing the important notion of animal sentience. An illustration of the practical application of the Five Domains approach to assess animal welfare with emphasis on the quality of an animal's experience is demonstrated by the Zoo and Aquarium Association of Australia (ZAA, 2022).

Through relatively simple visual representations of the metrics used to gauge welfare within audits, caretakers and other personnel may more effectively learn and remember how resources and management practices impact the animals, and how their effects manifest in positive and negative animal-based outcomes, which collectively influence animal mental states. Indeed, this approach could help to incentivize humane handling on farms and in plants, which is critical for animal experience, worker safety and morale, and public trust. In turn, this could enhance the credibility and efficacy of CSR programs that speak to social and environmental stewardship, of which animal welfare is a key component. With

care, application of the Five Domains would allow retention of quantitative scoring of observable/measurable indicators in the four physical/functional domains while emphasizing qualitative interpretation of these scores in terms of the animals' likely mental experiences and avoiding unscientific, unreliable, or entirely subjective scores and conclusions.

Finally, an ability to draw clear connections between each of the Five Domains, what is measured in an audit, and how it affects decision-making about interventions on- farm and in abattoirs would permit better demonstration of continuous welfare improvement. Importantly, this could enhance transparency, accountability, and related customer, shareholder, and public engagement and communications. In fact, visually representing the outcomes of audits based on the Five Domains model along with progress made in each area could potentially facilitate communication with shareholders, consumers and other stakeholders interested in understanding how the company monitors and measures animal welfare. This could clarify which metrics, especially those that are animal-based, provide insight that guide a company's decision-making, such as what types of enrichments or other resources might be offered to animals at different stages of life. Translation of audit findings through graphics that are easy to understand by laypersons might offer a valuable opportunity for engagement with consumers, who are unlikely to be experts in animal welfare assessment but whose trust in various food chain corporations may be relatively low based on information gleaned from media and other public discussions (Widmar et al., 2018). Because improved communication with consumers and other members of the public on animal welfare is critically needed to retain support for animal agriculture, depictions of progress on related CSR commitments that are readily understood by laypersons may facilitate two-way dialogue and trust-building.

Some limitations of the Five Domains should be noted, however. Representing all of the measurable domains within an audit may be constrained in some stages of the food chain, such as during short-term holding/housing, as occurs at abattoirs. Here, indicators of welfare tied to provisioned resources may be fewer than those seen during the on-farm early rearing to weaning period or the post-wean grow out (rearing) phases of market animals simply because of constraints on what can be provided at the abattoir. Similar concerns might be applied to opportunities to capture many animal-based and resource-based outcomes during catching or transportation. Because this in turn limits the number of validated metrics relating to animal outcomes at these phases of production, the assessment of the mental state of the animal is dependent upon inferences drawn from the evaluations of the accrued risks identified in Domains 1-4, which can be problematic (see 3.3.3). Drawing inferences about the mental state of the animal requires professional training and judgement (i.e. an interdisciplinary expert group effort). Finally, there is a possibility that the Five Domains model, like any other welfare assessment system, could be misused to justify practices that on principle may be socially unacceptable. If risks to the animal are underestimated in Domains 1- 4 or are not properly validated with animal-based measures, and a biased perspective is applied to inferences about the

mental state (Domain 5) of affected animals, the final assessment of animal welfare could be skewed toward justifying a questionable practice.

A final consideration for the application of the Five Domains model for animal welfare assurance and auditing is the method of reflecting overall compliance for a company or facility. While multiple criteria approaches to welfare assessment are now considered gold standard, a simple way of reflecting overall welfare state or impacts on welfare is often desired to allow comparison across animals, groups or facilities, among procedures or management options or to map changes in welfare over time. Thus, ways of integrating individual indicators and types of measures (e.g., animal-based and resource/management-based) within a domain as well as ways of integrating impacts across various domains or dimensions of welfare for the individual animal are needed. In addition, ways to aggregate the welfare states of individual animals within groups, each of which may have different interactions with, and experiences of, the same conditions, compounds these challenges (Sandøe et al., 2019).

The methods chosen for aggregation have significant ethical implications and the process should be carefully considered and transparently represented (Sandøe et al., 2019). A key problem that has arisen in multi-criteria protocols, such as the EU's Welfare Quality®, relates to 'compensation', that is bad things happening to some animals in the group being covered up or offset in the overall calculus by avoiding other bad things or by something good happening to other animals (Veissier et al., 2009). This is a feature of many existing auditing programs and makes it clear that animal welfare cannot be understood as a simple additive function of various dimensions (Sandøe et al., 2019). One approach to address this particular problem is to use expert judgement to generate weightings of the relative importance of different measures or dimensions of welfare (Sandøe et al., 2020) but this has only been attempted to compare theoretical animal management systems (i.e., not as a direct check of compliance) and does not directly address the issue of inter-individual compensation. Including 'key indicators' or 'automatic fails' within the relevant domain can help address this problem to some extent by putting greatest weight on measures reflecting impacts of unacceptable severity. This is demonstrated by the NCC broiler welfare audit points, that if not met, result in an automatic failure.

Other issues relate to how negative and positive experiences should be aggregated (see Mellor and Beausoleil, 2015 for some discussion of this) and how evidence of welfare *risks* can be integrated with evidence of *actual* welfare impacts. One approach to this latter problem was an attempt to integrate information about the likelihood of an individual animal within a group experiencing the proposed specific negative or positive affect (using data from previous studies on the percentage of animals observed with physical or behavioral evidence of impact) with the predicted severity of that mental impact on welfare if it did arise (NAWAC, 2022). Others have opted to present non-aggregated information on various actual welfare impacts (current welfare status) alongside non-aggregated information on various welfare risks (welfare-alerting resource/management-based indicators and some animal-based indicators) (Harvey et al., 2020; Boys et al., 2022).

Ultimately, there is no 'morally neutral' or scientifically ideal way to aggregate multiple dimensions of welfare (Sandøe et al., 2019) and the ethical and practical challenges associated with aggregation will apply equally to operationalizing the Five Domains model for assurance audits. To date, aggregation in the few operational systems has not occurred, e.g., acceptable performance in each domain is required for accreditation (ZAA, 2022) or certification is based on meeting selected resource and animal-based standards in each of the four physical/functional domains (NZ SPCA standards). Careful thought should be given to the ways in which multiple indicators of different types (e.g., resource/management-based versus animal-based indicators) are integrated to provide an overall grading for each of the four physical/function domains as well as how the various resulting affective states should be aggregated in Domain 5 to understand the overall welfare state.

## 5 Conclusions

Translation of complex phenomena such as animal welfare into workable audit tools will always be imperfect, and the priority must be to produce meaningful measures that can be usefully and practically employed to facilitate ongoing improvements in production animal welfare. The Five Domains model more closely reflects current scientific consensus about the centrality of affective states in welfare assessment, while overcoming several highly problematic features of using the Five Freedoms as a basis for benchmarking. While it is important to acknowledge the need for caution around inferring mental states, operationalizing the Five Domains offers several opportunities to improve the breadth and quality of welfare audits for production animals. While many of the same indicators as previously related to Five Freedoms systems may be used, application of the Five Domains provides a transparent structure to encourage comprehensive assessment and is likely to reveal new metrics. The resultant focus on the affective state consequences of housing, handling and husbandry procedures could underpin cultural progress within organizations, by improving the effectiveness of training and providing a basis for more transparent communication about animal welfare with stakeholders, and an increasing use of animal-based indicators. As CSR programs become increasingly scrutinized, at the very least, adoption of a scientifically robust approach based on the Five Domains signals a strong acknowledgement of animal sentience and a commitment to more closely examine and manage the myriad factors that contribute to animals' overall welfare.

## Author contributions

CC conceived the paper, wrote, reviewed, and edited all drafts and is the corresponding and senior author. NB wrote, reviewed, and edited the paper and is the first author. JS and DM each wrote specific sections of the paper and contributed to the editing. All authors contributed to the article and approved the submitted version.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The handling editor LK declared a past co-authorship with the author JS.

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