

Exploring the Present and Future of Home Cage Monitoring: A Comprehensive Survey

1 Introduction

This survey was designed to explore the interest in Home Cage Monitoring (HCM) technologies for animal monitoring in their natural environment, aiming to identify the potential benefits and challenges for the biomedical community. The survey was sent to members of the EU COST Action (TEATIME: <https://www.cost-teatime.org/>) and further shared through their networks, including various animal associations, scientific societies, and mailing groups. It gained additional exposure at conferences like FELASA 2022, where presentations and fliers helped spread the word. The survey ran for several months, attracting 279 responses from 37 countries, with a diverse representation from Europe, Asia, North America, and South America.

1.1 Survey Methodology

Work Group 1 of COST Action (20135 TEATIME) created the survey to identify the prevalence and use of HCM systems in science, application of the 3Rs and well-being principles, views on current and future use, barriers to adoption, and the need to improve HCM for scientific and welfare aims. The questions were developed by 11 WG1 members during a face-to-face meeting in May 2022, and 20 WG1 members attending online.

Five to six questions were developed for 4 target groups:

1. Researchers
2. Facility managers
3. Animal care and welfare specialist
4. Equipment/technology developer

The complete list of questions is attached at [Annex 1](#). The survey was open for about five months, from 10 June 2022 (launched at the FELASA conference) to 31 October 2022.

Invitations for the survey were sent to TEATIME Action participants and their wider network, promoted via social media (Twitter and LinkedIn), and further distributed through emails from Action members to various institutions, researchers, and relevant stakeholders. Additionally, it was featured in newsletters from LASA forum, EARA, and The North American 3Rs Collaborative.

The survey (available at Google platform) received 279 responses, which were analysed in Excel. For multiple entries from the same person, only the latest response was included in the analysis.

2 Surveyed community

2.1 Survey Respondent Distribution by Target Groups

The data collection from this survey was extensive, yet not all answers delivered clear indications about the trends or opinions of the whole community. We have used further categorisation in the analyses of some of the data to ensure that the responses from as many people as possible were included in this report. This includes the roles of the participants ([Figure 1](#)). Unless stated specifically,

the numbers reported within the results below do not differ according to roles or laboratory animal species.

These categories indicate a diverse range of professional backgrounds among survey respondents. The distribution of survey respondents is shown in [Figure 1](#). The majority of respondents categorized as researchers (72%), with animal care and welfare specialists and facility managers forming 14% and 11% and a small number of equipment and technology developers (3%).

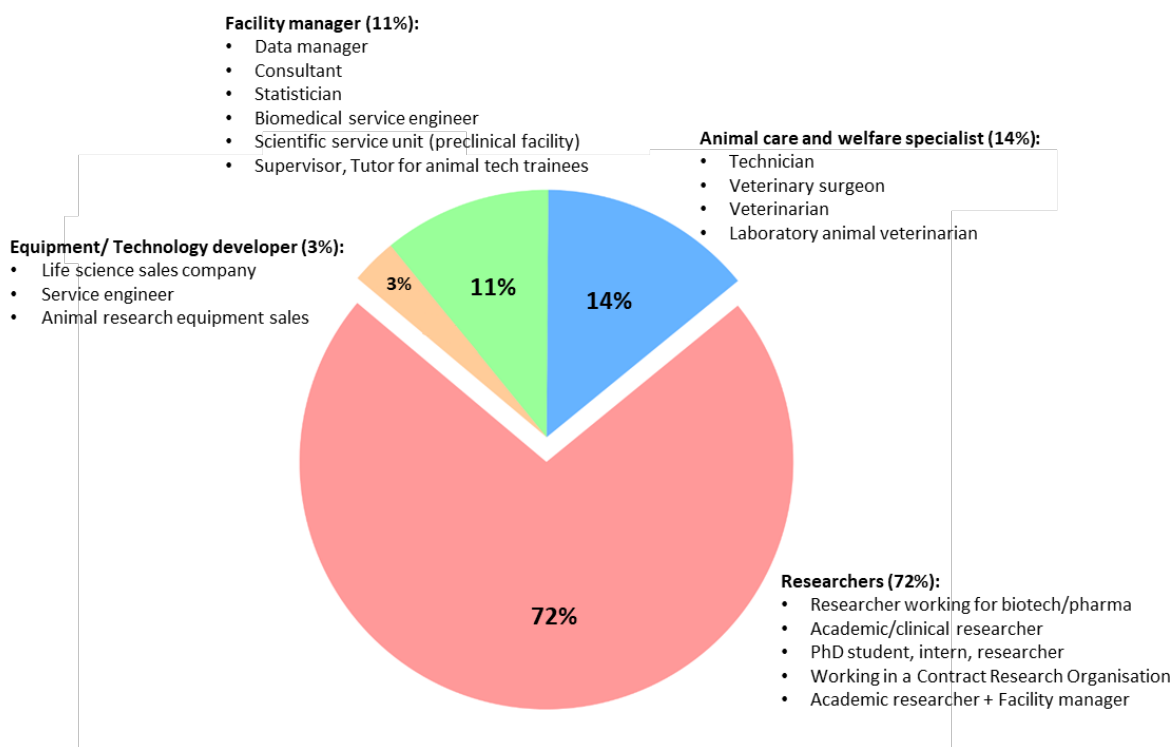


Figure 1. Survey respondents by professional groups

2.2 Use of Laboratory Animals Species

Species used by the population surveyed: 99% used rodents of these 51% used mice only, 8% rats only and 40% used both mice and rats ([Figure 2](#)).

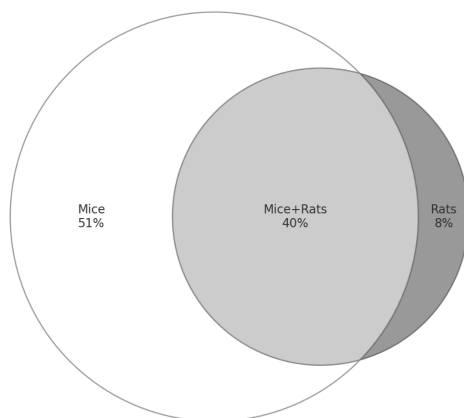


Figure 2. Rodent species used by survey respondents (researchers)

The results of the survey indicate that HCM is mainly used in rodent (predominantly mouse) research, as evidenced by the distribution of roles and species.

3 Challenges and Opportunities

3.1 Current users versus non-users of Home Cage Monitoring Systems

Survey respondents showed a ratio of 42% users to 58% non-users of HCM systems (Table 1). It is noteworthy that 86% of those working with rats alone did not use HCM, with only 14% using HCM. For those working with mice, 53% were using HCM and 47% were not.

Table 1. Users versus non-users of HCM systems

Home Cage Monitoring systems	Users (%)	Non-Users (%)
Overall Respondents*	42%, 118 individuals	58%, 161 individuals
Working with Mice only	53%	47%
Working with Rats only	14%	86%

Likewise, a high proportion of animal care and welfare specialist (n=30, 77%) and facility managers (n=23, 72%) did not use HCM (Figure 3).

It is of note, that among “researchers”, the survey successfully collected information from an equivalent number of researchers who “use” (n=95, 47%), or “do not use” (n=106, 53%). Therefore, answers from users of HCM systems in this report are more likely to closely reflect the views of researchers who make up 81% of the current user respondents.

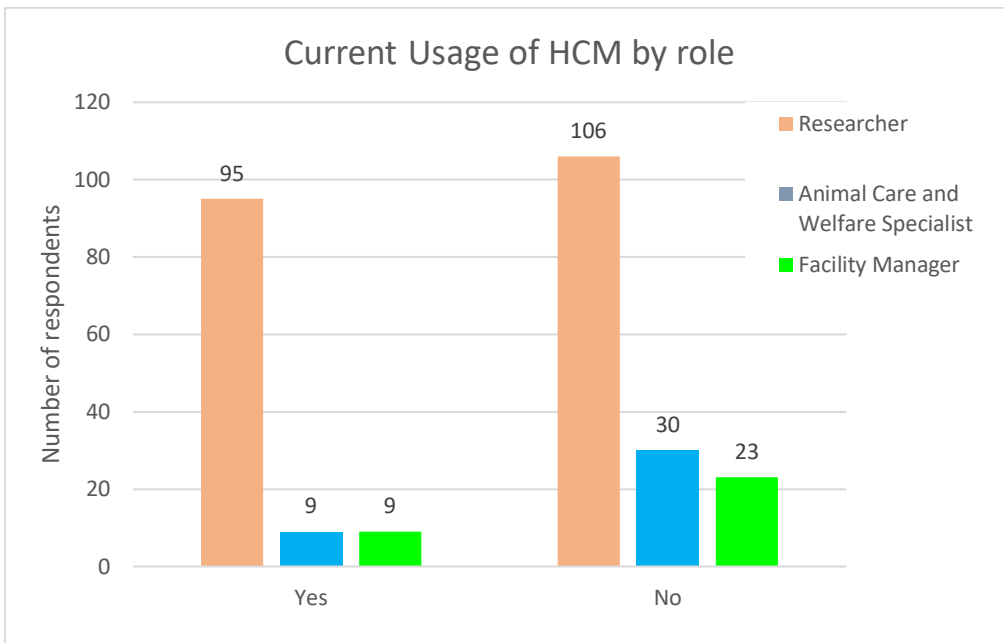


Figure 3. Number of users/not-users of HCM systems by professional group (numbers on the top of each bar represent total number of individuals of each role)

3.2 Opinions of current HCM users

The results in this section are mainly based on the responses of researchers, who accounted for 81% of HCM users. Therefore, answers from users are more likely to closely reflect the views of researchers.

Current users selected 3 most important advantages/limitations of HCM systems from a pre-defined list. The data shows the percentage of respondents who selected each attribute (Figure 4).

The greatest benefits, as indicated by the higher percentage in green, include "Long-term continuous data," "Reduced interference/disturbance," and "Discovery of novel phenotypes". These are unique aspects created by HCM according to current users.

The biggest constraints for current users, highlighted in red, are primarily "Financial aspects", "Group housing requirements", "Data analysis" and "Data integration".

Despite these limitations, the majority of current HCM predicted an increase in demand in coming years for HCM technology (90%).

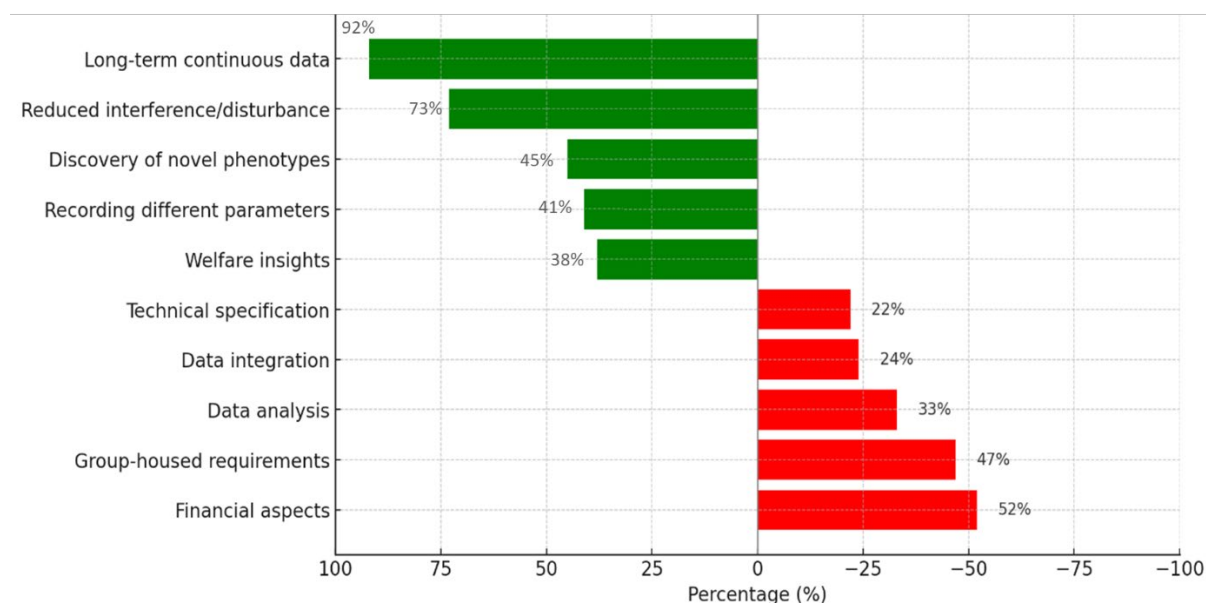


Figure 4. Current and future benefits (green) and limitations (red) of using HCM as % of responses from current users

3.3 Opinions of non-users of HCM systems

For non-users, the main concern is "Cost of ownership," marked by 67% of respondents (Table 2). There is some overlap with the current users' concerns about "Financial aspects," but it seems to be more pronounced among non-users.

"Technical and IT support/data management support" is the second most significant constraint for non-users, mentioned by 47%, which may correlate with the "Data Analytics" (33%) and "Data Integration" (24%) issues identified by current users, albeit at a lower percentage level.

"Acceptance of new testing methods" at 35% and "Facility space" at 32% are further unique concerns among non-users, suggesting hesitancy in adopting new technologies and practical limitations of space.

"IT infrastructure limitations" and "Awareness of capabilities," at 30% and 20% respectively, are less important to non-users compared to other factors. They may imply difficulties in understanding the technical aspects and potential of the systems.

Table 2. The limitations of HCM ranked as % of responses from non-users (n=161)

Limitations of HCM systems (non-users)	% of respondents
Cost of ownership	67%
Technical and IT support/data management support	47%
Acceptance of new testing methods	35%
Facility space	32%
IT infrastructure limitations	30%
Awareness of capabilities	20%

In summary, both users and non-users recognize the challenges associated with financial and technical support. Additionally, non-users emphasize acceptance of the new method and the practical limitations of the facility, pointing out the obstacles associated with implementing new research methods. Despite these concerns, 62% of non-users predicted that they would start to use HCM systems.

4 Requirements, needs and opportunities

4.1 Suitability of existing out-of-cage systems

When asked to assess how the existing "out of cage" tools satisfy their current needs in different types of research (including toxicology, multi-morbidities, long-term studies, disease progression, and translational data), a significant proportion of both users and non-users thought that the out-of-cage methods suited their studies "well" or "very well" (41% and 47% for users and non-users respectively).

However, it appears that there is significant room for improvement (Figure 5). With 22% of non-users and 27% of users indicated poor performance and around 30% of both users and non-users indicated only a moderate suitability.

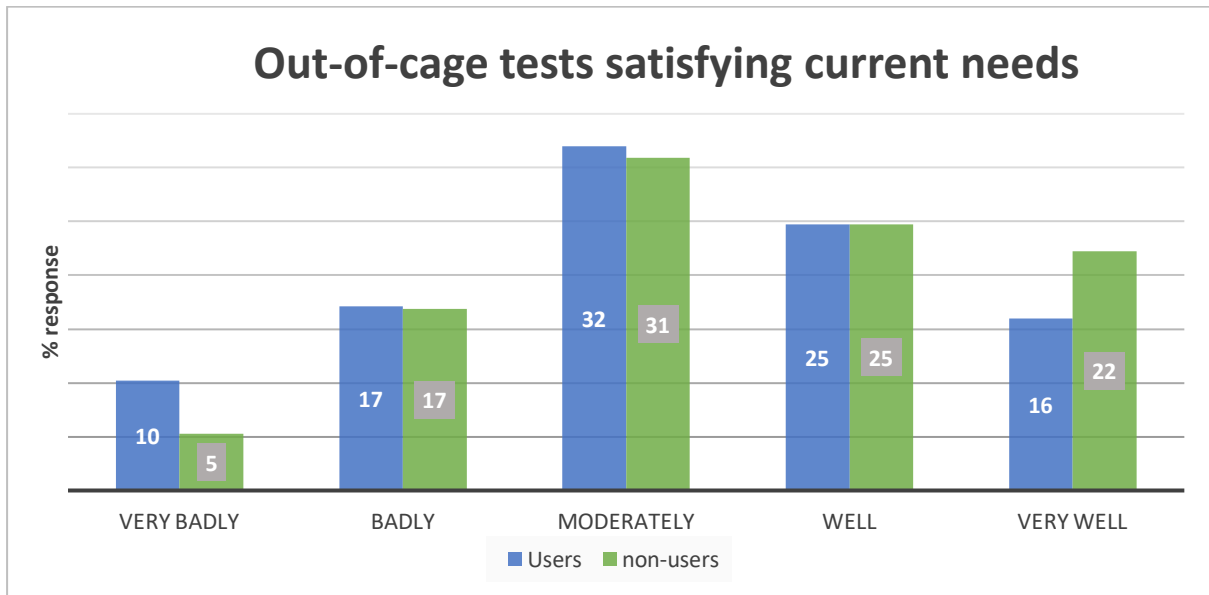


Figure 5. How does the existing out-of-cage tools satisfy current needs? This figure shows performance of out of cage tools as % of all responses (n=279).

4.2 Research needs identified for HCM systems

When asked what additional research data respondents would like to collect, there was again no significant difference between current users and non-users of HCM systems.

The community surveyed noted many parameters which they would like to include in their studies, including: behavioural parameters such as social interactions with individual animals in a social context and physiological indicators such as body temperature and food/water consumption, as selected from a pre-defined list (results in [Figure 6](#)).

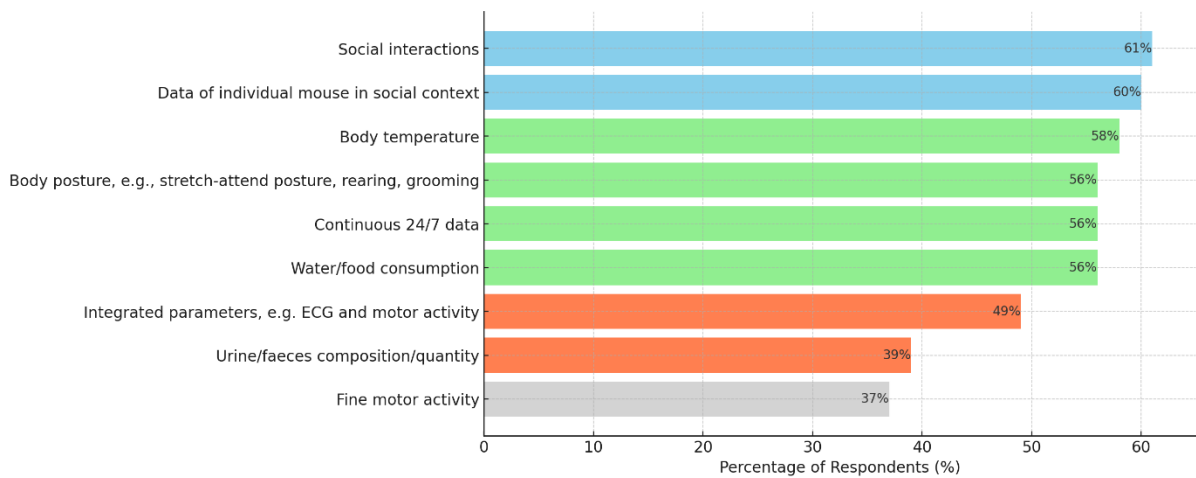


Figure 6. Additional parameters wish list as % of respondents (n=279)

5 Discussions and further opportunities

Action

Continue to proactively target other communities including welfare sector and those working with species other than mice for interaction with the TEATIME network over Years 3 and 4 of the ACTION (Nov 2023 to Oct 2025).

The majority of the respondents to this survey worked as researchers using rodents, with the majority of those already using HCM working with mice, not rats. This reflects the current state of HCM systems which have focused their development for mouse research purposes, while other fields are not necessarily seeing the same level of growth in uptake. There is a clear opportunity, especially with some of the developing technologies, to continue to expand the use of HCM into other fields such as welfare analysis (see below), husbandry, agricultural research and other laboratory models including rats, fish, chicken and larger species.

Action

Explicitly disseminate the huge number of advantages of HCM systems, with examples of their benefits to research widely to stakeholders (including funding bodies), further targeting both scientific and animal management meetings over Years 3 and 4 (Nov 2023 to Oct 2025).

The number one and most significant challenge from current users and non-users of HCM systems is the financial challenge of setting up a new system. Indeed, some sophisticated systems are priced higher than existing caging/phenotyping equipment and represent a significant strategic outlay for institutes, universities and companies. However, it is possible that the whole picture is sometimes being lost in a comparison with more conventional testing. A concern raised by non-users highlighted that the lack of acceptance of new testing methods is a significant challenge. HCM systems are additive to other methods of phenotyping and welfare assessments, presenting a whole new range of long-term and more continuous measuring that can complement phenotyping efforts. The potential scientific benefits of HCM are exemplified in the survey by the HCM current users highlighting the advantages of 24-hour monitoring of subtle and novel phenotypes without disturbing the animals.

Action

Expansion of WG3 to include a collaborative framework specifically to link up users of similar systems or those analysing similar datasets to promote validation of HCM systems in order to associate HCM indices with hard-core biological relevant data.

The second most significant challenge identified by this survey is that of data management. The vast array of different parameters which can be measured by the HCM systems is daunting, as well as logistically difficult, with some systems including high volumes of data collection and processing prior to any biological analysis. TEATIME Working Group 3 has been focussing on some of the issues relating to current and further development of HCM, in terms of data handling and analyses. Expanding the network to other potential users and offering the opportunity of collaborative working with laboratories already embracing these systems should be a future goal.

This survey indicates many opportunities that development and further adoption of HCM systems could fulfil in the future. A significant proportion of responses indicated a great dissatisfaction in the suitability of existing non-HCM systems (over 20%) with less than 50% indicating that their current tests worked well in meeting the current needs of their studies.

Respondents, both current 'users' and 'non-users' of HCM systems, indicated a wish to collect a range of behavioural indices and physiological parameters. The leading needs related to collecting 24/7 data from individual mice in social context, including social behaviours, body postures, but also welfare indicators, like body temperature and water/food consumption.

This is clearly the most demanding technical challenge to overcome within the settings of standard home cage rearing. Nevertheless, this may allow reduction of the use of some of the currently used "out of the cage" tests that appear to be not suitable tools for phenotyping because of low replicability, high interpretational ambiguity and/or high sensitivity to unspecific stressors. However, this does not apply to all "out of the cage" tests, although novelty-induced exploration can also be assessed when starting out from a home base to better assess the organization/progression of behavioural exploration (commonly as more deterministic than stochastic) as reported for open field exploration.

6 Concluding remarks

The survey conducted by COST TEATIME Action among diverse professional groups has shed light on the current usage of HCM systems and their anticipated future trends:

- 42% of respondents are current users of HCM (mainly Researchers using mice).
- 58% of respondents do not use HCM (mainly Animal Care and Welfare Specialists, Facility Managers, respondent using rats only).
- Current & future benefits of HCM systems focus on improving research quality and ethical standards by comprehensive rodents' longitudinal data collection, minimizing interference,

discovering new behavioural features, recording various experimental parameters, and gaining insights into animal well-being.

- Less favourable aspects are mainly financial and technical support, housing requirements, data analysis and integration issues. Non-users emphasize their concerns about adopting new methods and the practical limitations of the facility's space, pointing out the obstacles associated with implementing new research methods.
- Despite these concerns, 62% of non-users predict that they would start to use HCM systems and 90% of current users foresee an increased demand for HCM systems in the forthcoming years.
- The existing out-of-cage tools only moderately meet the current needs of respondents, indicating significant room for improvement.
- Potential future needs include the ability to study social behaviour and physiological parameters using HCM systems.

Further information:

- Behavioural forum - <https://www.cost-teatime.org/about/thebehaviourforum/>
- HCM catalogue - <https://www.cost-teatime.org/about/technologies/>
- YouTube channel - https://www.youtube.com/@cost_teatime

Acknowledgement

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Annex 1: TEATIME Home Cage Monitoring Survey Questions

1

Which of the following best describes your role?

- Academic/clinical researcher
- Researcher working for biotech/pharma
- Equipment/technology developer
- Animal care and welfare specialist
- Facility manager
- Data manager
- Working in a Contract Research Organisation
- Other: _____

Asked to all

2

Which rodent species does your work focus on? Tick all that apply.

Mice

Rats

Other: _____

Asked to all

3

Most work on rodents has involved them living in one cage (their home cage) and undergoing procedures or experiments in other environments. The idea of home cage monitoring systems is to allow data collection from mice in their home cage by modifying the cage to enable different kinds of measurements and observations.

Do you currently use home cage monitoring systems? *

Yes

No

Asked to all

4

What do you mainly use for in vivo testing?

- Conventional outside home cage tests
- Home cage monitoring systems
- Both

Asked to those who answered “Yes” to Q3 (they currently use HCM)

5

In your opinion, what are the main benefits of home cage monitoring? Select up to 3.

- Reduced disturbance
- Recording different and novel experimental parameters
- Discovery of novel or subtle phenotypes
- Welfare insights
- Long-term continuous data that doesn't miss any part of the circadian cycle
- Other: _____

Asked to those who answered "Yes" to Q3 (they currently use HCM)

In your opinion, what are the main limitations of home cage monitoring? Select up to 3.

- Technical specification, e.g. limited range of parameters
- Technical reliability
- Technical support
- Data storage and back-up
- Data integration from different systems
- Single versus group-housed requirements
- Space
- Financial aspects
- Data analysis
- Maintenance and cleaning
- Types of caging required
- Using enrichment in the cage
- Other: _____

Asked to those who answered “Yes” to Q3 (they currently use HCM)

7

Do you predict a need to increase your use of home cage monitoring systems? *

Yes

No

Asked to those who answered "Yes" to Q3 (they currently use HCM)

8

Do you predict a need to continue your use of home cage monitoring systems? *

- Yes
- No

Asked to those who answered “No” to Q7 (they don’t predict increase)

9

Not everything we do can currently be done with mice in their home cage. What procedures do you perform other than home cage monitoring?

- Additional handling (e.g. weight measurement)
- No other procedures
- Environmental perturbations
- Surgery, including device implantation
- Administration of drugs, gavage
- Behavioural testing
- Blood sampling
- Other: _____

Asked to those who answered “No” to Q7 (they don’t predict increase)

10

Do you predict a need to start home cage monitoring?

Yes

No

Asked to those who answered “No” to Q3 (they don’t currently use HCM)

Not everything we do can currently be done with mice in their home cage. What procedures do you perform outside of the home cage?

- Surgery, including device implantation
- Behavioural testing
- Environmental perturbations
- No special preparation
- Additional handling (e.g. weight measurement)
- Administration of drugs, gavage
- Blood sampling
- Other: _____

Asked to those who answered “No” to Q3 (they don’t currently use HCM)

12

Do you currently see demand for 24/7 monitoring of animals in their home cage?

- Yes
- No

Asked to all

In your opinion, what are the main obstacles to adopting home cage monitoring technologies? Select up to 3.

- Technical and IT support/data management support
- Acceptance of new testing methods
- Awareness of capabilities
- Lack of qualified personnel
- Facility space
- Justification for use
- Legislation
- Cost of ownership
- Difficulty of choice due to the large number of different systems available
- IT infrastructure limitations
- Procurement processes
- Other: _____

Asked to all

14

What data are you mainly interested in?

- Behaviour
- Physiology
- Both
- None of the above
- Other: _____

Asked to all

What additional research data would you like to obtain that your current tests are missing?

- Continuous 24/7 data
- Social interactions
- Urine/faeces composition/quantity
- Data of individual mouse in social context
- Fine motor activity
- Water/food consumption
- Body posture, e.g. stretch-attend posture, rearing, grooming
- Body temperature
- Integrated parameters, e.g. ECG and motor activity
- Other: _____

Asked to all

Where do you see a clear impact of home cage monitoring on welfare? Rank from most important to least important.

	1 - Most important impact	2	3 - Least important impact
Minimally intrusive	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
24/7 monitoring	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Enabling group-housing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Asked to all

How do you think using home cage monitoring could add to animal welfare monitoring? Select up to 3.

- Comprehensive 24/7 monitoring
- Undisturbed by human presence
- Objective and quantitative data
- Early identification of humane end-points
- Maximising data collection and analysis
- Sharing data/dissemination of information
- Other: _____

Asked to all

How important is it that the following automatic real-time notifications are implemented in a home cage monitoring system to trigger timely response?

1 - Very unimportant 2 - Unimportant 3 - Slightly unimportant 4 - Slightly important 5 - Important 6 - Very important

Pre-identified critical behaviours	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Technical issues, e.g. with food, water, flooding of cage	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Body temperature	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Birth	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Notification of humane end-points (e.g. BW<15%)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sudden death	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Asked to all

What else would you like a home cage monitoring system to provide with respect to animal welfare? Select the 3 most important to you.

- Monitor food and water intake
- Identify abnormal behaviour (e.g. stereotypical behaviour)
- Monitoring of reproduction (e.g. mating, birth, litters)
- Regular body weight recording
- Monitor social interaction and/or aggression
- Other: _____

Asked to all

Please rank the impact of the following points on animal welfare.

	1 - Highest impact	2	3	4 - Lowest impact
Non-enriched or suboptimal environment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Environmental stressors caused by the system (e.g. ultrasonic noise)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Single-housing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
ID tagging	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Asked to all

22

Are there additional welfare challenges?

Your answer

Asked to all

23

Please write any additional thoughts or comments.

Your answer

Asked to all

24

What country are you based in?

Your answer

Asked to all

25

If you would like to receive the final report prepared from the results of this survey, please enter your email address here. It will not be used for any other purpose.

Your answer

If you have provided your email address, would you also like to sign up to the TEATIME newsletter?

Yes

No

Asked to all