Journal of the American Association for Laboratory Animal Science
Copyright 2023
by the American Association for Laboratory Animal Science

Vol 62, No 2
March 2023
Pages 123–130

Using Stakeholder Focus Groups to Refine the Care of Pigs Used in Research

Lois M Wilkinson,[1] Carly I O'Malley,[1] Erik Moreau,[1] Timothy Bryant,[2] Brian Hutchinson,[3] and Patricia V Turner[1,4,*]

Research organizations should be proactive in regularly evaluating and refining their animal care and use programs in order to advance animal welfare and minimize distress. Pigs are often used in research, but few empirical studies have examined optimal husbandry and research use practices for pigs in a research environment. We developed the Pig Welfare Working Group (PWWG) to address the need for more formal guidelines on the management and use of pigs in research. The PWWG was a stakeholder focus group whose goal was to identify challenges and opportunities relevant to improving animal welfare through collaboration, knowledge sharing, and inclusive decision-making. Through consensus building, the PWWG developed 12 recommendations for behavioral management, housing, research procedures, transportation, and rehoming programs. The recommendations were rolled out across the contract research organization, business units, sites, and countries. Follow up will be conducted regularly to assess welfare, monitor progress toward implementing the recommendations, and recognize and reward participants making changes at their site.

Abbreviations and Acronyms: CRO, Contract research organization; GAW&T, Global Animal Welfare & Training; PWWG, Pig Welfare Working Group

DOI: 10.30802/AALAS-JAALAS-22-000089

Introduction

Refinements for research animals. Refinement is one of the 3Rs and a key consideration when working with animals in research. The goals of refinement are to advance the welfare of animals used in science while also minimizing any associated pain and distress.[23,31] Refinements are an important aspect of the ethical acceptability of animal use in science and contribute to improving reproducibility and translatability of the experimental data obtained.[37] As the public becomes more concerned about the welfare of research animals, and as we learn more about animal needs, research organizations should regularly evaluate their practices and implement refinements to their animal management and use practices.[29,37]

Contract research organizations (CROs) are complex businesses that house and manage a range of species for different research purposes and clients, each with its own requirements. In this type of setting, standardizing all practices may not be possible across business units, countries, and sites because of different research requirements, different regulatory restrictions, and availability of housing, equipment and other materials. Applying rigid standards across sites and business units in a CRO may not be possible, especially if personnel do not see the benefit of the refinements.[6] Some business leaders, scientists, veterinarians, and research personnel may be reluctant to change animal-related procedures and practices without scientific evidence that the changes will improve welfare, efficiency, or study data. Such changes may be associated with higher cost, effort, and even acceptance of study data, which is particularly important when working in a strict and highly regulated scientific environment, such as safety assessment. Organizations also may lack the resources needed to implement refinements.[29] Promoting animal welfare and the 3Rs as part of the overall culture of care in any institution can encourage the acceptance and adoption of refinements for research animals.[6,30]

Stakeholder focus groups are commonly used in animal industries to identify challenges and opportunities to drive welfare-related changes. Various stakeholders may have different opinions about what constitutes animal welfare and implementation of changes to improve welfare. For example, the attitudes of stakeholders toward livestock pig husbandry practices were recently investigated.[2] Pig farmers wanted to ensure the economic viability of their farms and may not recognize welfare issues with current practices, whereas the public is concerned with perceived gaps in animal welfare and inadequate opportunities for pigs to perform natural behaviors.[2] In research organizations, personnel working directly with animals at the technical level and those in a veterinary or doctoral-level role show significant differences in attitudes and perceptions about refinements.[25] Several types of businesses that rely on animals (for example, dairy cattle[39] and equine industries[7,16]) have used formal stakeholder focus group studies to understand attitudes toward specific welfare-related changes.[13]

Stakeholder focus groups provide opportunities to understand differences in attitudes between different stakeholders and also offer the opportunity for collaboration, knowledge sharing, and inclusive decision-making based on consensus; this approach generally promotes cooperation and innovative solutions.[10] Focus groups are often used in qualitative research to guide discussion around predetermined topics while allowing participants to share ideas and discuss areas of agreement and

Submitted: 09 Sep 2022. Revision requested: 10 Nov 2022. Accepted: 27 Dec 2022.
[1]Global Animal Welfare and Training, Charles River, Wilmington, Massachusetts; [2]Ocular and Neuroscience, Charles River, Senneville, Quebec, Canada; [3]Reporting and Technical Services, Charles River, Ashland, Ohio; and [4]Department of Pathobiology, University of Guelph, Guelph, Ontario, Canada
**Corresponding author. Email: pvturner@uoguelph.ca*

disagreement.[22] Successful animal welfare stakeholder groups should be built on the following 5Rs.[10,36]

- Reflexivity: taking multiple perspectives into account
- Responsiveness: adjusting goals to fit changing demands from stakeholders
- Revitalization: responding to conflict by redirecting stakeholders to the common goal
- Resilience: maintaining flexibility with regard to unpredicted difficulties
- Relational capital: establishing and maintaining collaborative relationships between stakeholders

Following these principles can help to build collaborative networks of stakeholders. Stakeholder groups have previously been used by The Australian Animal Welfare Strategy and The EU Platform on Animal Welfare to develop and promote changes that improve animal welfare.[10] Involving a broad range of stakeholders and having frequent meetings were crucial for success of both of these efforts.[10]

Stakeholder focus groups in practice: Pig Welfare Working Group. Since the late 1970s, the use of pigs in biomedical research settings has increased due to their similarities to humans in a number of key areas such as anatomy, physiology, organ size, metabolism, skin structure, diseases, and lifespan.[12,19,40] Pigs are often used for surgical modeling and xenotransplantation, as well as to study skin-related and infectious diseases.[12] Minipig breeds were developed to provide a more convenient and economic model for maintenance at a research facility, although large breeds of pigs are also commonly used.[12]

Managing and using pigs in research facilities can be challenging due to their size and strength and to potentially poor socialization to people prior to arriving at a research facility. Pigs are often housed in modified dog cages or elevated floor pens that are not ideal for their physical build and movement, which might pose risks to their safety. Pigs are often manually restrained, which can lead to animal stress and the potential for injury to pigs and research personnel. As a common food animal species, pigs generally have not received the same attention to their welfare as compared with dogs and primates. The environment and interactions that will promote positive experiences for pigs and personnel in a biomedical facility have not been well studied. Some activities and situations that take place in a research environment can increase the risk of injury for pigs, including flooring with large gaps between slats or bars, use of housing enclosures that require pigs to be picked up, technical procedures such as restraint, blood collection, weighing, routine handling for husbandry procedures, and transportation. Pigs are highly intelligent animals and can be trained using operant conditioning techniques;[15,26,32] however, training techniques such as positive reinforcement, habituation, and desensitization are not widely used for technical and husbandry procedures involving pigs.

Most countries have guidance for managing the welfare of production animals, including pigs; however, specific guidance is often not available for pigs used in biomedical research. *The Guide for the Care and Use of Laboratory Animals*,[24] which is used by AAALAC International as a standard for facility assessment and accreditation, provides general comments for the care, husbandry, and space requirements of pigs, but specific practices are determined at the institutional level. The Institutional Animal Care and Use Committee (IACUC) or similar animal ethics committees, working together with husbandry, veterinary, and research personnel, are ultimately responsible for ensuring that suitable programs of research animal care and management are in place for every facility. While some studies may require special housing for pigs, such as single housing, these should be regarded as exceptions and should not be the norm for routine care and management of pigs. Beyond minimum standards for space allocation for research pigs,[24] published internationally recognized standards are not available for behavioral management of research pigs.

The Pig Welfare Working Group (PWWG), a stakeholder focus group, was developed in recognition of the need for more formalized recommendations for the care and use of research pigs in a biomedical setting. The goal of the PWWG was to establish global guidelines and best practices for research pigs based on topics considered to be primary welfare concerns. To that end, the PWWG was comprised of a diverse group of stakeholders in the CRO environment who were asked to provide input on refinements that would be suggested for implementation across sites, countries, and business units.

Materials and Methods

The PWWG was formed and organized in February 2019 by members of the welfare oversight group, Global Animal Welfare and Training (GAW&T) of a single company. Authors of this manuscript are members of both groups. As a basic standard, all sites within the company must meet country-specific animal-related regulations and legislation and all sites housing pigs must be accredited by AAALAC International. GAW&T organized and facilitated meetings and discussions of the PWWG and all parties drafted the final report. The PWWG had 30 members (primarily technical personnel, but also animal care attendants, veterinarians, study directors, and operations management) from 16 locations of one company in 6 countries (the United States, Canada, the United Kingdom, the Netherlands, France, and Denmark). PWWG members were recruited by GAW&T from sites that housed research pigs based on interest in pig refinement, their role within the company, and their expertise with research pigs.

The work of the PWWG was divided among 7 subcommittees assigned to topics that included:

1. behavioral management programs
2. housing
3. euthanasia
4. restraint, transportation within the facility, and specific pig care practices
5. blood collection techniques
6. adoption and rehoming programs
7. future research areas

PWWG members were assigned to subcommittees based on level of interest, experience, and expertise. Subcommittees were assigned one chair by GAW&T (or 2 co-chairs for more complex topics); the chairs were responsible for creating meeting agendas and leading discussions. At least one member of GAW&T also served on each subcommittee to provide administrative support and to ensure that discussions moved beyond the status quo to consider novel possibilities. Subcommittee meetings were held virtually and met weekly or biweekly for 1 quarter (3 months) to allow the subcommittee to generate information and reach a consensus for drafting recommendations on a specific topic. Subcommittees drafted 1 to 3 high-level recommendations based on the scientific literature, if available. Because little published peer-reviewed literature is available on research pigs, recommendations also included anecdotal and experiential information.

GAW&T members overseeing the PWWG met monthly to share progress, review draft recommendations, and plan next steps. Activities were staggered such that approximately 3 to 4 subcommittees were active in any given quarter.

The PWWG met in May 2019 at an in-person Pig Refinement Workshop. The workshop consisted of internal and external speakers and a hands-on, low-stress handling 'train the trainer' workshop. Once the PWWG had finalized their recommendations and best practices, GAW&T prepared a summary that was forwarded for senior-level review to regional managers and operations personnel. After approval from senior leadership, the recommendations were disseminated to all member company stakeholders as a final report in March 2020.

Results

Summary of recommendations. The recommendations developed by the PWWG are presented in Table 1. The final report contained 12 recommendations that covered key areas of interest for research pigs, including behavioral management, housing, handling and restraint, blood collection, study endpoints, and recommendations for the development of a welfare assessment tool specific to research pigs. To ensure clarity, recommendations were written plainly to avoid confusion, as English was not the primary spoken language across all sites. Recommendations apply to all breeds of pigs (that is, conventional and mini-pig).

Behavioral management programs. To ensure their suitability as models in research, pig care must allow normal physiologic and psychologic functioning. Pigs are highly intelligent, social animals. Due to their size and weight, they require appropriate management and personnel training. To ensure the health and welfare of research pigs while providing a safe work environment for employees, sites should **develop a comprehensive behavioral management program for research pigs (Recommendation 1)**.

Many elements, such as social housing, positive human-animal interactions, comfortable resting places, opportunities for exercise, temperament assessments, manipulanda, food rewards, habituation, and training, etc., are important in developing a behavioral management program and contribute to pigs being better research subjects by addressing their biologic functioning, affective states, and natural behaviors.[9] Domestic pigs under natural outdoor conditions spend 75% of their day rooting, exploring, and foraging for food,[33] but pigs often cannot perform these activities in a research setting. Providing pigs with opportunities to root, forage, and chew on and manipulate objects allows them to engage in their natural behaviors.[34] Ideally, pigs would receive this opportunity daily using materials that can be investigated, manipulated, chewed, and eaten.[38] Pigs should also have the opportunity to explore and exercise outside of their enclosure on a regular basis.[9] Animals benefit from having choice of and control over their environment and behavior; therefore this should be a key component of a behavioral management program.[3]

Housing. To best meet the behavioral needs of pigs, research housing should provide enough space for pigs to move freely, walk around, stand up, lie down without touching other pigs, thermoregulate, have separate resting and elimination areas, and display natural behaviors. The housing structure should also have secure and comfortable footing that causes regular wear of hooves, with enough waterers and feeders to minimize competition over resources; they should also be easy to sanitize and safe for the pigs and the personnel.[9,19]

To meet these housing standards, the PWWG **recommends housing research pigs in floor pens whenever possible (Recommendation 2)**. Floor pens with solid, nonslip flooring and bedding are preferred (Figure 1A) over elevated floor pens (Figure 1B), which may require pigs to be removed by lifting them or require training them to exit via a ramp. Solid floors reduce the risk of injury and lameness.,[17,18] Furthermore, housing them on the floor reduces the risk of pigs falling from elevated caging and reduces risk of injury for personnel working with pigs.

Domestic pigs are highly social. Singly housed pigs experience chronic stress, which is detrimental to both pig welfare and the data being collected.[9] Therefore, the PWWG **recommends that pigs always be socially housed in pairs or groups, unless constrained by study design (Recommendation 3).** Social housing should be considered the standard in all pig housing unless scientifically justified and approved by the facility animal ethics committee.

Handling and restraint. In research settings, pigs are often restrained for study procedures (for example, examination, diagnostic procedures, and dosing). Pigs are heavy and relatively nonathletic and can be injured if they struggle or fall during attempts at restraint. Severe injuries caused by poor restraint may require euthanasia. Human caregivers and technicians can also be injured when trying to restrain or carry a pig. To reduce risks to pigs and their handlers, the PWWG **recommends that restraint be limited to the extent possible, and pigs be trained to voluntarily cooperate with needed procedures**. They also recommended that **pigs be habituated in advance to all methods of restraint required, including hand carrying (Recommendation 4).**

Operant conditioning using a clicker, target, or food reward (positive reinforcement training) can be used to minimize the

Table 1. Summary of overall recommendations from the PWWG subcommittees.

Recommendations
1. Develop a comprehensive behavioral management program for research pigs.
2. Pigs should be housed in floor pens, when possible.
3. Pigs should always be housed in pairs or groups, unless constrained by study design
4. Restraint should be minimized as much as possible, and animals should be trained to voluntarily cooperate with needed procedures. Pigs should be habituated in advance to all methods of restraint required, including hand carrying.
5. When pigs are restrained in a sling, the use of tie ropes should be minimized or eliminated through improved desensitization and habituation techniques.
6. A program of regular hoof care should be established.
7. Pigs should be trained to walk independently. When it is not possible, mobile transfer carts are preferred over hand carrying.
8. Peripheral bleeding sites should be used, wherever possible. Catheters should be placed when repeated blood sampling is needed.
9. When central venous access is necessary for blood collection, instrumentation with a port or indwelling catheter should be considered.
10. Pigs should be rehomed at study conclusion, when possible.
11. When using intravenous barbiturate solutions for euthanasia, pigs should first be deeply sedated or anesthetized.
12. Conduct periodic comprehensive welfare assessments to evaluate program progress and impact.

Figure 1. Housing structures for research pigs: (A) Site using floor pens; (B) site using elevated floor pens.

need for restraint.[9,19,26] The use of a sling for restraint reduces the need for manual restraint and is safer for pigs and their handlers.[27,35] Pigs require desensitization and habituation training for the sling. Inadequate training results in pigs being fearful and struggling against the sling. Tie ropes can be used to restrain the legs, but this will likely increase fear and discomfort. The PWWG **recommends that the use of tie topes during sling restraint should be minimized or eliminated through improved desensitization and habituation techniques (Recommendation 5)**. Desensitization and habituation can be used to reduce fear and increase comfort while in the sling,[9,26] making it safer for both pigs and their human handlers (Figure 2A). Slings can also be modified to create carrying devices, as demonstrated with the Piggy Snuggle (Figure 2B); this can be useful for tonometry readings in ophthalmic studies or for other procedures requiring restraint. If slings are not available, mini-pigs can also be trained to sit quietly on platforms, similar to dogs (Figure 2C).

Pig hooves grow continuously and require regular care. Overgrown hooves can lead to lameness and even secondary conformational abnormalities.[14] The PWWG **recommends that a program of regular hoof care be established for research pigs (Recommendation 6).** Routine husbandry should include at least monthly evaluation of hoof length. Pigs that are housed on partially abrasive flooring or provided opportunities for exercise or walking on gritted floors rarely require hoof trimming; this is therefore the preferred method of regular hoof care. Pigs housed on plastic or vinyl coated flooring will require regular trimming to maintain optimal hoof length. Pigs should be desensitized and habituated to hoof trimming through positive reinforcement training.

Pigs must often be transported within a research facility to different work areas (for example, moving them to the holding rooms on arrival, to study or procedure rooms, onto a scale for weighing, onto an elevated platform for treatments, or for a variety of other reasons. The PWWG **recommends that pigs be trained to walk voluntarily (Figure 3). When this is not possible, mobile transfer carts are preferred to hand carrying (Recommendation 7)**. If pigs cannot be trained to walk to necessary locations, mobile transport carts provide the highest level of safety and security for moving them. Target training (training a pig to touch their nose to an object; see Figure 3), combined with rewards, can be used to rapidly train, pigs to stand on a weigh scale, enter and exit their pen, and enter and exit a transport cart.

Blood collection. The most common anatomic site for blood collection in pigs is the anterior vena cava;[35] this site presents a number of risks. Unlike other common research species, the jugular vein and anterior vena cava of pigs are both located deep within the neck musculature. Blood collection from the anterior vena cava is typically a 'blind stick' using common anatomic landmarks.[9] If the pig moves during blood collection, the vessel, heart, and surrounding structures can be lacerated. Given the location, hemostasis is not possible, and pigs can bleed to death. To protect animal health and welfare, the PWWG **recommends the use of peripheral bleeding sites (for example, auricular, radial, cephalic, and saphenous veins[20,35]) whenever possible to minimize potential for pain and injury. Catheters should be placed when repeated blood sampling is necessary (Recommendation 8)**.

Use of temporary or indwelling catheters in pigs reduces the need for heavy restraint, the potential for pain from repeated venipunctures, and the potential for significant animal injury from inadequate hemostasis, and they increase the accuracy and precision for collection of blood at the correct time interval. The PWWG **recommends that when central venous access is necessary for blood collection, implantation of a port or indwelling catheter should be considered (Recommendation 9)**.

Consideration should be given to minimizing volume requirements for blood collections in pigs. The use of microsampling methods will permit more sustained use of peripheral sites. For example, if only small volumes of blood are needed, the auricular (ear) vein can be used.[35] Repeated samples can be obtained with a catheter for up to 30 d, maintaining the integrity of the ear vein.

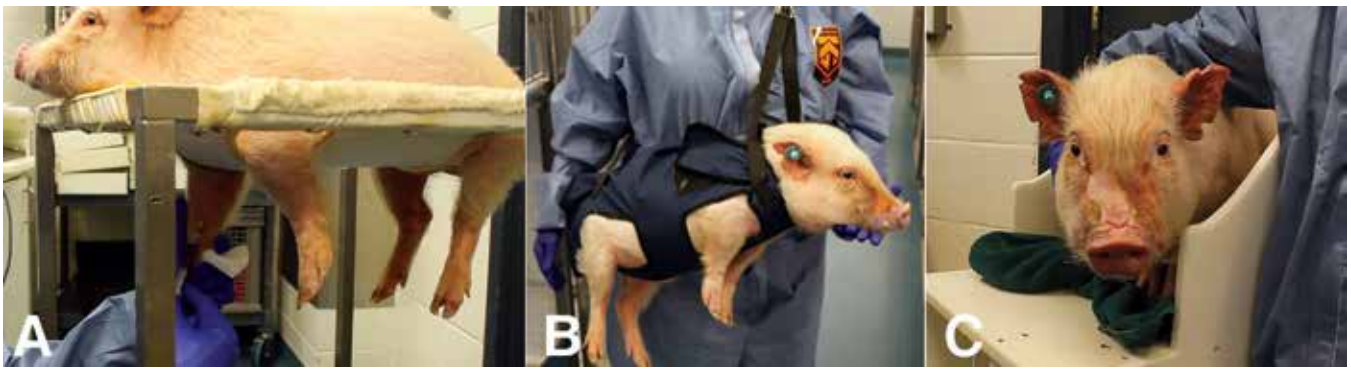

Figure 2. Refinements to restraint techniques in research pigs: (A) pig in hammock sling after habituation, which allows radial vein blood collection by one technician without the need for additional restraint techniques, such as tie ropes; (B) modified sling restraint known as the 'Piggy Snuggle' designed for use in ophthalmic studies; (C) training pig to sit on a platform.

Study endpoints. Pigs have a long life expectancy and can make good companion animals. Because of this, the PWWG **recommends that pigs be rehomed at study conclusion if possible (Recommendation 10)**. Before permitting rehoming, the local animal ethics committee must consider the adequacy of long-term care and housing, legislation, and research use of each individual pig and home. Prospective adopters must understand and accept a commitment to properly care for the pigs for their lifetime. All rehoming must be done in accordance with relevant local guidelines and laws. Pigs should be surgically sterilized prior to release whenever possible.

If rehoming is not an option, based on the current standard of veterinary practice,[1] the PWWG **recommends that pigs should be deeply sedated or anesthetized before the administration of intravenous barbiturate solutions for euthanasia (Recommendation 11)**. Pigs should be handled calmly and respectfully to reduce excitement and fear prior to euthanasia. After euthanasia, death should be confirmed by approved methods.[1] In some jurisdictions, research pigs may be humanely killed by an approved physical method (for example, penetrating captive bolt[1]). Local authorities may be consulted to ensure the method of euthanasia and carcass disposal meet regulatory requirements.

Welfare assessments. A program of animal care should include a companion program to assure that the former is functioning as expected. Welfare assessment should be a routine activity that is easy to use, conducted at regular intervals, and validated for the specific population.[4,5] The PWWG **recommends that sites conduct periodic and comprehensive welfare assessments to evalute program progress and impact (Recommendation 12).** Results of these assessments should be made available to relevant internal groups and individuals (for example, the animal ethics committee or, for allocation of resources, site leadership).

The features that should be evaluated during a welfare assessment vary by species and animal use, but in general, should include assessments of animal behavior, affective state, and physiology,[11] and consider positive affective states and human-animal interactions.[5,21] Welfare assessment protocols are available for commercial pigs.[2,8] These tools may be useful starting points for assessment of the welfare of research pig welfare as a published, validated welfare assessment for research pigs has not been developed.[19] Future work on the welfare of research pigs should include development and validation of a welfare assessment tool.

Future research areas. Throughout its work in 2019, the PWWG found diverse approaches to management of research pigs. For example, methods routinely used for housing pigs vary considerably. This variation reflects differences across and within companies, variations in international regulatory guidance, and diversity in research needs across sites. This diversity is also seen at research institutions that house pigs for biomedical compared with agricultural research and presents opportunities for future studies on research pig management and welfare. The PWWG noted several suggested topics for future studies in research pig care and welfare (Table 2). This list is not exhaustive but rather is intended to specifically address applied aspects of care and husbandry.

Figure 3. Pig being target trained with a target to voluntarily walk onto a scale.

Discussion

The primary objectives of the PWWG were to establish global guidelines and best practices for management of research pigs with regard to key areas of welfare concern. Stakeholder focus groups were used to bring together diverse perspectives and opinions relevant to developing achievable refinements that would be adopted across sites. Compared with other research animal species, such as dogs and primates, pigs do not always receive the same attention with regard to welfare assessments. Although all participating sites were accredited by AAALAC International and had high expectations for animal welfare, we wanted set common goals and performance-based measures to benchmark the welfare needs of research pigs.

The PWWG had representation from 100% of the sites that used pigs, which allowed all sites to share the details of their

Table 2. Future research areas for refining research pig management.

Category	Research Topic
Housing and Resources	1. Can nesting materials improve pig welfare? If so, what material is best and how should it be provided to maximize welfare? 2. Are hanging chains useful or harmful for pig welfare? 3. What type of flooring and bedding are most comfortable for pigs housed in a research facility? 4. What pen layouts are best for working with pigs? 5. How can foraging be provided in elevated floor pens? 6. What are preferred exercise opportunities for pigs?
Behavior and Training	7. How does social housing influence training? 8. Under what conditions is a trainer pig most beneficial? 9. Are some methods of habituation more effective than others? 10. Can a simple temperament test be developed to optimize social groupings? 11. Does a short period of play with humans after training reinforce learning, as in dogs?
Clinical Pathology	12. What are alternative central venous access sites for venipuncture and infusion? 13. Does central as compared with peripheral blood collection affect clinical pathology results?
Other	14. Can a power lift or sling be used to substitute for manual lifting of pigs? 15. Does routine neutering offer long-term health advantages or disadvantages for pigs that are rehomed?

pig management programs, discuss challenges and progress in their facility, and work together to develop practical recommendations that would be feasible to implement across sites. Throughout the project, draft recommendations were reviewed by various internal stakeholders to determine feasibility and to gain support from operations management, veterinarians, animal ethics committees, study directors, and senior leadership. After consensus approval of the final recommendations, the PWWG recommendations have been used during internal site discussions and visits to assess the uptake and evolution of pig management programs and to monitor site progress on enhancing approaches to research pig welfare. Sites have also used the recommendations to leverage resources for improvements in housing, restraint, and handling techniques, and have also used the recommendations to drive internal research to develop evidence-based processes geared to an applied research setting.

The recommendations provided by the PWWG were developed to provide additional guidelines for sites to strive toward, regardless of geographic location, national welfare regulations and legislation, and local policies. The multinational approach of the PWWG supported the incorporation of varying perspectives and ideas. The recommendations were structured to avoid exhaustive or prescriptive goals, but rather to bring pig care and management to levels expected for other large animal species. The recommendations can also be used to provide baseline targets while allowing flexibility for their modification as needed to optimize research pig management in different settings. Quarterly pig behavioral management calls help to maintain the collaborative relationships between members located at different sites and to encourage them to continue to share knowledge and progress and to troubleshoot challenges together.

As with any project involving multiple stakeholders, this project had to overcome a number of challenges. Much of the work of the PWWG was done virtually using online meeting platforms, collaborative software, and email correspondence. The members of the PWWG also represented 6 countries, which introduced language barriers that had to be addressed. Maintaining momentum can also be challenging in collaborative projects, especially in a virtual setting in which conflicting time zones and schedules can hinder progress. Along with maintaining momentum, we also had to maintain focus toward a common goal based on the identified key welfare areas of interest. Because the goal of the PWWG was to develop realistic and feasible recommendations that could be applied across sites, countries, and research purposes, ensuring members did not become overly committed to or prescriptive with the recommendations was crucial for achieving consensus and implementation. Differences in resources across sites and countries had to be considered when building the recommendations. In addition, we realized that implementation would be asynchronous. Sites started at different levels in their pig behavioral management programs, sometimes varying widely between pig breeds, and needed the flexibility to prioritize the recommendations based on their current physical plant, personnel, and resource availability. The final ongoing challenge is ensuring forward momentum across all sites regardless of personnel turnover and pandemic-related challenges with staffing.

The work of the PWWG led to the following recommendations, which are summarized below to allow other research institutions to form stakeholder focus groups that can encourage and support welfare-related change at the organizational level:

1. Carefully select topics of interest – the goals of the focus groups must be realistic and achievable. Topics should be selected based on key areas of welfare concern, breadth of knowledge available to make evidence-based decisions, and resources available to implement changes.
2. Recruit diverse stakeholders – members from all levels of the organization should be included to achieve consensus on welfare-related changes.
3. Assign an organizing committee or project leader(s) to provide administrative support and to maintain momentum and communication. An organizing committee should be appointed to set meetings and take minutes, to organize and distribute information, and to ensure the focus is forward-thinking. This structure allows stakeholders to focus on key topics and, and on building team consensus.
4. Schedule hands-on opportunities to see and practice new techniques, when possible. In-person opportunities to learn and participate in team building exercises will encourage long-term collaboration and communication that will help drive future welfare changes as priorities change.
5. Keep options open. Build recommendations based on what should be done rather than what must be done, especially in complex organizations. Allow stakeholders choice and control over how they implement the change and to prioritize changes based on their

resources. Allowing choice and ownership over the changes could lead to innovation.
6. Follow up. Build in a system to assess welfare and monitor progress toward achieving the recommendations, while also recognizing and rewarding participants that are making changes.

Legislation and regulations cannot cover every eventuality when working with animals in science. Challenging the status quo is important to ensure that practices remain up-to-date and relevant. Some species such as pigs, sheep, and calves fall into a gray zone in research settings, which may be agricultural or biomedical in purpose. Specific guidance and welfare research for these species in biomedical settings is sparse, and institutions may need to work closely with researchers to ensure that the needs of these animals are thoroughly considered. As demonstrated by this project, when specific guidance is not available, the use of stakeholder focus groups can be an effective way to build consensus for change and leveraging resources within an institution to enhance animal welfare.

Acknowledgments

We acknowledge and thank all the members of the Pig Welfare Working Group at Charles River for their assistance in drafting these recommendations.

References

1. American Veterinary Medical Association. 2020. [Internet]. AVMA guidelines for the euthanasia of animals. [Cited 04 Jan 2021]. Available online: avma.org/sites/defaukt/siles/2020-01/2020_Euthanasia_Final_1-15-20.pdf.
2. **Bergstra TJ, Hogeveen H, Stassen EN**. 2017. Attitudes of different stakeholders toward pig husbandry: A study to determine conflicting and matching attitudes toward animals, humans and the environment. Agric Human Values **34**:393–405. https://doi.org/10.1007/s10460-016-9721-4.
3. **Bloomsmith MA, Perlman JE, Hutchinson E, Sharpless M**. 2018. Behavioral management programs to promote laboratory animal welfare. In: Weichbrod RH, Thompson GAH, Norton JN, editors. Management of animal care and use programs in research, education, and testing. Boca Raton (FL): CRC Press.
4. **Botreau R, Bonde M, Butterworth A, Perny P, Bracke MBM, Capdeville J, Veissier I**. 2007. Aggregation of measures to produce an overall assessment of animal welfare. Part 1: a review of existing method. Animal **1**:1179–1187. https://doi.org/10.1017/S1751731107000535.
5. **Botreau R, Bracke MBM, Perny P, Butterworth A, Capdeville J, Van Reenen CG, Veissier I**. 2007. Aggregation of measures to produce an overall assessment of animal welfare. Part 2: analysis of constraints. Animal **1**:1188–1197. https://doi.org/10.1017/S1751731107000547.
6. **Brønstad A, Berg AGT**. 2011. The role of organizational culture in compliance with the principles of the 3Rs. Lab Anim (NY) **40**:22–26. https://doi.org/10.1038/laban0111-22.
7. **Butler D, Valenchon M, Annan R, Whay HR, Mullan S**. 2019. Stakeholder perceptions of the challenges to racehorse welfare. Animals (Basel) **9**:363. https://doi.org/10.3390/ani9060363.
8. **Dalmau A, Velarde A, Scott K, Edwards SA, Butterworth A, Veissier I, Keeling LJ, Overbeke G, Bedaux V**. 2009. Welfare Quality ® assessment protocol for pigs (sows and piglets, growing and finishing pigs). Welfare Quality® consortium, Lelystad, Netherlands. Available at: http://www.welfarequalitynetwork.net/media/1018/pig_protocol.pdf.
9. **Ellegaard L, Cunningham A, Edwards S, Grand N, Nevalainen T, Prescott M, Schuurman T**. 2010. Welfare of the minipig with special reference to use in regulatory toxicology studies. J Pharmacol Toxicol Methods **62**:167–183. https://doi.org/10.1016/j.vascn.2010.05.006.
10. **Fernandes J, Blache D, Maloney SK, Martin GB, Venus B, Walker FR, Head B, Tilbrook A**. 2019. Addressing animal welfare through collaborative stakeholder networks. Agriculture **9**:132. https://doi.org/10.3390/agriculture9060132.
11. **Fraser D, Weary DM, Pajor EA, Milligan BN**. 1997. A scientific conception of animal welfare that reflects ethical concerns. Anim Welf **6**:187–205.
12. **Gutierrez K, Dicks N, Glanzner WG, Agellon LB, Bordignon V**. 2015. Efficacy of the porcine species in biomedical research. Front Genet **6**:293. https://doi.org/10.3389/fgene.2015.00293.
13. **Hawkins P, Prescott MJ, Carbone L, Dennsion N, Johnson C, Makowska IJ, Marquardt N, Readman G, Weary DW, Golledge HDR**. 2016. A good death? Report of the second Newcastle meeting on laboratory animal euthanasia. Animals (Basel) **6**:50. https://doi.org/10.3390/ani6090050.
14. **Hepworth K, Neary M, Kenyon S**. 2004. [Internet]. Hoof anatomy, care, and management in livestock. [Cited 10 Jun 2022]. Available at: https://www.extension.purdue.edu/extmedia/id/id-321-w.pdf.
15. **Herskin MS, Bundgaard CJ, Ottessen JL, Sørensen DB, Marchant-Forde JN**. 2021. The pig. In: Sørensen DB, Cloutier S, Gaskill BN, eds. Animal-centric care and management: Enhancing refinement in biomedical research. Boca Raton (FL): CRC Press.
16. **Horseman SV, Hockenhull J, Buller H, Mullan S, Barr ARS, Whay HR**. 2017. Equine welfare assessment: exploration of British stakeholder attitudes using focus-group discussions. J Appl Anim Welf Sci **20**:176–191. https://doi.org/10.1080/10888705.2017.1283226.
17. **Jørgensen B**. 2003. Influence of floor type and stocking density on leg weakness, osteochondrosis and claw disorders in slaughter pigs. Anim Sci **77**:439–449. https://doi.org/10.1017/S1357729800054382.
18. **Kilbride A, Gillman C, Ossent P, Green P**. 2009. Impact of flooring on the health and welfare of pigs. In Pract **31**:390–395. https://doi.org/10.1136/inpract.31.8.390.
19. **Marchant-Forde JN, Herskin MS**. 2018. Pigs as laboratory animals. In: Špinka M, ed. Advances in pig welfare. Duxford, United Kingdom: Woodhead Publishing. https://doi.org/10.1016/B978-0-08-101012-9.00015-0
20. **Mazzachio K**. 2019. [Internet]. Radial vein blood collection in the miniature pig. [Cited 10 Jun 2022]. Available online: https://lafeber.com/vet/radial-vein-blood-collection-in-the-miniature-pig/.
21. **Mellor DJ, Beausoleil NJ, Littlewood KE, McLean AN, McGreevy PD, Jones B, Wilkins C**. 2020. The 2020 Five Domains Model: Including human-animal interactions in assessment of animal welfare. Animals (Basel) **10**:1870. https://doi.org/10.3390/ani10101870.
22. **Morgan DL**. 1997. Focus groups as qualitative research, 2nd ed. Thousand Oaks (CA): Sage. https://doi.org/10.4135/9781412984287
23. National Centre for the Replacement Refinement & Reduction of Animals in Research (NC3Rs). 2022. [Internet]. The 3Rs. [Cited 9 Jun 2021]. Available online: https://nc3rs.org.uk/who-we-are/3rs.
24. National Research Council (NRC). 2011. Guide for the care and use of laboratory animals. 8th ed. Washington (DC): National Academies Press.
25. **O'Malley CI, Hubley R, Moody CM, Turner PV**. 2022. Use of nonaversive handling and training procedures for laboratory mice and rats: Attitudes from Canadian and U.S. laboratory animal professionals. Front Vet Sci **9**:1040572. https://doi.org/10.3389/fvets.2022.1040572.
26. **O'Malley CI, Hubley R, Tambadou H, Turner PV**. 2022. Refining restraint techniques for research pigs through habituation. Front Vet Sci **9**:1016414. https://doi.org/10.3389/fvets.2022.1016414.
27. **Panepinto LM, Phillips RW, Norden S, Pryor PC, Cox R**. 1983. A comfortable, minimum stress method of restraint for Yucatan miniature swine. Lab Anim Sci **33**:95–97.
28. Pork Quality Assurance (PQA) Plus. 2015. Building a stronger industry, 3rd ed. Des Moines (IA): National Pork Board.

29. **Prescott MJ, Lidster K**. 2017. Improving quality of science through better animal welfare: The NC3Rs strategy. Lab Anim (NY) **46**:152–156. https://doi.org/10.1038/laban.1217.
30. **Robinson S, Sparrow S, Williams B, Decelle T, Bertelsen T, Reid K, Chlebus M**. 2020. The European Federation of the Pharmaceutical Industry and Associations' Research and Animal Welfare Group: Assessing and benchmarking 'Culture of Care' in the context of using animals for scientific purpose. Lab Anim **54**:421–432. https://doi.org/10.1177/0023677219887998.
31. **Russell WMS, Burch RL**. 1959. The Principles of Humane Experimental Techniques. London (UK): Russell.
32. **Sørensen DB**. 2010. Never wrestle with a pig. Lab Anim **44**:159–161. https://doi.org/10.1258/la.2010.009100.
33. **Stolba A, Wood-Gush M**. 1989. The behaviour of pigs in a semi-natural environment. Anim Prod **48**:419–425. https://doi.org/10.1017/S0003356100040411.
34. **Studnitz M, Jensen MB, Pedersen LJ**. 2007. Why do pigs root and in what will they root? A review on the exploratory behaviour of pigs in relation to environmental enrichment. Appl Anim Behav Sci **107**:183–197. https://doi.org/10.1016/j.applanim.2006.11.013.
35. **Swindle M**. 2010. [Internet]. Blood collection in swine. [Cited 29 Dec 2020]. Available online: https://info.sinclairresearch.com/blood-collection-in-swine.
36. **Termeer CJAM, Dequlf A, Breeman G, Stiller SJ**. 2015. Governance capabilities for dealing wisely with wicked problems. Adm Soc **47**:680–710. https://doi.org/10.1177/0095399712469195.
37. **Turner PV**. 2021. Moving beyond the absence of pain and distress: Focusing on positive animal welfare. ILAR J **60**:366–372. https://doi.org/10.1093/ilar/ilaa017.
38. **van de Weerd HA**. 2019. Appropriate Enrichment. In: Camerlink I, ed. Animal welfare in practice. London (UK): 5M Publishing.
39. **Ventura BA, von Keyserlingk MAG, Weary DM**. 2015. Animal welfare concerns and values of stakeholders within the dairy industry. J Agric Environ Ethics **28**:109–126. https://doi.org/10.1007/s10806-014-9523-x.
40. **Vodička P, Smetana K Jr, Dvořánková B, Emerick T, Xu Y, Ourednik J, Ourednik V, Motlík J**. 2005. The miniature pig as an animal model in biomedical research. Ann N Y Acad Sci **1049**:161–171. https://doi.org/10.1196/annals.1334.015.