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Publication date:
2016

Document version
Publisher's PDF, also known as Version of record

Citation for published version (APA):
Nøhr, R., Lund, T. B., & Lassen, J. (2016). *The Danish 3R survey: knowledge, attitudes and experiences with the 3Rs among researchers involved in animal experiments in Denmark*. Department of Food and Resource Economics, University of Copenhagen. IFRO Report No. 249

Download date: 10. 10월. 2026

DEPARTMENT OF FOOD AND RESOURCE ECONOMICS
UNIVERSITY OF COPENHAGEN

IFRO Report

The Danish 3R Survey

Knowledge, attitudes and experiences with the 3Rs among researchers involved in animal experiments in Denmark

Rikke Nøhr
Thomas Bøker Lund
Jesper Lassen

249

IFRO Report 249

The Danish 3R Survey:
Knowledge, attitudes and experiences with the 3Rs among researchers involved in animal experiments in Denmark

Authors: Rikke Nøhr, Thomas Bøker Lund, Jesper Lassen

Published May 2016

This report is the result of a project commissioned by the Danish 3R Center.

IFRO Report is a continuation of the series FOI Report that was published by the Institute of Food and Resource Economics.

ISBN: 978-87-92591-69-2

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Preface

A significant part of the Danish 3R Centers' work is dedicated to supporting the implementation of the 3Rs in practice by, amongst other things, disseminating knowledge about the principles to relevant stakeholders. In order to reinforce the activities and assess their effect, the centre commissioned a study of stakeholders' knowledge and experience of the 3Rs in Denmark.

The study was carried out at the Department of Food and Resource Economics, University of Copenhagen, between May 2015 and March 2016 and is reported in this publication. The project was designed and carried out by a research group consisting of

- Jesper Lassen, professor
- Thomas Bøker Lund, associate professor
- Rikke Nøhr, research assistant.

We would like to take this opportunity to thank the advisory group that has provided valuable input and comments along the entire project – the advisory group consisted of

- Lisbeth E. Knudsen, professor, Department of Public Health, University of Copenhagen (board member at the Danish 3R Center)
- Jan Lund Ottesen, Jan Lund Ottesen, Laboratory Animal Science, Novo Nordisk A/S (board member at the Danish 3R Center).

We would also like to extend our thanks employees at the Danish 3R Center, who have also offered valuable comments and provided practical assistance during the project: Tom Bengtsen, head of Secretariat; Louise Bjørn Brønden, academic staff member; Anne Sofie Grove, academic staff member and Eyd Anni Nilssen.

Despite the invaluable contributions from the advisory group and the staff at the Danish 3R Center, it must be stressed that the report's wording, content and conclusions is the responsibility of the research group.

Last, but not least, we would like to thank the eight license holders, animal technicians and former animal experiment practitioners who so generously offered their valuable time and participated in interviews in the summer 2015, as well as all the animal researchers who took their time to complete the questionnaire.

Frederiksberg, March 2016

1 Summary

The newly established Danish 3R Center aims to focus on alternatives to animal testing and to create better conditions for laboratory animals and to support the implementation of the 3Rs in practice by, amongst others, disseminating knowledge about them to relevant stakeholders. In order to reinforce the Danish 3R Center's activities and assess their effect, a study was conducted to examine relevant stakeholders' knowledge and experience of the 3Rs.

The purpose of this project is to conduct a study of the knowledge of, attitudes to and experiences with the 3Rs amongst Danish researchers involved with animal experiments, as well as their expectations of the Danish 3R Center, including how the centre can assist in disseminating knowledge about the 3Rs throughout the research community. Together, this will help to improve the basis for further implementation of the 3Rs with respect to laboratory animals in Denmark, while it will also establish a baseline that will enable the future evaluation of efforts in this area.

The study comprises a quantitative study with a questionnaire issued to animal researchers. A total of 293 animal researchers participated in the online survey, of which 234 responded to all 54 questions. This questionnaire was developed following in-depth interviews to uncover relevant aspects concerning the research environment of animal experiments.

The majority of the animal researchers assessed their knowledge of the 3Rs to be good. Researchers from the private sector are particularly confident regarding their knowledge of the 3Rs. The level of understanding of the principles of reduction, refinement, and replacement is, in general, relatively high, although a considerable proportion responded incorrectly to one or a few of the presented statements.

The majority of the animal researchers have the opinion that it is acceptable to use animals for important research endeavours, and that it is acceptable to use a range of animals. Despite this, there is also considerable agreement that the welfare of animals is very important.

Only a minority of the researchers think that the complete replacement of animal experimentation will be achieved in the future, e.g. by replacing whole animals with computer simulations. On the other hand, a considerable proportion is of the opinion that the implementation of the 3Rs will not be detrimental to their work.

Regarding the animal researchers' experience with implementation and barriers and attention to the 3Rs, a clear majority of the researchers said that refinement and reduction play a role when they plan and carry out experiments, and many have developed techniques to refine and reduce the use of animal. Even replacement plays a role for many when planning and designing experiments, although it is less clear how this happens in practice. The majority of animal researchers talk about the 3Rs and animal welfare conditions, in general, with their colleagues in their daily work.

The majority of the researchers point to a lack of appropriate scientific or technological innovation as the main obstacle to implementing the 3Rs, though a great proportion does not think that there are any obstacles.

The researchers perceive the main requirements regarding the implementation of reduction to be increased data sharing or collaboration between research groups and companies.

The majority reports that no factor would allow them to continue to achieve their research objectives without using animals since their work demands that they look at the whole animal system. Scientific

factors such as greater availability of human tissues, more relevant cell cultures and more predictive computer models were the most important requirements in terms of being able to replace animals in experiments.

Concerning knowledge sharing regarding the 3Rs, the majority of the researchers turn to their network or the Internet when seeking information about the 3Rs. Most of the researchers experience that knowledge sharing about the 3Rs works very well between researchers at their workplace and between researchers and animal keepers.

The Danish 3R Center can be said to be fairly well known among the researchers in this field, and the majority think that the centre is important for people working with experiments in Denmark. The researchers from the public sector consider applying for research funding from the Danish 3R Center more often than researchers employed in the private sector.

Regarding the *frequency of communication about animal welfare* and *understanding of refinement*; both depend on whether the animal researcher works in the public or private sector as there is more communication about animal welfare issues in the private sector compared to the public sector, while the level of understanding is lower in the public sector.'

Whether the *3Rs are considered during the design phase* depends on a number of factors; the focus is significantly more prevalent among scientists working in the public sector and among those who have managerial responsibility. More research activities devoted to teaching and higher applied research activity results in significantly less focus on 3Rs during the design phases. Propensity to *consider the 3Rs at an everyday level* is higher in the private sector, while no other factors explained this. *Reluctance to implement animal welfare concerns* was higher among researchers working in the public sector. Reluctance was also higher among men, researchers with higher responsibility, researchers with Danish background, and medical scientists (compared with researchers with veterinary or biological/chemist educational background).

The results from this survey point at some future action points that the Danish 3R Center can pursue in their future activities. A dual strategy is recommended where the centre, on one hand, focusses its attention on disseminating information about the 3Rs to scientists in the public sector, where it is especially relevant to increase knowledge and the understanding as to how to make the 3Rs operational in the daily work, and to decrease reluctance. On the other hand, it is also important to offer conferences/seminars (e.g. the annual symposia). This is requested especially much by scientists in the private sector. The meetings should focus on inviting the researchers to exchange experiences under less formal conditions.

2 Introduction

The Danish 3R Center was established on 4 June 2013 by the Food Minister as collaboration between the Ministry of Food, the pharmaceutical industry and animal welfare organizations. The name for the centre was inspired by the principles of the 3Rs suggested by Russell and Burch (1959); Replacement, Reduction and Refinement. The principles provide the basis for working towards a research practice where animal testing/experiment is unnecessary (replacement); which uses as few animals as possible (reduction), and; ensures that the laboratory animals that are still necessary are burdened as little as possible (refinement). The centre aims to initiate activities that may result in the implementation of the 3Rs. Moreover, the Danish 3R Center must work to create a forum for collaboration and knowledge sharing about the 3Rs and investigate research in the area.

A significant part of the centre's work is dedicated to supporting the implementation of the 3Rs in practice by, amongst other things, disseminating knowledge about the principles to relevant stakeholders. In order to reinforce the activities of the Danish 3R Center and assess their effect the centre financed the study reported here, which sheds light on stakeholders' knowledge and experience of the 3Rs in Denmark.

Today, more than 50 years after Russell and Burch (1959) suggested the principles of the 3Rs, they constitute an integral part of the regulation regarding the use of laboratory animals in many countries. Thus, in the EU, the 3Rs represent a core element in the revised directive on the protection of animals used for scientific purposes (European Parliament and Council 2010). The scope of the directive as described in article 1 is to establish "measures for the protection of animals used for scientific or educational purposes". To this end, it lays down rules on the following: (a) the replacement and reduction of the use of animals in procedures and the refinement of the breeding, accommodation, care and use of animals in procedures;…".

Despite this regulatory focus on the 3Rs, relatively few studies have documented knowledge of and attitudes to the 3Rs among animal researchers, just as few studies have examined the extent to which the 3Rs are implemented and taken into consideration in actual research practice. Some studies have, however, addressed the relationship between the general public's acceptance of animal experiments and the 3Rs, while a few other studies have examined the perceptions and practices of researchers, members of the animal ethics committees or others in the daily work or training for the use of laboratory animals. Existing studies have been carried out covering some, but not all countries in the EU and countries like Canada, Portugal, the Netherlands and the UK. Therefore, no published studies focus on researchers' practices or perceptions of 3Rs in a Danish context.

Results from the existing studies show that, on the one hand, the 3Rs are received favourably by practitioners and researchers involved in animal experiments (Fenwick, Danielson & Griffin 2011; van Luijk et al. 2013; Schiffelers et al. 2007). On the other hand, studies show that there are differences in the degree to which the various principles are implemented. The typical picture seems to be that the principle of replacement, in particular, causes problems, while there are better experiences with refinement and reduction. This issue is likely to reflect an underlying value-based conflict (Sandøe et al. 2015); namely that replacement is based on the aim of not using laboratory animals at all, while the other two Rs are based on the idea that the use of laboratory animals is necessary.

Several studies point to knowledge and understanding of the 3Rs as essential for successful implementation. A Dutch study of Animal Welfare Officers, responsible for monitoring the welfare of laboratory

animals and training relevant staff, indicated that although knowledge to some extent is available, it is considered difficult to access (van Luijk et al. 2013). A Portuguese study of participants in Laboratory Animal Science (LAS) courses, which among other things included training in the 3Rs, showed that the level of knowledge before the start of the course was relatively low (Franco & Olsson 2014). A follow-up survey showed that the teaching was effective, and that after a year, awareness and knowledge of the 3Rs had increased - particularly regarding refinement - just as the participants reported increased implementation of the 3Rs in their daily work with laboratory animals.

Studies in other areas suggest that researchers working with laboratory animals are more inclined to accept the use of animals in experiments than other societal groups (Knight et al. 2009). It is likely that this also applies when it comes to the perception and the willingness to implement the 3Rs. An important factor in relation to attitudes to and implementation of the 3Rs presumably is the character of the experiment – including, not least, where the animal is placed on the socio-zoological scale (Franco & Olsson 2014).

However, it should be emphasized that because of national and cultural differences in the institutions and companies involved with laboratory animals, as well as differences in, e.g. regulations it is simply not possible to generalize these results to Denmark. Nevertheless, the existing studies seem to point to some common features that have inspired the Danish survey of knowledge and experience among researchers involved with animal experiments reported in this publication.

2.1 Purpose and research questions

The overall purpose of this project is to survey knowledge, attitudes and experiences with the 3Rs among researchers involved in animal experiments in Denmark, as well as their attitudes to the use of animals in experiments. Furthermore, the aim is examine how the Danish 3R Center may assist to ensure knowledge production and the dissemination of the 3Rs in the research community.

Specific attention is payed to examining the differences between researchers working in public research institutions and private (typically medical) companies. This is relevant since the differences between the sectors can help the Danish 3R Center identify where special attention regarding activities about implementation and dissemination is required. Taken together, this will help improve the basis for further implementation of the 3Rs with respect to laboratory animals in Denmark and establish a baseline enabling the future evaluation of efforts in this area.

To meet these aims, the project has been guided by the following research questions:

1. How well do researchers working with animal experiments in Denmark know the 3Rs and what are their attitudes to animal experimentation and the 3Rs?
2. To what extent have the 3Rs been implemented and how much attention are they given by researchers working with animal experiments in Denmark - from the design of projects to the daily practice at experimental facilities - and what are the barriers to deployment?
3. How do researchers working with animal experiments in Denmark perceive the accessibility of knowledge and information regarding the 3Rs and concrete measures that can help improve their practice?
4. How familiar are researchers working with animal experiments in Denmark with the Danish 3R Center and how do they perceive its role in relation to current and future actions concerning the 3Rs?

As previously mentioned, this report also attempts to identify possible differences between researchers employed in the public and private sector. The fifth aim is to explore the most pertinent differences that have been identified by the first four research aims in more detail:

5. Do socio-demographic factors, different types of research activity and managerial status explain the differences between public and private sector researchers regarding *frequency of communication about animal welfare issues*, *understanding of refinement when the 3Rs are considered* in the research process and *reluctance* towards implementing animal welfare concerns?

3 Method and data

The study design included an initial qualitative interview study aimed at exploring the relatively unmapped field. This was followed by a survey of researchers working with animal experiments in Denmark.

3.1 The qualitative interviews

Due to the scarcity of studies in the area, and because most of the existing studies are quantitative, qualitative interviews with license holders, animal technicians and former animal experiment practitioners were carried out. This population was chosen to uncover relevant aspects surrounding the research environment of animal experiments, while respecting that relevant concern could be expressed not only by the researchers themselves, but also other persons engaged in animal experiments.

The aim of these preliminary interview-based studies was to create an understanding of knowledge, attitudes and practices relevant to the five research questions that could be used to strengthen the basis for developing the questionnaire and qualify the interpretation of the results of the questionnaire.

8 interviews were conducted in June-July 2015 with license holders, animal technicians and toxicologists (non-animal users). Respondents were recruited using the snow-balling method, where one or more persons within the field identify and contact relevant respondents, and a number of criteria are established by the project team. The interviews lasted around one hour, and took place at the respondent's workplace. The interviews were structured by an interview guide, and were prepared based on an initial literature review of existing scientific studies in the field. The interview guide included aspects of knowledge, attitudes and practices in relation to the five research questions, with a special focus on the challenges of replacement. The analysis of these interviews helped identify relevant aspects that were included in the quantitative survey such as:

- Participation in the 3R-training and/or education regarding the 3Rs
- Specific experiences concerning implementation of the 3Rs
- Attitude to animal experiments in a teaching context
- The need for knowledge sharing regarding the 3Rs
- Economic constraints related to the implementation of the 3Rs
- Arguments against replacement
- Attitude to the 3Rs in general
- General barriers to the 3Rs, including administrative requirements, lack of equipment/knowledge, data requirements.

3.2 The survey

This is a total population study of researchers working in Denmark in public and private research institutions involved in animal experiments. The study addresses this population because these researchers have the practical responsibility for organizing each of the experiments carried out and thus make up an essential group when it comes to integrating the 3Rs in the experimental protocols and daily practices. By choosing this particular population, we exclude other relevant groups such as stu-

dents, who may be expected to work with laboratory animals in the future, as well as other employees handling the experimental animals on everyday daily basis.

3.2.1 Recruitment and response rate

Since there is no census registration of all scientists fulfilling the population criteria, it was not possible to contact all members of the population directly. However, an important part of the population, namely the 455 researchers holding a license to conduct animal experiments in Denmark, is registered by the Danish Veterinary and Food Administration (DVFA). This sub-population was approached directly by DVFA in order to respect legal concerns about the use of this database. Specifically, DVFA invited the 455 registered license holders in Denmark to participate in the survey by email which contained a link to the online questionnaire.

Since there is no systematic registration, it was not possible to send the link to the survey directly to the other important part of the population, i.e. researchers working with animal experiments who do not have a license themselves, but who are covered by another person's license. Instead, these individuals were approached indirectly via the license holders, who were encouraged to forward the link to the survey to all relevant researchers within their organization. In addition, the 41 Animal Welfare Bodies which is mandatory for all institutions to have conducting animal experiments were also approached and encouraged to pass on information about the survey to relevant researchers.

These activities resulted in a total of 293 researchers participating in the online survey. 234 respondents completed the entire 54 questions. As noted above, because there are no available data regarding the total size of the population, response rates could only be calculated based on the sub-population comprising the license holders. Of the 234 respondents who completed the survey, 168 were license holders. This gives a response rate of 37%.

3.2.2 Non-response analysis

Since the response rate is below 100%, the total population is not included in the data set. This raises the question of whether the data suffer from non-response bias. Unfortunately, there are no census data available that can be used to test how representative the dataset is or subsequently assess non-response bias. Nevertheless, a rough assessment of the quality of the data is possible by analyzing the regional distribution of the respondents from public research institutions. Thus, since Danish universities are placed in different administrative regions in Denmark, the sample would be expected to reflect this and that the respondents employed in the public sector would be distributed across these regions. Indeed, this is the case as public sector researchers works in the Capital Region (University of Copenhagen), Region Zealand (Roskilde University), Region of Southern Denmark (SDU), and Region of Central Denmark (Aalborg and Aarhus University) - see table 1.

Table 1. Distribution of respondents by administrative region and sector

Region/Sector	Private sector		Public sector		Both sectors		Total	
	Percent	N	Percent	N	Percent	N	Percent	N
Capital Region of Denmark	83	60	52	79	88	7	62	139
Region Zealand	14	10	5	7	0	0	7	17
Region of Southern Denmark	1	1	12	18	0	0	8	19
Region of Central Denmark	1	1	32	49	13	1	22	50
Total	100	72	100	153	100	8	100	233

As most medical firms are located in the Capital Region or Region Zealand, assessing the quality of the private sector respondent pool on this point is not relevant. A potential concern is that researchers employed by the few major medical companies like Lundbæk and Novo Nordisk may be over-represented in the sample. However, table 2 indicates that this is not the case since there is a fairly even distribution of privately employed respondents by company size, where private sector respondents who work in companies with less than 10,000 employees are presumably from medical companies other than Lundbæk and Novo Nordisk.

Table 2. Distribution of privately employed respondents by company size

Number of employees (private sector only)	N	Percent
1-100	19	24
101-1,000	12	15
1,001-10,000	20	25
10,001-35,000	28	35
Total	79	100

(Company size is based on the respondents' assessment of the number of people employed by their company in Denmark.)

All in all, it seems fair to conclude that the sample represents a fairly wide spectrum of public and private employed researchers as assessed according to the distribution of region and company size. This, however, does not rule out the risk of non-response bias. Essentially, the effect from non-response bias on reported proportions and means cannot be estimated. However, in section 4.7, a multivariate analysis is conducted with respect to a number of important dimensions. This analysis shows that the covariates included in the models, on average, do not significantly affect the examined dimensions. This suggests that non-response bias may be low. An exception to this is the case of reluctance towards implementing animal welfare concerns in animal experimentation. Here, covariates, such as educational background, gender, and nationality are associated with propensity for reluctance. For this reason, it cannot be ruled out that the overall level of reluctance may deviate from the true level.

3.2.3 The questionnaire

Apart from being based on the qualitative interviews, another source of inspiration for the questionnaire was a survey carried out by the British *National Centre for the Replacement, Refinement and Reduction of Animals in Research* (NC3R 2008). The NC3R study examined how British researchers using animals understand and implement the 3Rs. In order to enable comparison to Britain, several of the questions in the NC3R survey were replicated in the questionnaire.

The questionnaire included sections on the respondents' socio-demographic background; knowledge and attitudes towards the 3Rs; implementation and barriers to the 3Rs from the design of projects to the daily practice in laboratory facilities; accessibility of knowledge and information on the 3R's and, finally, knowledge of the Danish 3R Center.

3.2.4 The quantitative analysis

The quantitative analysis is reported in chapter 4 and is structured around the following five themes:

- Researchers' knowledge of and attitudes to the 3Rs
- Implementation to the 3Rs
- Sharing knowledge about the 3Rs
- Researchers' attitudes towards the use of animals in research in general
- Researchers' views of the Danish 3R Center

Throughout the analysis, relevant comparisons with the NC3R survey are made just as there is a continual focus on identifying possible differences between the public and private sector researchers. When statistically significant differences exist between the sectors, the p-value from the chi^2 tests is reported below the relevant figure. The statistical level of significance is set to 5%.

In the analysis, the sample total is the 234 respondents who completed the questionnaire. Since eight respondents reported that they work in both sectors, these individuals were excluded from the sector comparisons – resulting in a total of 226 respondents.

The analysis concludes with an examination of whether socio-demographic factors, different types of research activity and managerial status explain the differences between the two sectors. This part of the analysis focuses on the following three aspects; 1) the frequency of communication about animal welfare issues; 2) understandings of refinement, and; 3) when the 3Rs are considered in the research process and reluctance to implement animal welfare concerns. In this analysis, composite variables were constructed to analyse the associations through a multivariate analysis.

4 Results

The population of 234 researchers in the survey is divided according to gender. Thus 117 of the respondents are male and 117 were female. The average age of the respondents is 43.9 with a standard deviation of 11 years; and the majority (43%) is in the age group 40-55 years. 82.5% of the researchers are Danish, and over half (63%) work in the Capital Region of Denmark.

65% of the respondents have a Ph.D., 24% have a Master's degree, 1% a Bachelor's degree, while 10% reported having another educational level above Bachelor level (e.g. Dr. Med.).The majority has an educational background in biology/chemistry/pharmacy (55%). 27% have a veterinary education; while 15% are medical doctors. 3% have another educational background (including, e.g. agronomy, animal technician, animal keeper). Most of the researchers from the public sector (60%) have an educational background in biology, chemistry or pharmacy, while fewer have a veterinary education (17%) or an education in medicine (22%). By contrast, of the private sector researchers, 49% are veterinarians, 51% have an educational background in biology, chemistry or pharmacy, while there are no (0%) medical doctors.

The majority (72%) of the respondents are license holders, while the remaining 28% are researchers involved with animal experiments working under another person's license.

More than a fourth (27%) did not work with animal experiments in their previous positions. Close to half (48%) have 1-10 years of experience with animal experiments from previous employment. Looking at their current research position, 15% report that they have more than 20 years of experience. 21% have between 11 and 20 years of experience with animal experiments, while more than half (53%) have 1-10 years of experience. 10% have less than one year of experience in their current job position.

66% of the sample is employed in the public sector, 31% in the private sector, while 3% reported working in both sectors. See Appendix 1 for an overview table.

4.1 Knowledge of and attitudes to the 3Rs

This section examines knowledge and awareness of and attitudes to the 3Rs among researchers in Denmark. Knowledge is reported by examining respondents' self-reported knowledge and their factual knowledge (or understanding) as determined by a 'knowledge quiz'. Awareness is captured by seminar attendance and first encounter with the 3Rs. Finally, attitudes to the 3Rs are assessed by examining a number of statements related to the 3Rs, in general, or one of the specific R principles, where respondents were asked to note their level of disagreement/agreement.

4.1.1 Sources of knowledge

69% of the researchers reported that they had first heard about the 3Rs five or more years ago – with the privately employed generally having known about the concepts for longer than those from the public sector (see figure 1)

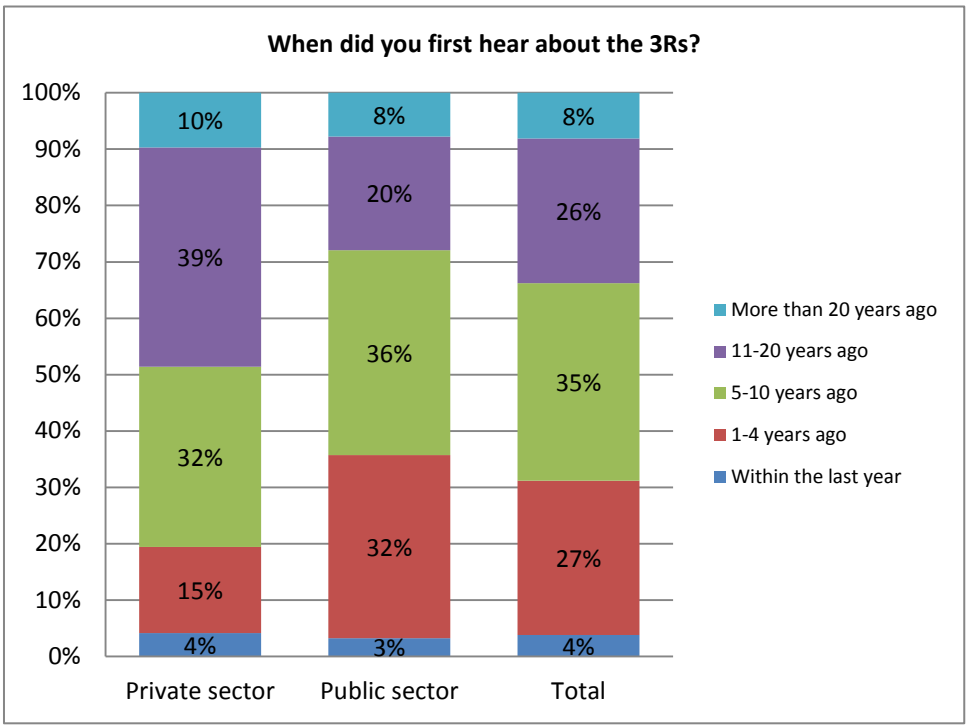

Figure 1. Time elapsed since first encounter with the 3Rs – total and by sector

(The sample total is 234, while the category of the public and the private sector contains 226 respondents. P-value: 0.013)

As can be seen in figure 2, half of the researchers (52%) first encountered the 3Rs during their education. This group is dominated by the privately employed of whom 65% had their first encounter during their education, compared with only 45% of the publicly employed. By contrast, the 14% who heard about the principles for the first time at other courses or seminars is dominated by the publicly employed. Most of the remaining 34% of the respondents could either not recall their first encounter (8%), had heard about the 3Rs from colleagues (7%) or during in-house training. Notably few (4%), all publicly employed, had heard about the 3Rs for the first time from the Danish 3R Center.

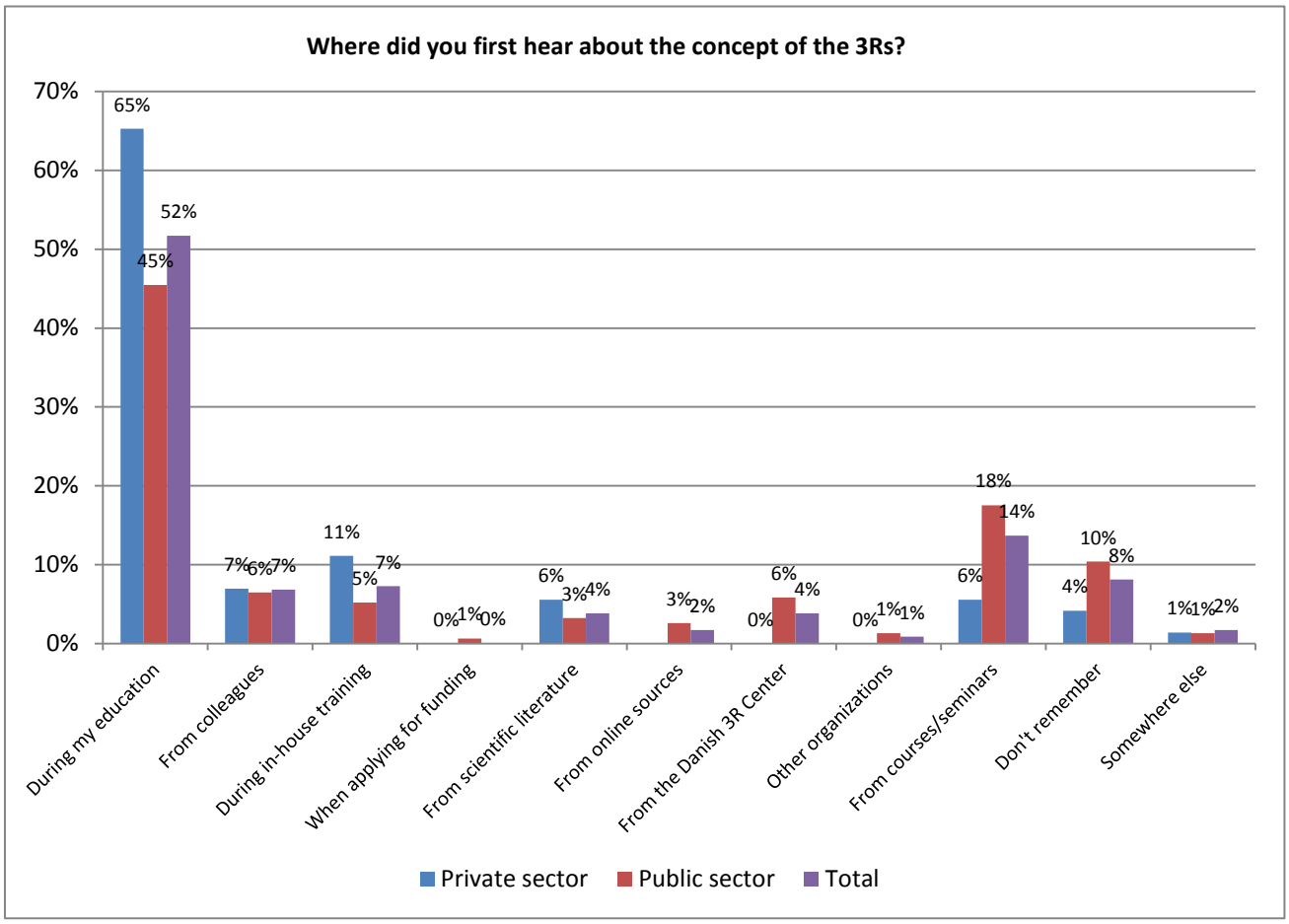

Figure 2. Location of first encounter with the 3Rs – total and by sector

(The sample total is 234, while the category of the public and the private sector contains 226 respondents. Respondents were asked to choose only one answer. P-value: 0.017)

Almost a third (31%) of the researchers have never participated in a seminar, conference and/or workshop about the 3Rs (see figure 3); another third (37%) have attended such activities 1-2 times and the remaining third, three or more times. Private sector researchers attend significantly more seminars, etc. than do public sector researchers – thus only 10% of the private sector researchers have never attended such activities, compared to 42% of the public researchers.

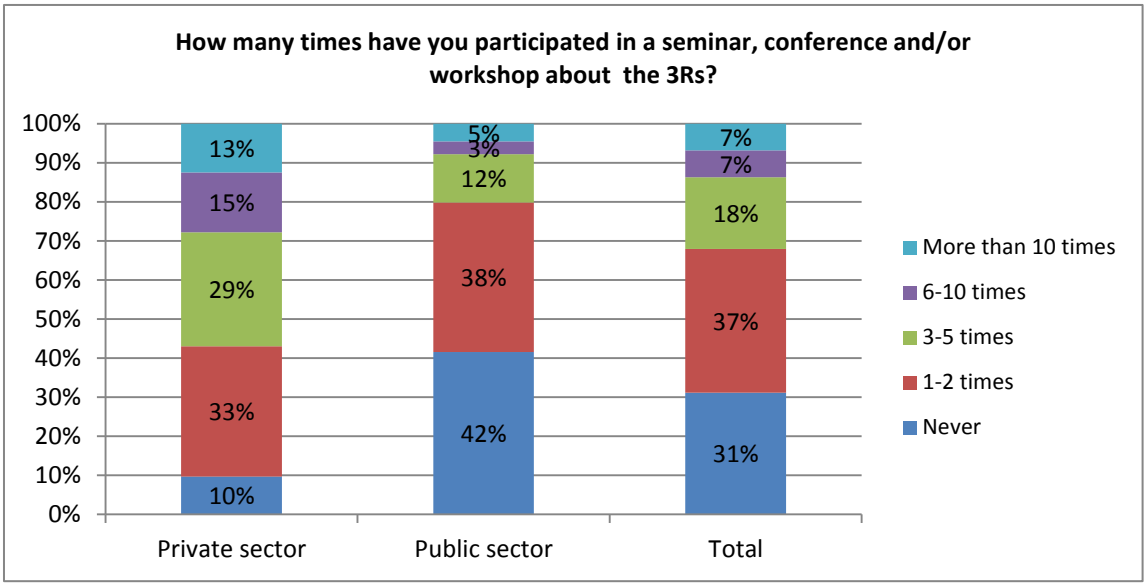

Figure 3. Frequency of participation in 3R related arrangements – total and by sector

(The sample total is 234, while the category of the public and the private sector contains 226 respondents. P-value: 0.00)

4.1.2 Self-reported knowledge of the 3Rs

Overall, the level of self-reported knowledge is high – see figure 4. When asked how familiar they were with the 3Rs, the majority of the researchers reported that they knew them *well* (47%) or *very well (45%).* By contrast, few respondents (8%) when asked how well they knew the 3Rs replied *not very well*, while none (0%) replied that they did not know the 3Rs at all. Between the sectors, the level of self-reported knowledge was significantly higher among the privately employed; 67% answering *very well* compared to 35% for the public sector employees. Similarly, 1% of the private sector employees reported that they did not know the principles at all compared to 11% of the publicly employed.

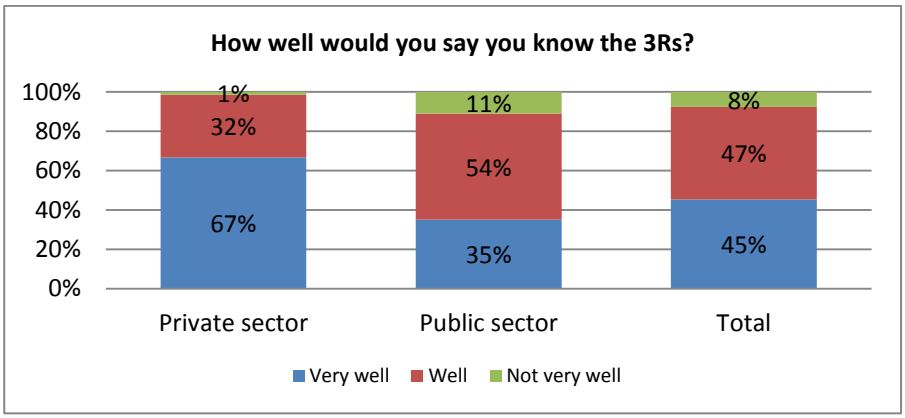

Figure 4. Self-reported knowledge of the 3Rs – total and by sector

(The sample total is 234, while the category of the public and the private sector contains 226 respondents. P-value: 0.00)

4.1.3 Factual knowledge: Understandings of the 3Rs

Inspired by the British NC3R survey, respondents were presented with a knowledge quiz, where they were asked if a number of claims fit their understanding of replacement, reduction and refinement. The claims included false as well as correct statements about the principles. The results show that Danish researchers involved in animal experiments, in general, have a good understanding of the 3Rs, although there are some exceptions. There is no sector specific difference in the understanding of reduction and replacement, while the public sector researchers have a poorer understanding of refinement compared to researchers from the private sector.

Replacement

The majority of the researchers selected the three correct statements about replacement - see figure 5. Thus, 93% agreed that replacement involves *replacing animals with in vitro techniques;* 72% agreed that replacement involves *redesigning experiments in order to avoid the use of animals* and 76% agreed with the last correct claim that stated that *replacing animals with computer modelling techniques* is replacement. 29% chose the incorrect answer *replacing vertebrates with invertebrates* while even fewer (22%) ticked the false statement that replacement involves *replacing higher mammals with lower mammals*. The only sector specific difference in the understanding of replacement appeared in relation

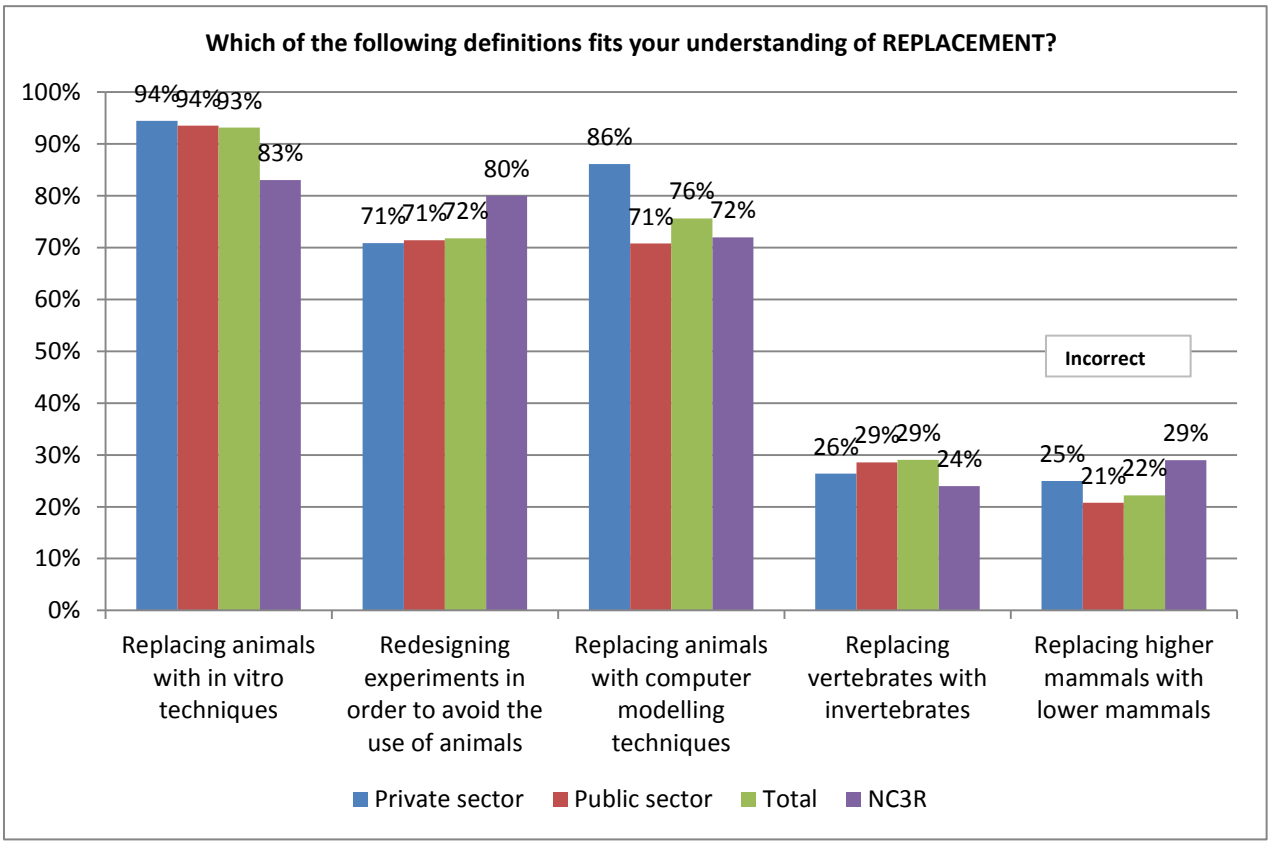

Figure 5. Researchers' understanding of replacement – total and by sector and compared to NC3R

(The sample total is 234, while the category of the public and the private sector contains 226 respondents. The NC3R sample includes 1,529 British researchers. Respondents were asked to tick all that apply.)

to the (correct) statement which suggested that the replacement of animals with computers is a replacement initiative with a significantly higher share of the publicly employed agreeing (p=0,012).

Refinement

A relatively high proportion of the researchers chose the three correct statements about refinement – see figure 6. Thus, 87% chose *improving procedures so that the animals experience less pain and suffering*; 72% selected *improving animal welfare by minimizing suffering and providing better housing conditions* and 59% identified *improving the conditions in which animals are kept* as a correct statement. For all of the correct statements, a notably higher share of researchers from the private sector identified the correct statement.

Several studies suggest that the concept of refinement is often misinterpreted. This is also the case in this study in which about half (47%) of the researchers chose the incorrect statement, defining refinement as *Improving experiments so that fewer animals are used,* while more than half (57%) chose the other incorrect statement that refinement is about *improving experiments to yield better data.* The misinterpretation of refinement can be said to be a bit more prevalent in the public sector, since over half (53%) of the public sector chose the incorrect statement *Improving experiments so that fewer animals are used* while only 33% of the researchers from the private sector chose this statement.

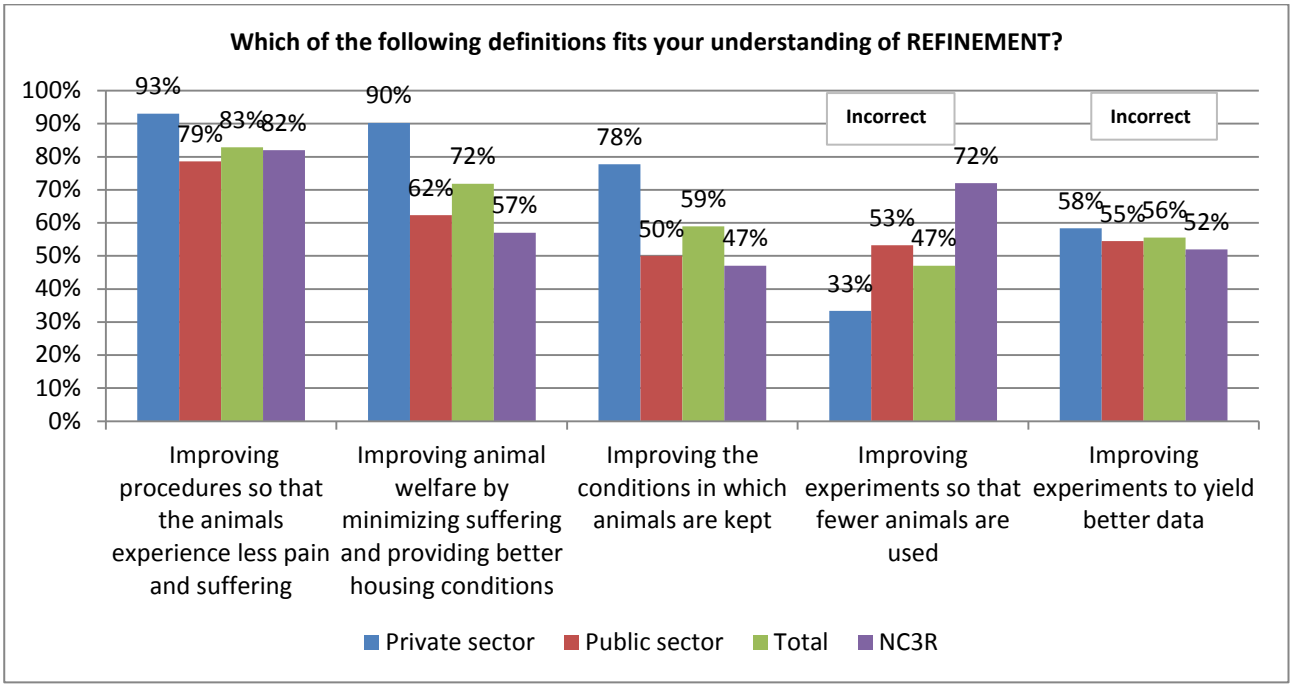

Figure 6. Researchers' understanding of refinement – total and by sector and compared to NC3R

(The sample total is 234, while the category of the public and the private sector contains 226 respondents. The NC3R sample includes 1,529 British researchers. Respondents were asked to tick all that apply. P-values: Improving procedures so that the animals experience less pain and suffering: 0.007; Improving animal welfare by minimizing suffering and providing better housing conditions: 0.00; Improving the conditions in which animals are kept: 0.00; Improving experiments so that fewer animals are used: 0.006)

Reduction

Almost all respondents (95%) identified the correct statement that reduction is about *obtaining comparable levels of information in your experiment while using fewer animals.* 78% identified the correct

statement about reduction being about *reducing the number of animals used per experiment,* while 56% identified the statement *obtaining more information in your experiment while using the same number of animals* as the correct definition of reduction – see figure 7. There is no significant difference between the sectors concerning the understanding of reduction.

The incorrect answer *reducing the degree of pain and suffering caused to animals by your procedures* was chosen by a quarter of the respondents (23%), while the other incorrect statement suggesting that reduction is about *reducing the overall number of animals used in research overall in Denmark* was chosen by a third (34%) of the respondents.

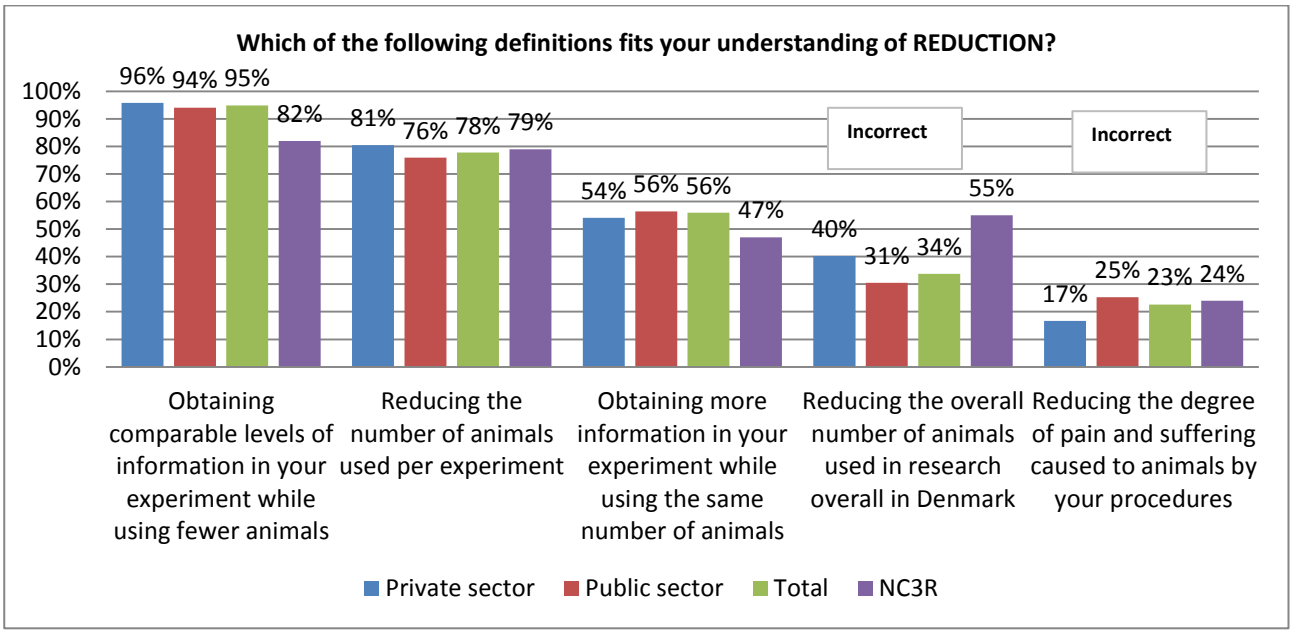

Figure 7. Researchers' understanding of reduction – total and by sector and compared to NC3R

(The sample total is 234, while the category of the public and the private sector contains 226 respondents. The NC3R sample includes 1,529 British researchers. Respondents were asked to tick all that apply.)

4.1.4 Attitudes to the 3Rs

To uncover the respondents' attitudes to the 3Rs, a number of questions were included in the questionnaire. Figure 8 shows how the researchers view the possibility of completely replacing the use of animals in research and testing. 79% either strongly agree or agree with the statement that this will never happen, while only 6% of the researchers tend to disagree, and consider it likely that complete replacement will be realized. Researchers from the private sector tend to be slightly more optimistic regarding the prospects of achieving complete replacement than publicly employed researchers.

To uncover the perceived relation between implementing the 3Rs and the quality of research, the researchers were also asked to indicate to what degree they agreed with the statement that implementing the 3Rs would be detrimental to the quality of their results. As figure 9 shows, the majority (76%) either disagreed or strongly disagreed with the statement, while only a minority (9%) tended to agree.

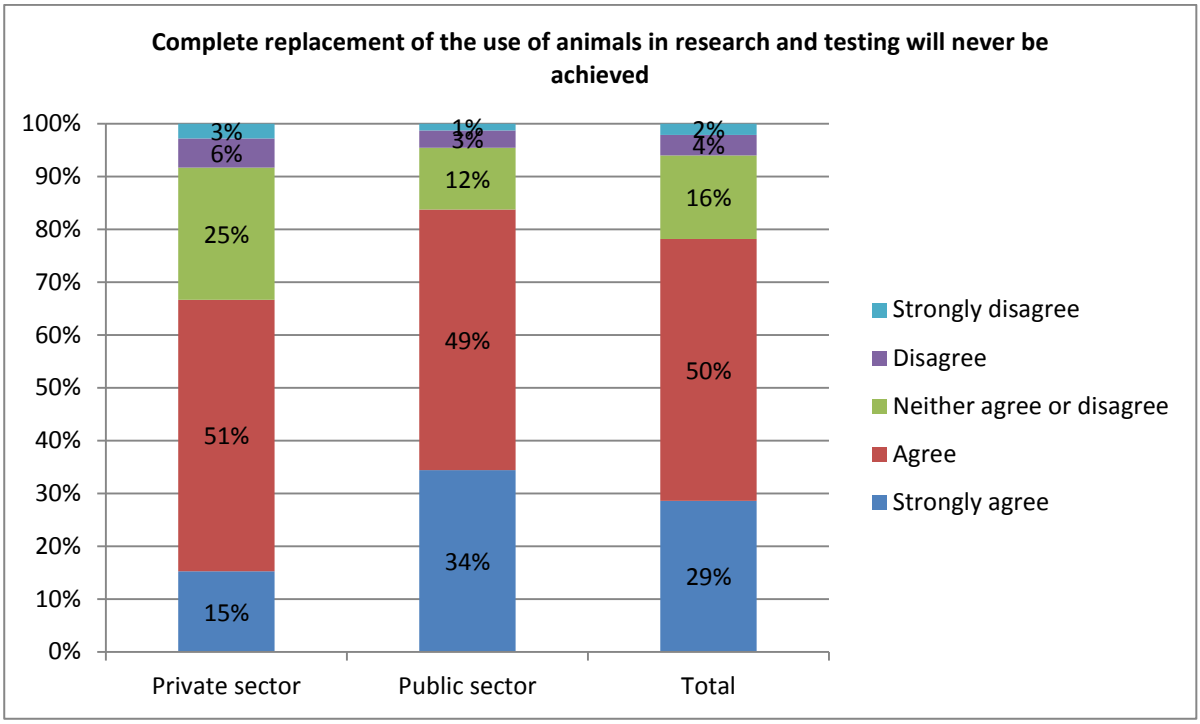

Figure 8. Expected realization of complete replacement – total and by sector

(The sample total is 234, while the category of the public and the private sector contains 226 respondents. P-value: 0.011)

There is, however, a highly significant difference between the sectors as more than half (53%) of the private sector researchers strongly disagreed that the 3Rs would be detrimental to the quality of their research, compared to about a fifth (22%) of the publicly employed.

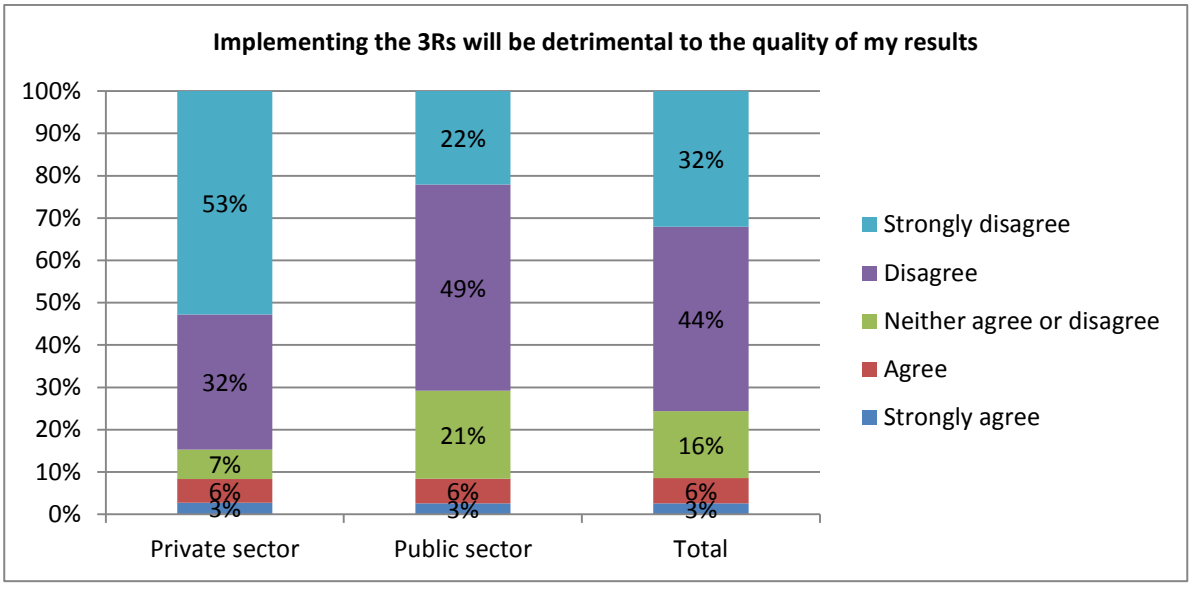

Figure 9. Perceived impact of the 3Rs on the quality of results – total and by sector

(The sample total is 234 respondents, while the category of the public and the private sector contains 226 respondents. P-value: 0.00)

Further, the researchers were asked to indicate to what extent they agreed that using computer simulation would one day accurately represent whole animals – see figure 10. Here the majority (57%) of the researchers answered that they either disagreed or strongly disagreed with the statement that this would happen in the future. Again, there is a significant difference between the sectors, as private researchers tended to be more optimistic regarding the prospects of computer models replacing animals.

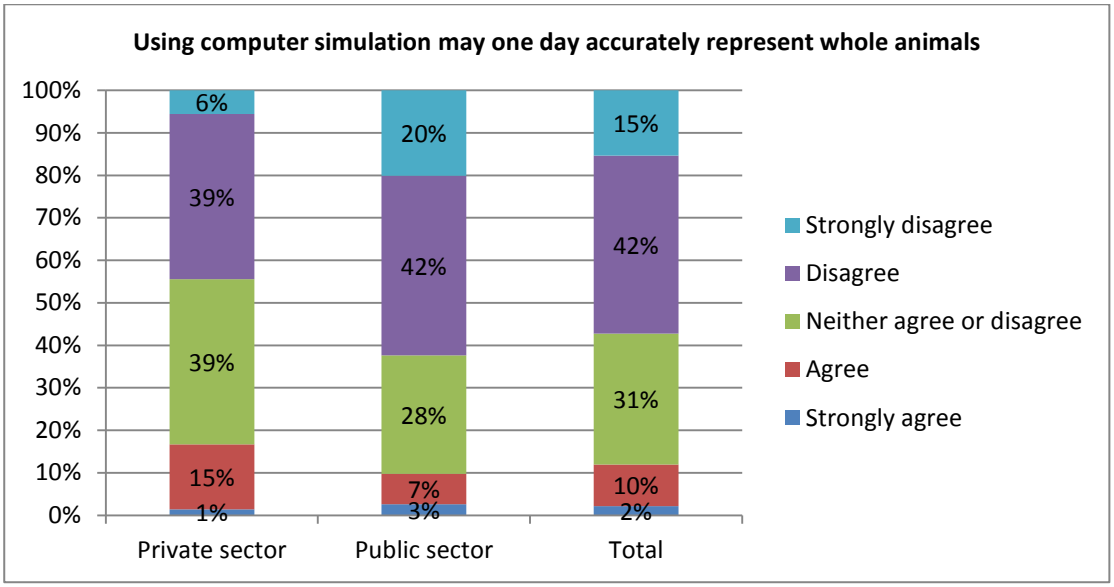

Figure 10. Perceived chance of computer simulation replacing whole animals – total and by sector

(The sample total is 234, while the category of the public and the private sector contains 226 respondents. P-value: 0.015)

The data indicate that the vast majority of the researchers thought that experiments should not be used blindly without considering possibilities of refinement and replacement – see figure 11. Thus 99% agreed or strongly agreed that the experimental design should always be optimized to minimize harm to the animal (refinement); and 97% agreed that researchers should first check to see if there are alternative methods before using laboratory animals.

As can be seen in figure 12, only 7% agreed or strongly agreed that the use of alternatives will increase costs, while more than a third (39%) disagreed or strongly disagreed. The figure also shows that the researchers are divided about whether alternative methods are recognized throughout the research community. Thus, 37% tended to agree that alternatives are recognized, while 29% tended to disagree with this.

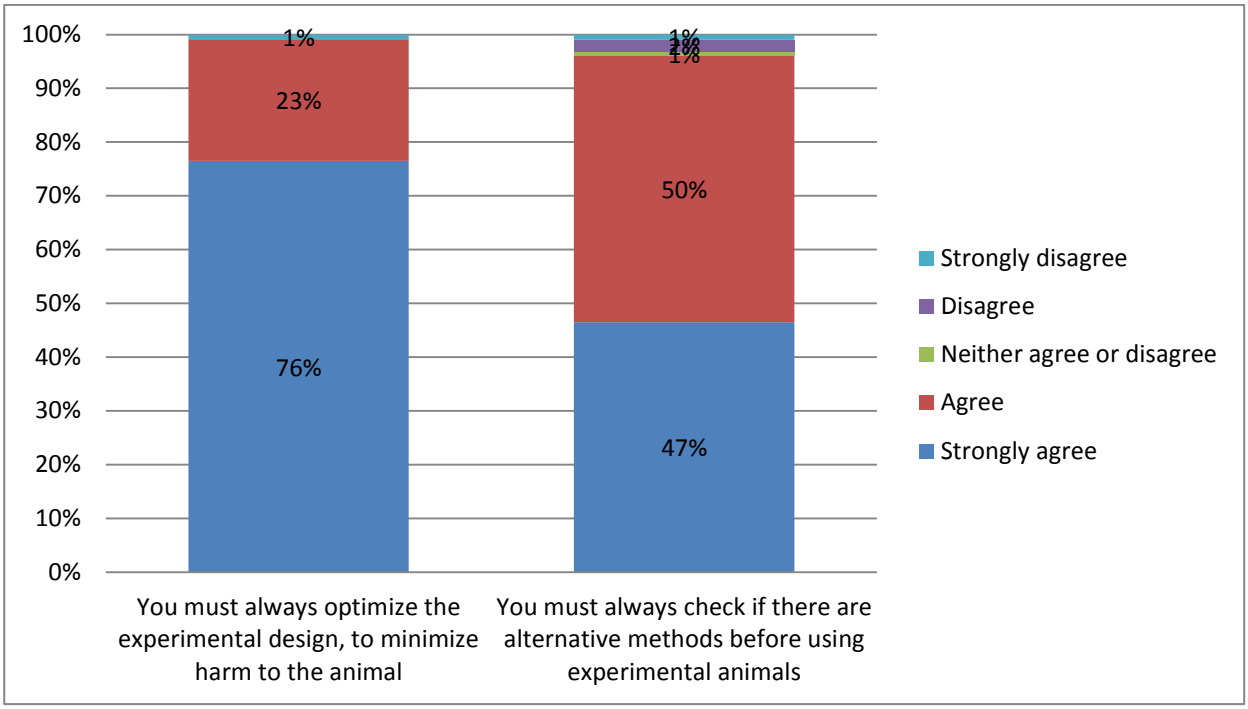

Figure 11: Agreement with statements about refinement and replacement

(The sample total is 234.)

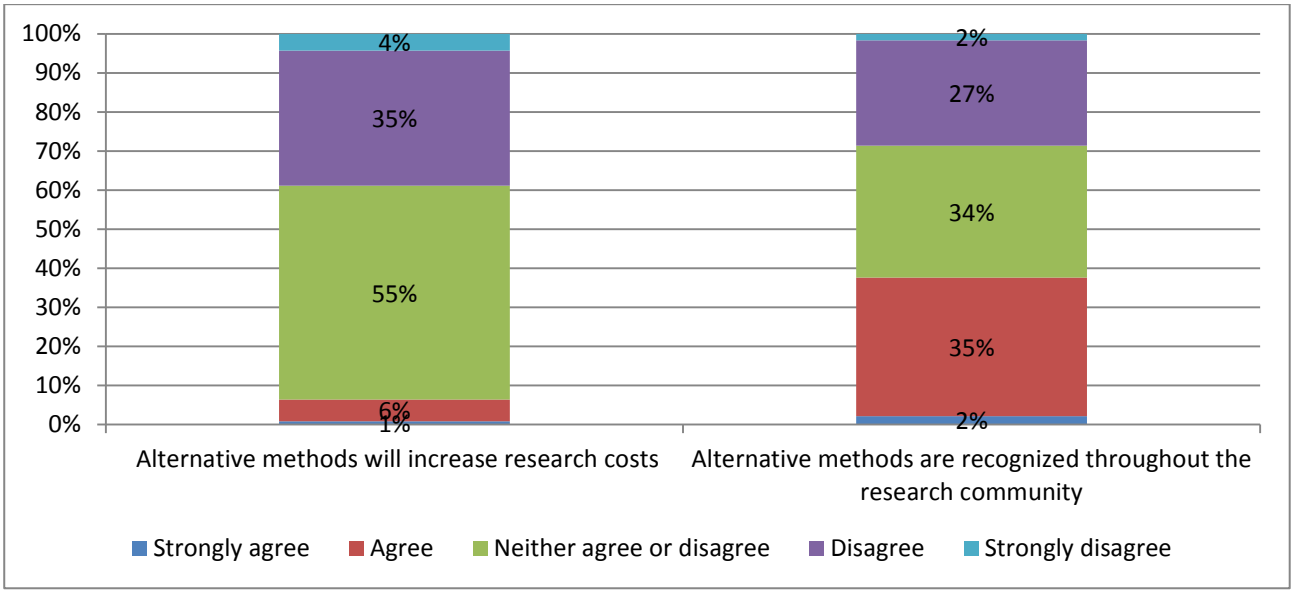

Figure 12. Costs and recognition of alternatives

(The sample total is 234.)

4.2 Implementation to the 3Rs

Based on the researchers' answers, this section examines to what extent the 3Rs are implemented at the researchers' workplaces and what obstacles they see for further implementation.

4.2.1 The role of the 3Rs in research

The researchers were asked to state how often the 3Rs play a role when they plan and carry out animal experiments. As figure 13 shows, *Refinement* is the 3R concept that most frequently plays a role when researchers plan and carry out animal experiments – thus more than a third (39%) state that this very frequently plays a role and another 45% that it frequently plays a role. Just 4% state that refinement rarely or never plays a role during these phases of their research. *Reduction* follows a similar pattern, though slightly fewer researchers find that it very frequently or frequently plays a role in their research. In contrast, *replacement* is reported to play a role much less frequently. Hence, almost a third (30%) state that replacement never or rarely plays a role, while 43% state that it does so frequently or very frequently.

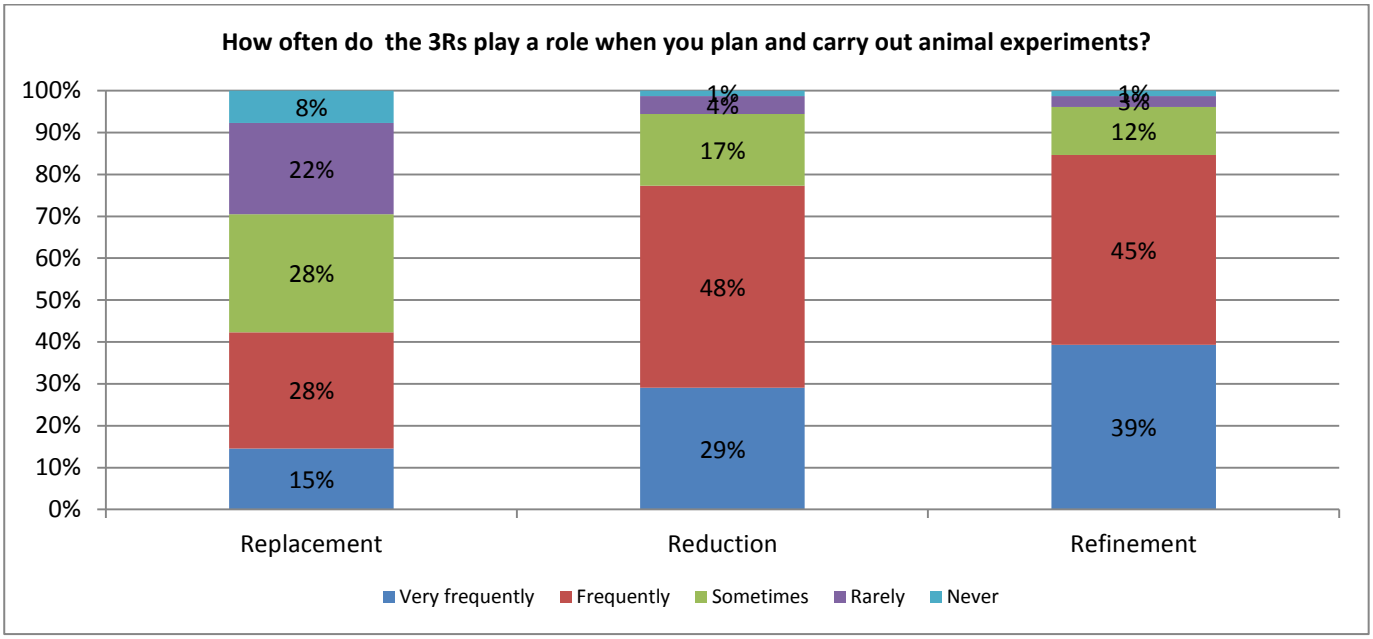

Figure 13: Stated role of refinement, reduction and replacement in researchers' work

(The sample total is 234.)

To follow up on the role of the 3Rs in their work, the researchers were asked to state what 3R techniques they had developed. While many stated that they had been engaged in developing techniques for refinement (78%) and reduction (69%), fewer (29%) reported having developed techniques of replacement – see figure 14. 11% stated that they had never developed any of the 3R techniques. No significant differences between the sectors were identified, but the figures are markedly different compared to the figures from the NC3R survey. Thus the Danish researchers seem to develop 3R techniques twice as often as their British colleagues – and many more British scientists (47%) report that they have never developed any 3R techniques.

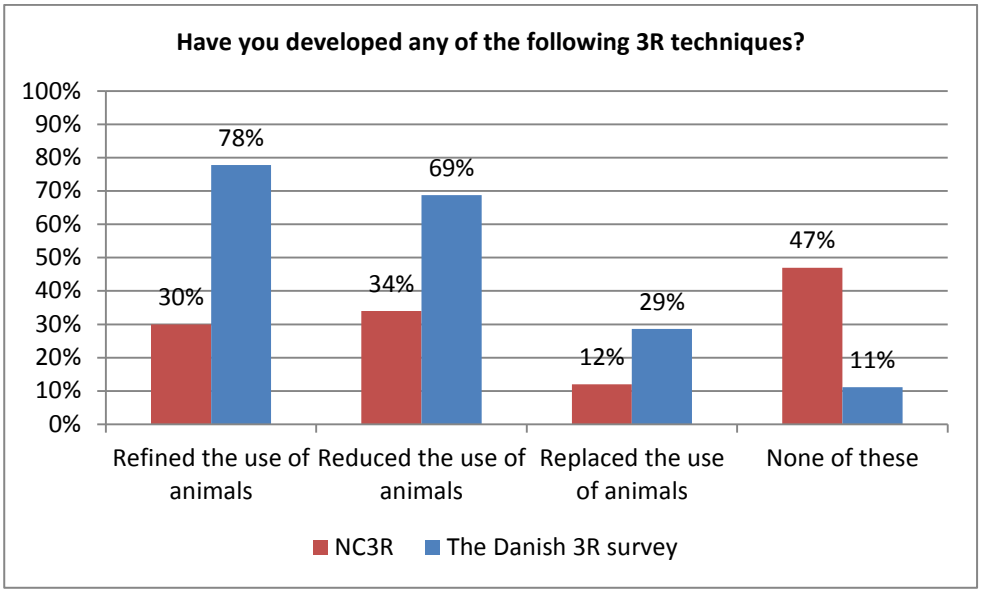

Figure 14. Researchers' development of 3R techniques

(The sample total is 234 in the Danish 3R survey and 1,529 in the NC3R survey. Respondents were asked to tick all that apply.)

4.2.2 The researchers' attention to the 3Rs

The researchers were asked to indicate when they consider the 3Rs in their work. As figure 15 shows, a third (32%) consider the 3Rs as part of their daily work, but the attention is much higher (79%) when preparing the application for the Ethical Review Process. Overall, the researchers mostly consider the 3Rs in the designing and planning parts of their research. All the factors reported in figure 15 are significantly different when comparing the two sectors. The private sector researchers consider the 3Rs relatively more often than the public sector employees as part of their day-to-day activities (54% compared to 23%); when in contact with the animals (63% compared to 45%); when attending conferences (35% compared to 21%) and when considering compliance (29% compared to 9%). By contrast, public researchers consider the 3Rs more often when preparing applications for ethical review (88% compared to 58%); when applying for funding (63% compared to 18%) and when submitting license applications (56% compared to 22%). As we discuss later (see section '5 Discussion'), these noticeable differences may very well reflect differences in the nature of the jobs in the two sectors.

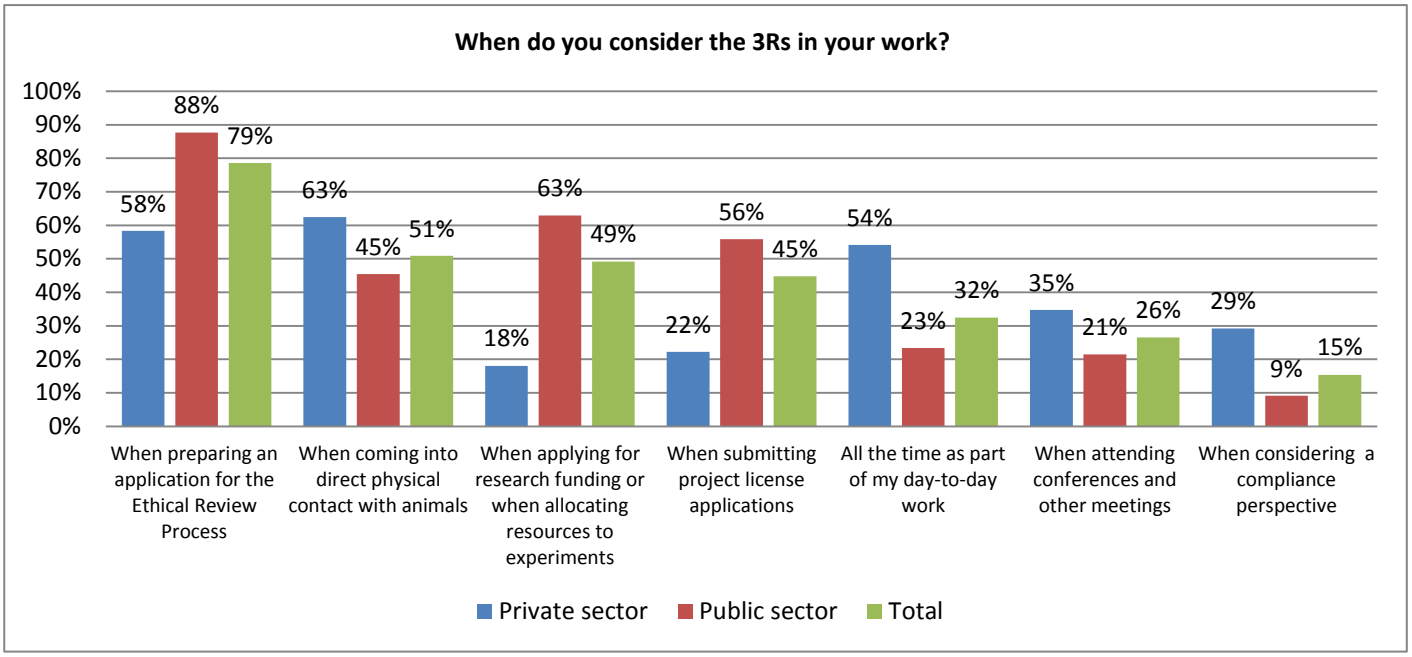

Figure 15. Work phases when the 3Rs are considered by the researchers – in total and by sector

(The sample total is 234, while the category of the public and the private sector contains 226 respondents. Respondents were asked to tick all that apply. P-values: When preparing an application for the Ethical Review Process: 0.00; When coming into direct physical contact with animals: 0.017; When applying for research funding or when allocating resources to experiments: 0.00; When submitting project license applications: 0.00; All the time as part of my day-to-day work: 0.00; When attending conferences and other meetings: 0.033; When considering a compliance perspective: 0.00)

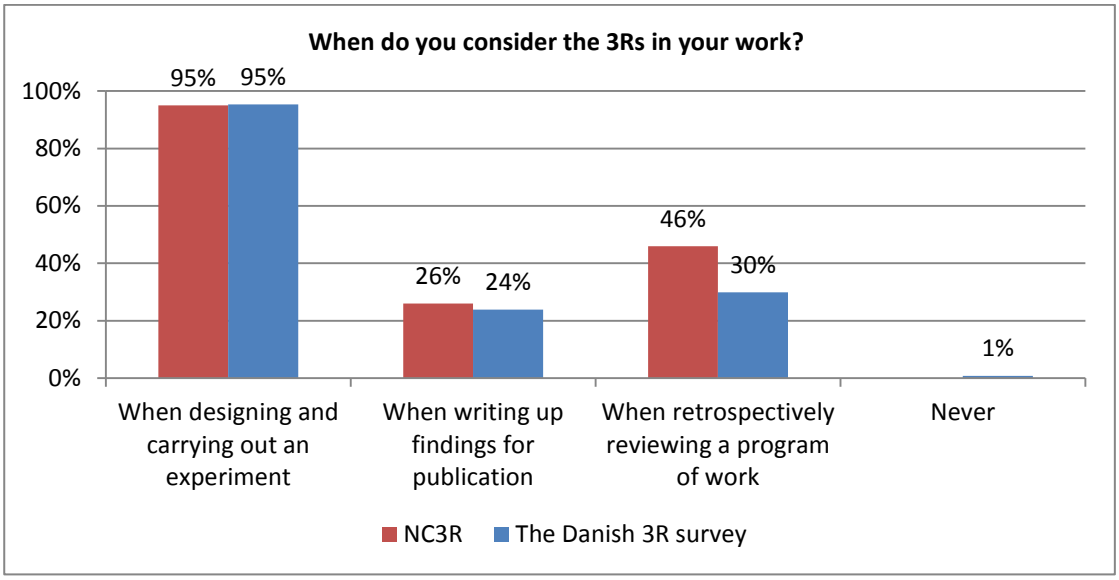

Figure 16. Work phases where the 3Rs are considered by the researchers – in total compared to NC3R

(The sample total is 234, while the category of the public and the private sector contains 226 respondents. Respondents were asked to tick all that apply.)

To maintain comparability with the NC3R survey, the Danish survey replicated three questions addressing researchers' attention to the 3Rs where the research activities are grouped in broad categories (reviewing; designing and carrying out the research as well as writing publications) – see figure 16. First it should be noted that there is no significant difference between the public and private sector in the Danish survey, indicating that despite the difference shown in figure 15, the sectors pay equal attention to the 3Rs during their work as a whole. It should also be noted that the only difference between Danish and British researchers is when they review a program of work with the British considering the 3Rs more often than the Danish researchers (46% compared to 30%).

4.2.3 Attention to the 3Rs at the workplace

Two approaches were used to estimate attention paid to the 3Rs at the workplace: which of the 3Rs the researchers hear the most about as well as a number of questions addressing the role of the 3Rs in discussions between colleagues at the workplace.

When asked which of the 3Rs they hear the most about at their workplace, 7% reported that they never hear about any of the Rs, while fewer (5%) hear most about replacement – see figure 17. 33% hear most about refinement and 22% hear most about reduction. A third (33%) thinks that information is equally divided between the 3Rs. There is a significant difference between the sectors where private sector researchers hear more often about refinement than do public sector researchers (44% compared to 27%), while public sector researchers hear about reduction more often (25% compared to 15%). A striking 10% of the public researchers have never heard about any of the 3Rs at the workplace, compared to only 1% of the privately employed.

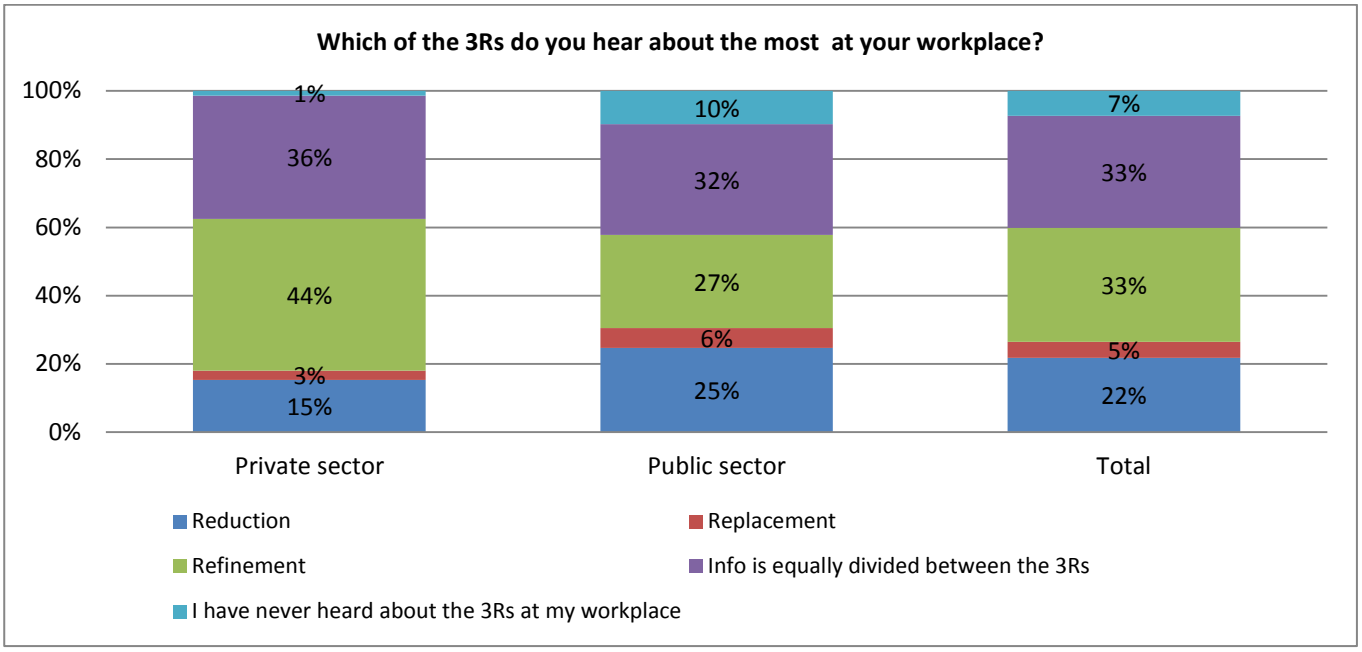

Figure 17. Attention to the 3Rs at the place of work – total and by sector

(The sample total is 234, while the category of the public and the private sector contains 226 respondents. Respondents were asked to one answer. P-value: 0.015)

When asked how often they discuss the improvement of animal conditions in the laboratory (housing conditions) about half (53%) stated that they do so frequently or very frequently, while 12% do so rarely or never – see figure 18. There is a significant difference between the sectors, indicating that the private sector researchers discuss housing conditions much more frequently than their colleagues in the public sector.

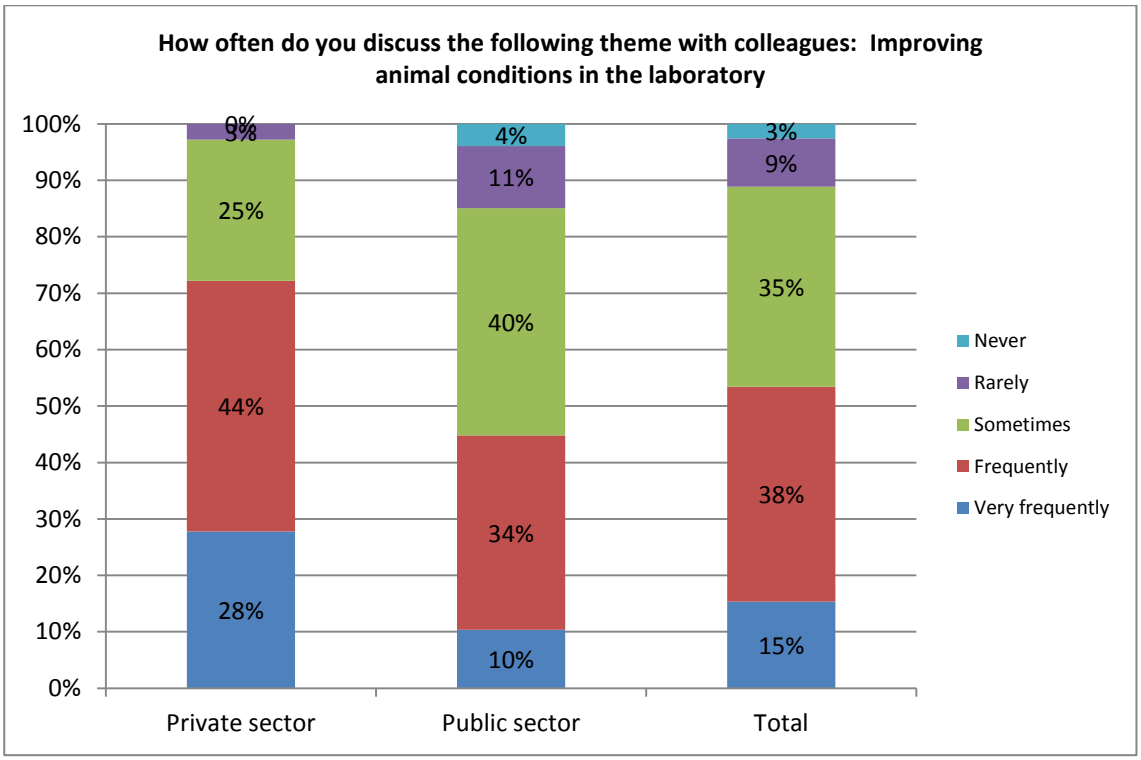

Figure 18. Frequency of discussions about housing conditions – in total and by sector

(The sample total is 234, while the category of the public and the private sector contains 226 respondents. Respondents were asked to one answer. P-value: 0.00)

When asked how often they discuss their experiences with the 3Rs with their colleagues, there was also a significant difference between the sectors, showing that private sector researchers seem more engaged in discussions about the 3Rs. Thus half (50%) of the private researchers are engaged in such discussions frequently or very frequently, compared to 18% of those employed in the public sector. (See figure 19).

Almost three quarters (74%) of the researchers stated that they discuss barriers/possibilities in terms of implementing the 3Rs with colleagues sometimes, frequently or very frequently – see figure 20. Here there is also a significant difference between the sectors, showing that private sector researchers tend to discuss this issue more frequently than public researchers.

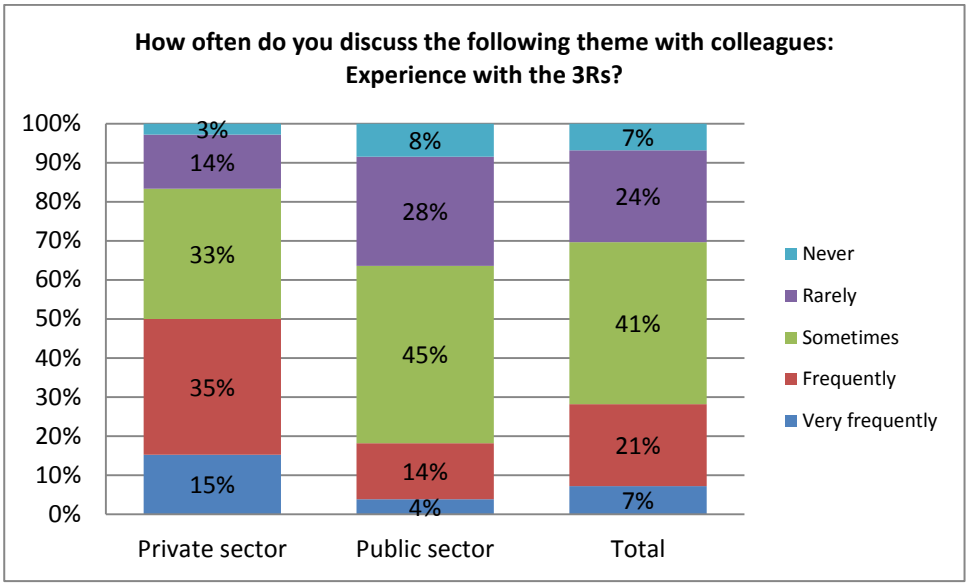

Figure 19. Discussing experiences with the 3Rs with colleagues – in total and by sector

(The sample total is 234, while the category of the public and the private sector contains 226 respondents. Respondents were asked to one answer. P-value: 0.00)

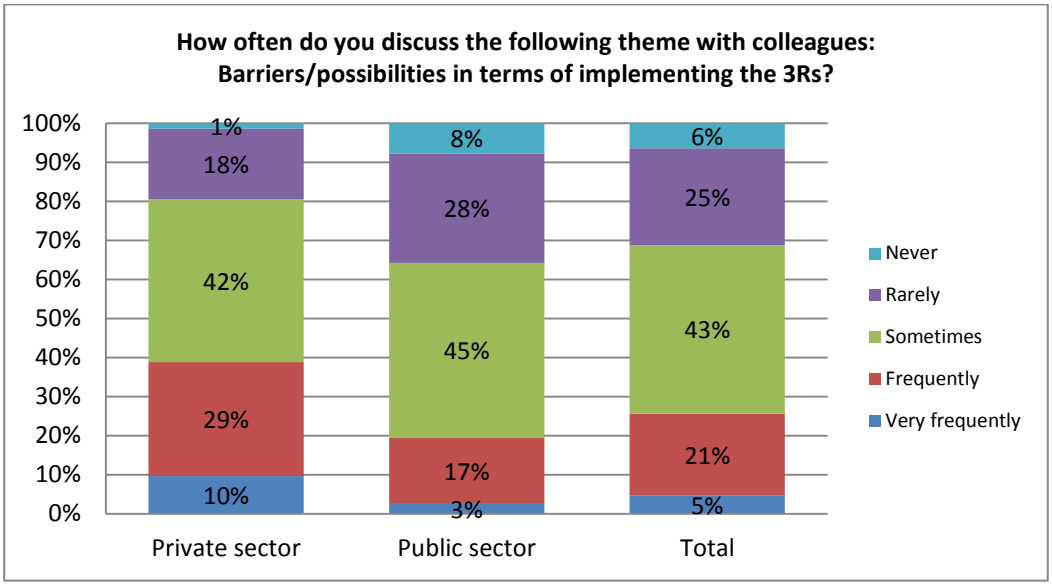

Figure 20. Discussing possibilities and barriers regarding the 3Rs with colleagues – in total and by sector

(The sample total is 234, while the category of the public and the private sector contains 226 respondents. Respondents were asked to one answer. P-value: 0.007)

4.2.4 Guidance/support from the ethical committee

Guidance and support from local ethical committees may be of importance for the implementation of the 3Rs. To explore this aspect, the researchers were asked to indicate if they are familiar with the ethical committee at their workplace. Overall, most researchers (77%) knew of the committee, but there are, as can be seen in figure 21, significant differences between the sectors. Almost all research-

ers from the private sector (96%) state that they know of the committees, whereas the total is only a third (32%) for the publicly employed.

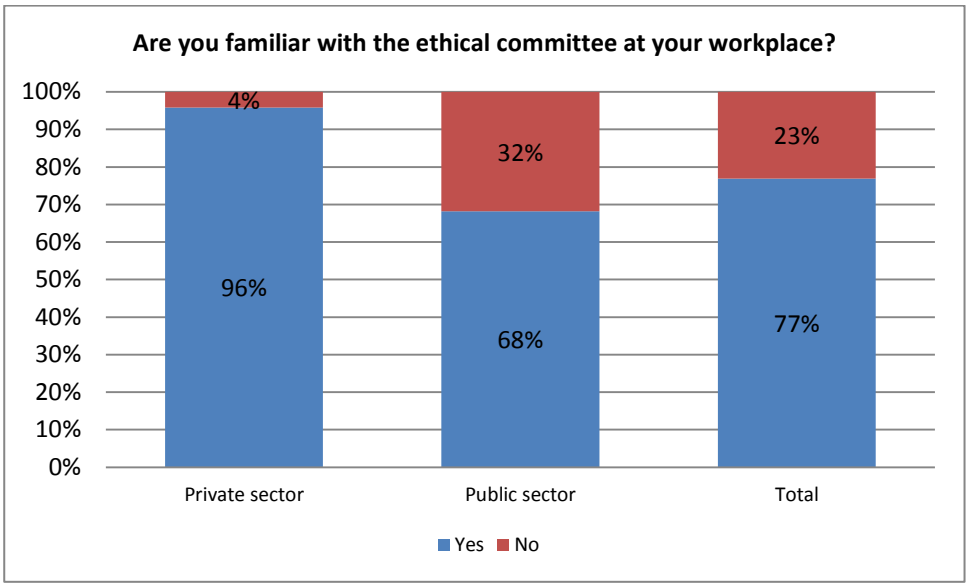

Figure 21. Knowledge of the local ethical committee – in total and by sector

(The sample total is 234, while the category of the public and the private sector contains 226 respondents. Respondents were asked to one answer. P-value: 0.00)

To determine how helpful the researchers found the ethical committees, they were asked to assess the ethical committee at their workplace with regard to improving standards of animal care, replacing, reducing and refining animal use respectively and improvement/adjustment of the protocol. Figure 22 shows the proportion of researchers that considered the committee helpful in relation to these aspects. Overall, the committees are considered to be most helpful when it comes to improving the care of the animals (stated by 70%), in relation to refinement (52%) and when preparing the protocol (55). Just a third (33%) finds that the committees are helpful in relation to replacement, while 44% state that they are helpful when it comes to reduction. There is a significant difference between the sectors on all of these issues with the private sector researchers finding the committees more helpful in relation to all factors. Three of the four factors were also included in the NC3R survey and a comparison of the results shows only minor differences regarding the helpfulness of the ethical committees in relation to the 3Rs, while Danish researchers find the committees more helpful when improving the standards of animal care.

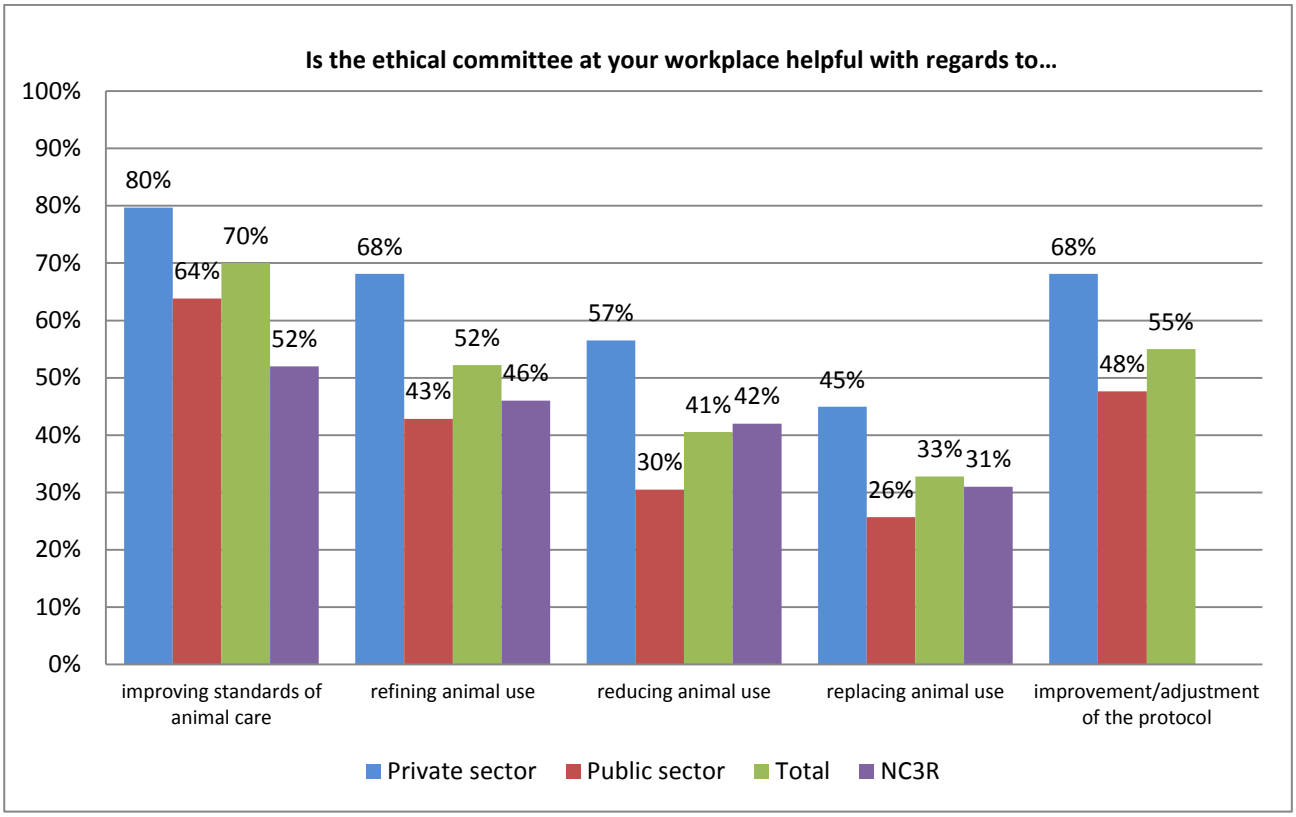

Figure 22. Helpfulness of the local ethical committee – in total, by sector and compared to NC3R

(The sample total is 184 respondents, while the category of the public and the private sector contains 180 respondents. The NC3R sample includes 1,455 British researchers. The NC3R survey does not include the question about the protocol. The respondents were asked to assess the factors on a three point scale (Helpful/ Neither helpful nor unhelpful/ not helpful). The figure shows only the frequencies for those answering helpful. P-values: improvement/adjustment of the protocol: 0.02; reducing animal use: 0.007; refining animal use: 0,005; improving standards of animal care: 0.036)

4.2.5 Barriers to implementing the 3Rs

To get an impression of the problems faced when implementing the 3Rs, the researchers were asked to report the main obstacle to implementation. Overall, a third (30%) saw no obstacles; another third (30%) pointed to the comparability of data and a fourth (25%) to a lack of scientific and technical innovation as the main obstacle – see figure 23. There is a significant difference between the sectors; the privately employed researchers more often think there are no obstacles (40% compared to 26%), and do not see funding as the main obstacle at all (0% compared to 10%). By contrast, fewer researchers in the public sector point to time (3% compared to 10%) and regulation (3% compared to 15%) as the major obstacle, while a lack of innovation and the comparability of data are considered more important obstacles. There is a slight difference between the Danish figures and the results from the NC3R survey in that a lack of scientific and technological innovation is considered a more important factor in Britain (33% compared to 25%).

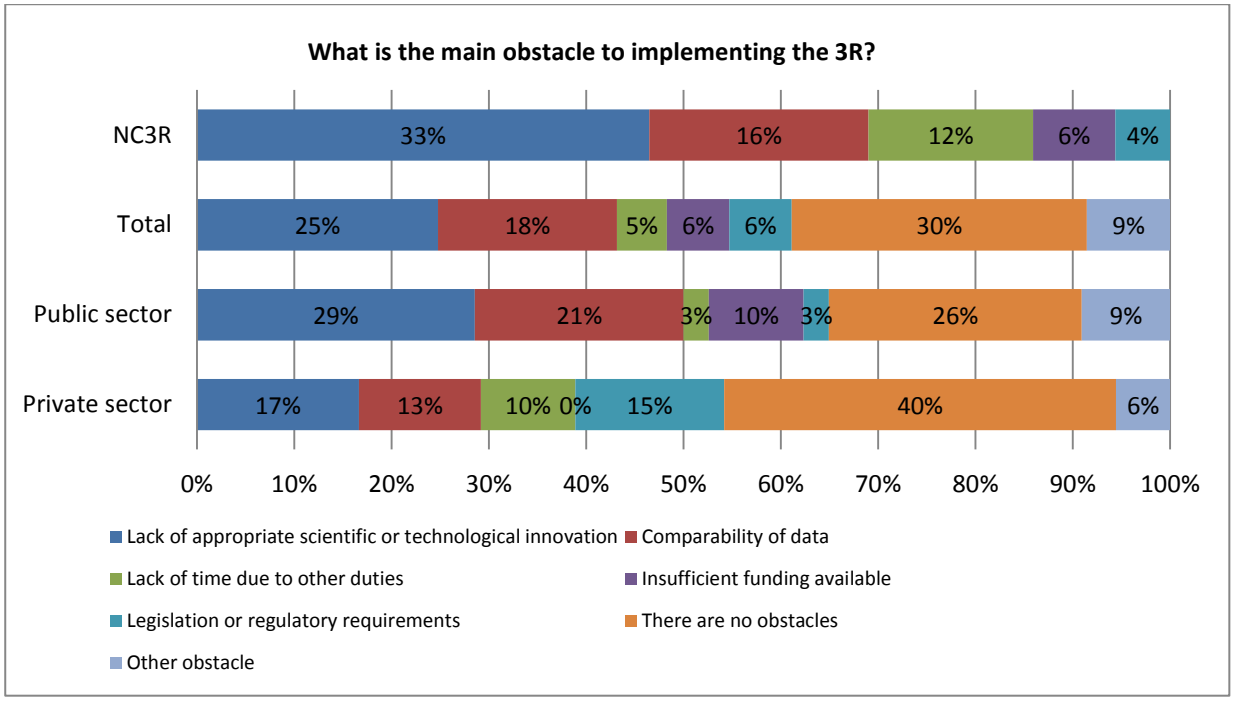

Figure 23. Main obstacles to implementing the 3Rs – total, by sector and compared to NC3R

(The sample total is 234, while the category of the public and the private sector contains 226 respondents in the Danish survey. The sample total is 1,455 in the NC3R survey (The categories from the NC3R do not sum up to 100 % since they included a no answer category, where we chose to use the category 'there are no obstacles'). Respondents were asked to tick one answer only. P-value: 0.00)

4.2.6 Implementing the 3Rs: Researchers' wishes

Researchers were asked to state which factors they thought would help them the most to achieve reduction and replacement. To obtain a better graphical presentation of the results, two figures are displayed for each of the two Rs: one show factors where there is a significant difference between the sectors and one where there is no difference.

When it comes to reduction, the overall picture (see figure 24) is that data sharing (52%) and statistical evidence (46%) were seen as the most important followed by improved funding (33%) and regulators' willingness to accept non-animal alternatives (26%). Few (12%) pointed to changes in the legislation as a means of obtaining reduction. There is a significant difference between the sectors for all the suggested factors which shows that the privately employed researchers found that data sharing (74% compared to 42%), statistical evidence (58% compared to 39%), acceptance of non-animal alternatives (43% compared to 18%) and changes in regulation (22% compared to 7%) would allow reductions. Only better funding was identified as an important factor by more public than private researchers (37% compared to 22%). When comparing the Danish results to the NC3R, the major difference concerns legislation, where three times as many British researchers (36% compared to 12%) point to this as a factor that would improve reduction.

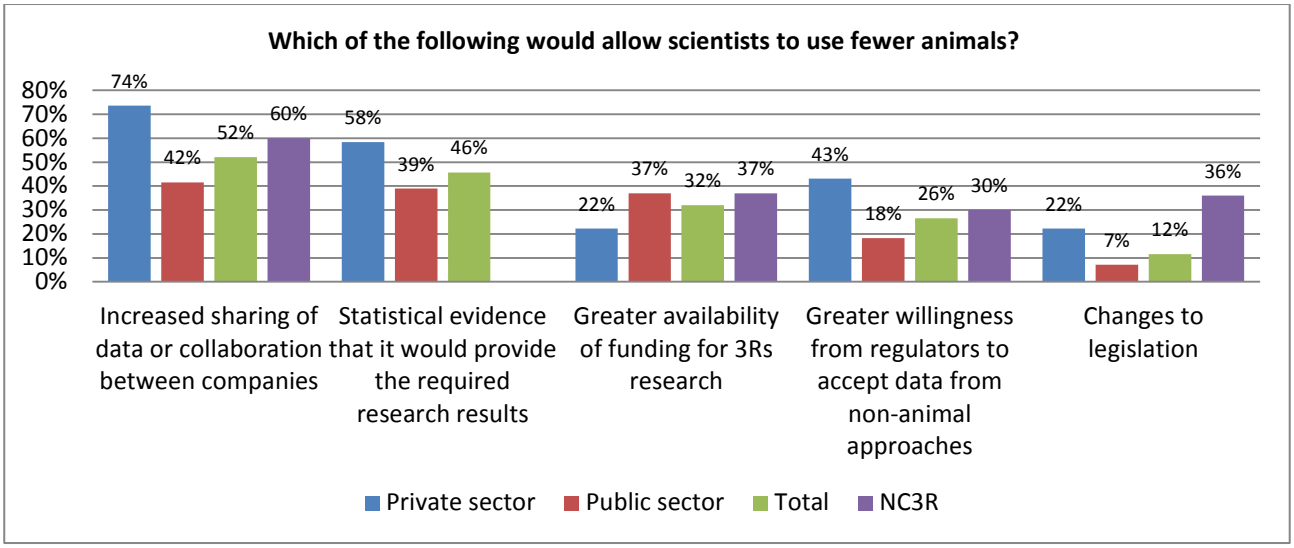

Figure 24. Factors that would allow reduction, with significant differences between sectors – total, by sector and compared to NC3R

(The sample total is 234 respondents, while the category of the public and the private sector contains 226 respondents in the Danish survey. The sample total is 1,529 in the NC3R survey. The NC3R survey did not include the question about statistical evidence. Respondents were asked to tick all factors that apply. P-values: Increased sharing of data or collaboration between companies: 0.00; Statistical evidence that it would provide the required research results: 0.006; Greater availability of funding for 3Rs research: 0.027; Greater willingness from regulators to accept data from non-animal approaches: 0.00; Changes to legislation: 0.001)

For a number of other factors displayed in figure 25, there are no significant differences between the sectors. A large proportion (71%) reports increased sharing of data or collaboration between research groups to be a factor that would allow scientists to use fewer animals. The second most reported factor (41%) is a greater willingness among researchers to change their methods, which, again, may indicate a need for change within this specific research culture. As can be seen from the figure, the Danish figures do not differ noticeably from the results from the NC3R survey.

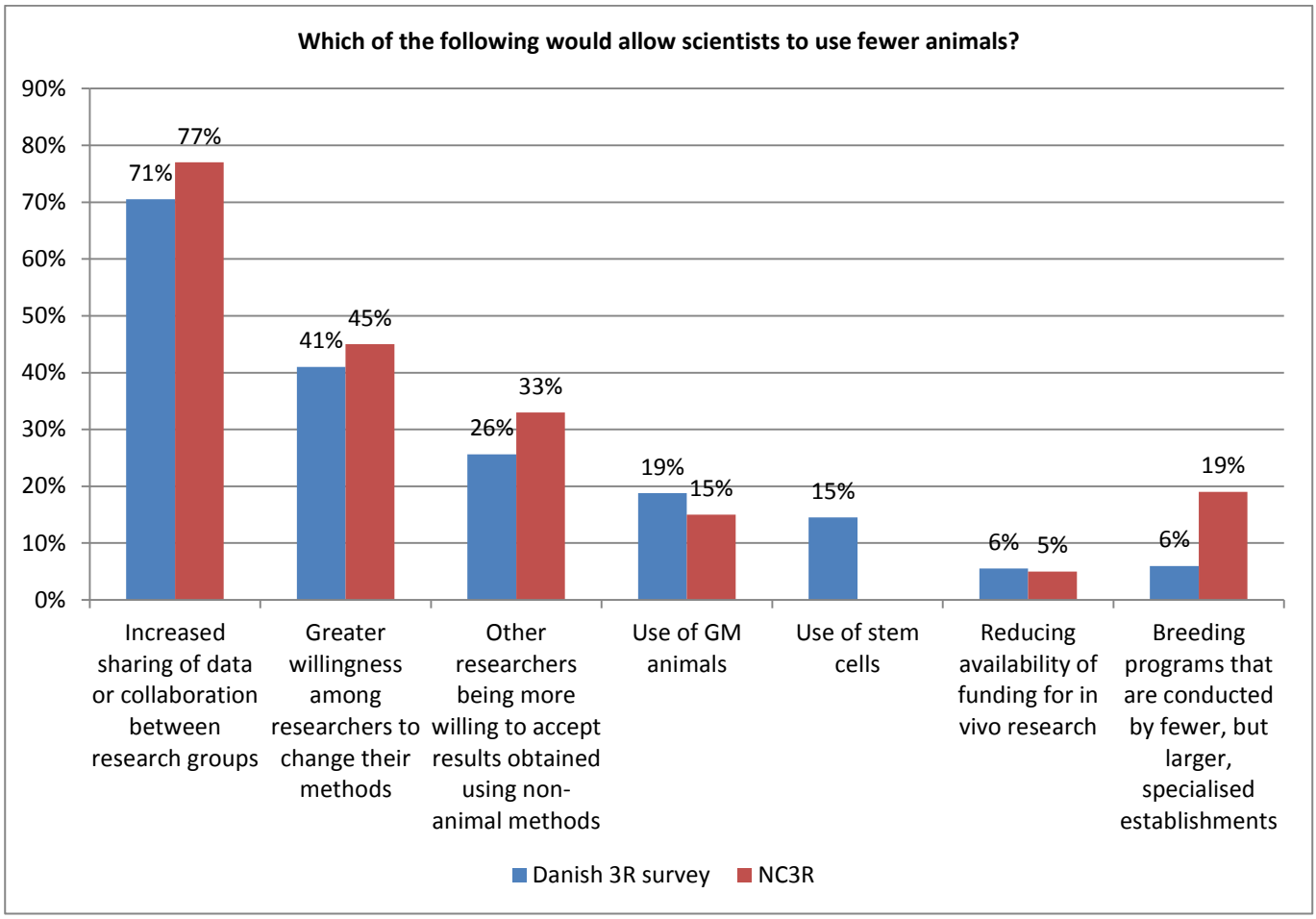

Figure 25. Factors that would allow reduction, with no significant differences between sectors – total compared to NC3R

(The sample total is 234 respondents in the Danish survey. The sample total is 1,529 in the NC3R survey. The NC3R survey did not include the question about the use of stem cells. Respondents were asked to tick all factors that apply.)

The researchers were also asked about factors that may improve their opportunities for conducting their research without using animals. Figure 26 shows the factors that are significantly different between the sectors, and as it appears, none of the suggested factors were found to be very helpful in this respect. More predictive computer models (15%) and increased funding (12%) were seen as the most helpful changes. Better access to relevant literature and changed legislation were not perceived as particularly important changes – selected by 4% and 5% respectively. There is, however, a significant difference between the sectors in that a fourth (26%) of the private researchers point to more predictive computer models as a change that would allow alternatives – by comparison this was only chosen by 10% of the publicly employed. Similarly, more private researchers point to regulatory changes as an important factor (14% compared to 1%). By contrast, more public researchers point to better funding as an important factor (15% compared to 6%). Compared to the NC3R survey, the Danish results only show minor differences – most markedly when it comes to predictive computer models which are suggested by 15% in Britain compared to 10% in Denmark.

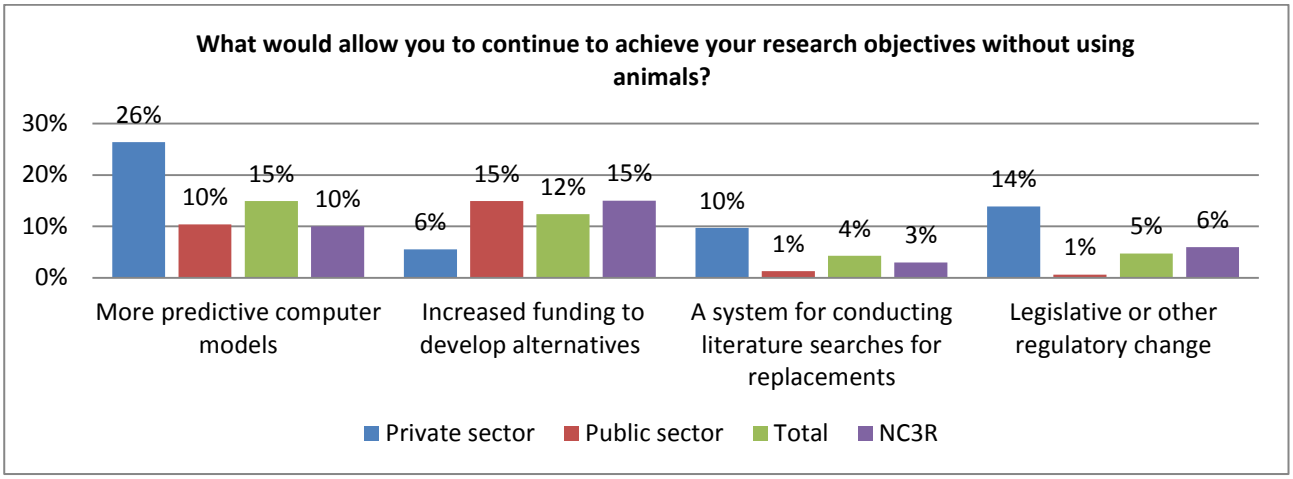

Figure 26. Factors that would allow replacement, with significant differences between sectors – total, by sector and compared to NC3R

(The sample total is 234 respondents, while the category of the public and the private sector contains 226 respondents in the Danish survey. The sample total is 1,529 in the NC3R survey. Respondents were asked to tick all that apply. P-values: More predictive computer models: 0.002; Increased funding to develop alternatives: 0.043; A system for conducting literature searches for replacements: 0.003; Legislative or other regulatory change: 0.00)

With regards to the factors where there is no significant difference between the sectors, the most noticeable result is that the vast majority of the researchers (82%) state that since their work demands that they look at the entire animal system, considering alternatives is not relevant. The remaining factors shown in figure 27 are only pointed to by less than 20%. Only minor differences can be observed when comparing the Danish results to the NC3R survey.

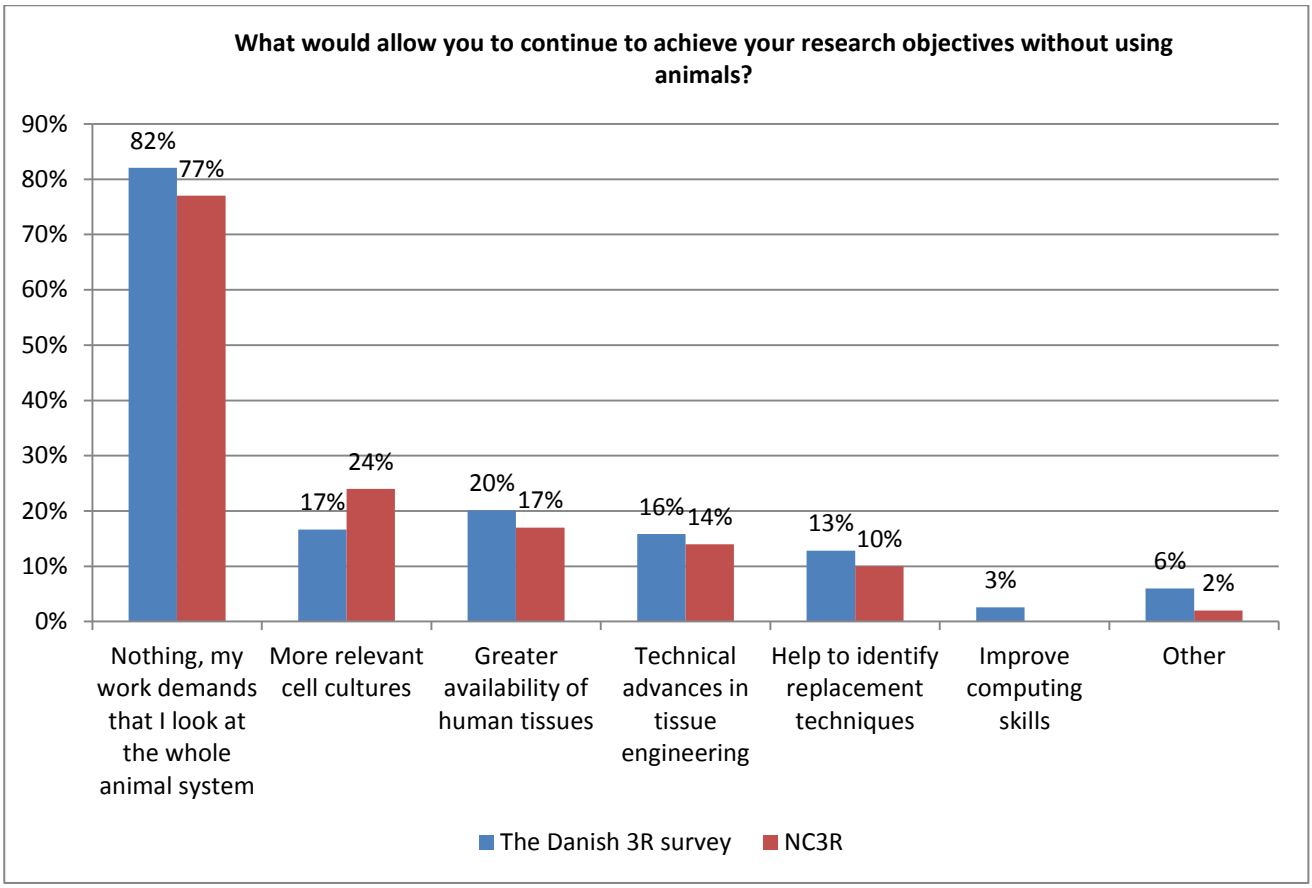

Figure 27. Factors that would allow replacement, with no significant differences between sectors – total compared to NC3R

(The sample total is 234 respondents in the Danish survey. The sample total is 1,529 in the NC3R survey. The NC3R survey did not include the question about the improvement of computer skills. Respondents were asked to tick all factors that apply.)

4.3 Sharing knowledge about the 3Rs

This section examines the researchers' view on the accessibility of knowledge and to what extent they find that knowledge is actually shared.

When looking at the sources of information about the 3Rs the researchers would typically turn towards (displayed in figure 28), a number of sources are chosen by half or more of the respondents. Thus more social sources which are close to the researcher such as their network (63%), colleagues (55%) and the local ethical committee (52%) are important as well as scientific articles (48%) and the Internet (63%). Conferences and reference books are considered less important (24% and 12% respectively). There is a significant difference between the sectors regarding the choice of colleagues, the ethical committees and conferences as sources of knowledge in that colleagues and committees, in particular, are favored by the private employed researchers (72% for both).

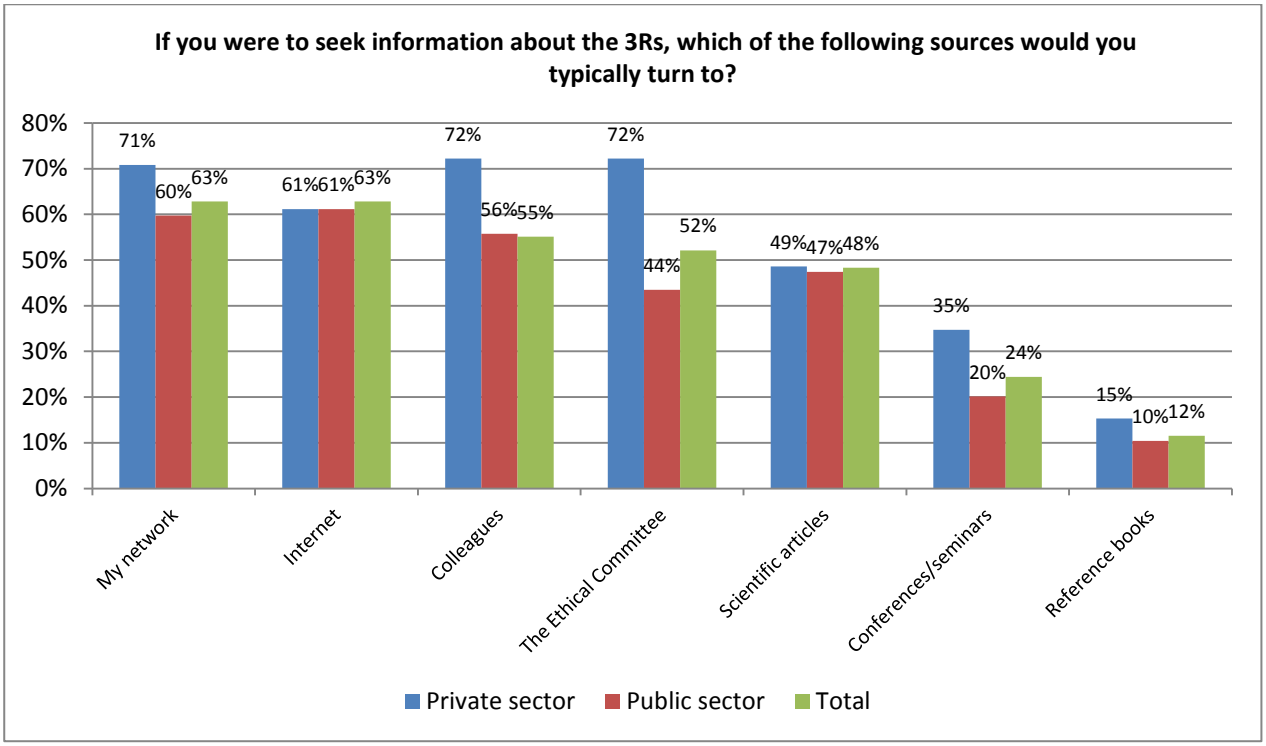

Figure 28. Most popular sources of knowledge about the 3Rs

(The sample total is 234 respondents, while the category of the public and the private sector contains 226 respondents. The respondents were asked to tick all that apply. P-values: The ethical committee/ the animal welfare body at my workplace: 0.00; Conferences/seminars: 0.018; Colleagues: 0.001)

When looking at the researchers' assessment of the actual knowledge sharing that takes place – see figure 29 - it is noticeable that almost two thirds find that knowledge sharing works well at their workplace – both between researchers (63%) and between researchers and animal keepers (66%). There are no significant differences between the sectors, but when asked directly, the researchers find that knowledge sharing within the public sector works better (stated by 23%) than within the private sector (stated by 10%).

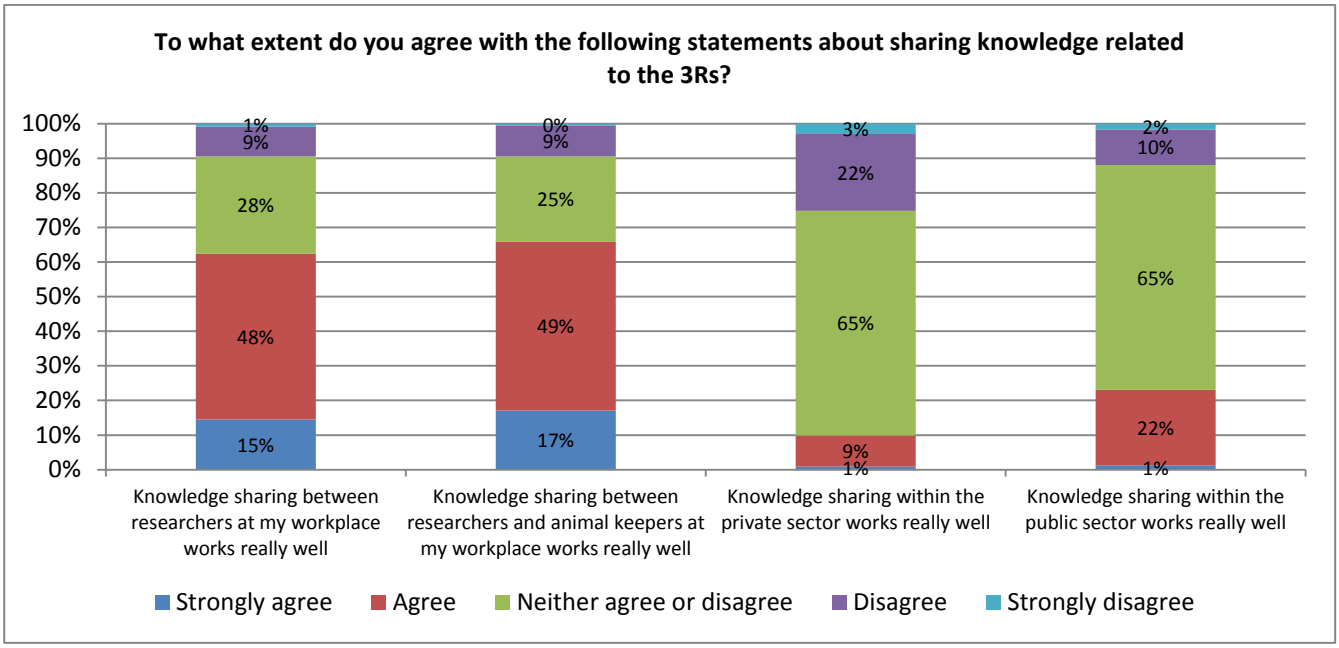

Figure 29. Sharing knowledge about the 3Rs in practice

(The sample total is 234 respondents.)

4.4 Researchers' attitudes towards the use of animals in research in general

The survey included a number of questions aimed at examining the researchers' more general attitudes regarding the use of animals in experiments. This included questions about the importance of the use of experimental animals for scientific progress, the acceptability of the use of animals in different contexts and for different purposes as well as some questions about the quality of the data produced in animal experiments.

The answers to one of these questions is reported in figure 30, showing that the majority of the researchers do not find that the extensive focus on the welfare of animals used in experiments is a barrier to scientific breakthroughs. Thus the majority (78%) disagrees or strongly disagrees with the statement that this welfare focus hinders scientific breakthroughs. There is a significant difference between the sectors as almost all private sector researchers (91%) disagree or strongly disagree with the statement, while the same is true for only 73% of the publicly employed.

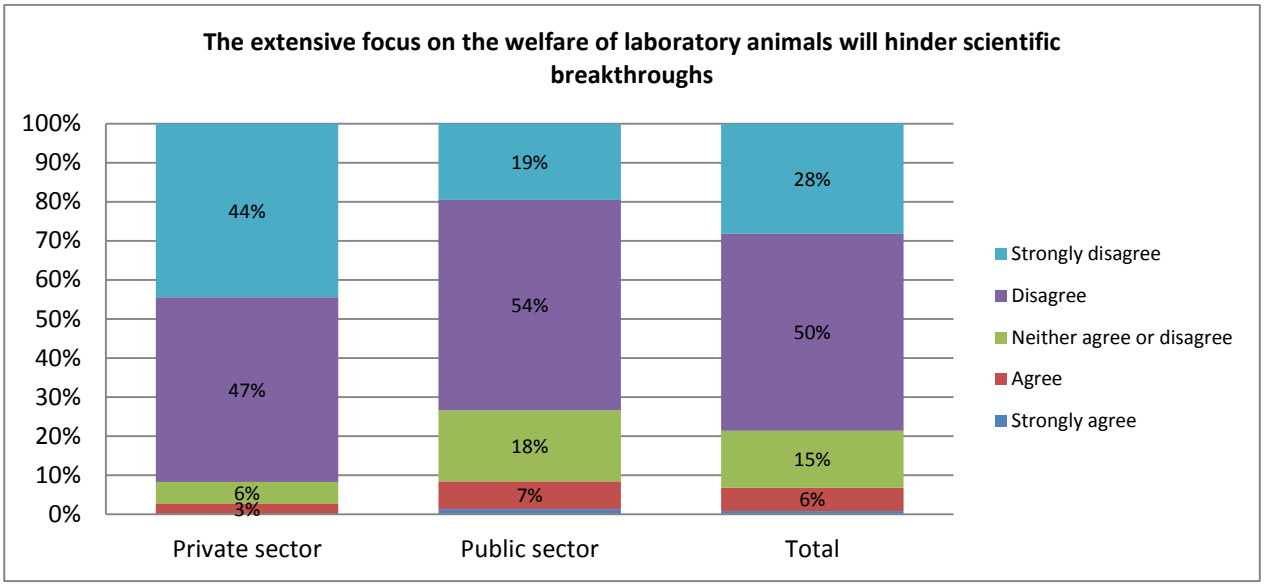

Figure 30. Perceived impact of the focus on the welfare of laboratory animals on scientific breakthroughs – total and by sector

(The sample total is 234, while the category of the public and the private sector contains 226 respondents. P-value: 0.01)

The researchers were asked to indicate to what extent they were reluctant to change the way they work because of the need for comparability with earlier findings – see figure 31. Here, the majority of the researchers (62%) do not agree with this statement. Researchers employed in the public sector are more reluctant to change the way they work than researchers employed in the private sector.

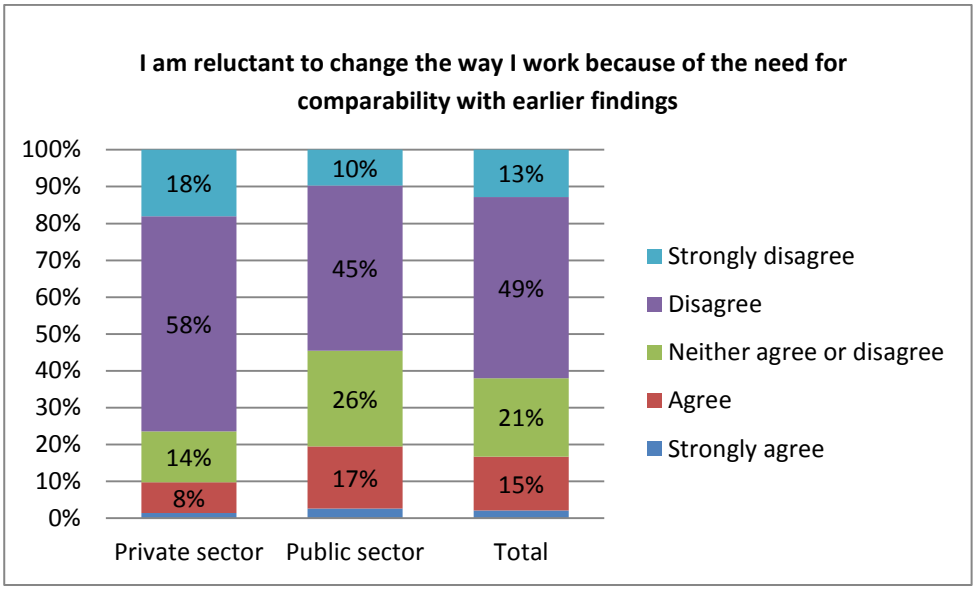

Figure 31. Willingness to change working procedures to obtain comparability with earlier findings – total and by sector

(The sample total is 234, while the category of the public and the private sector contains 226 respondents. P-value: 0.031)

Figure 32 shows the researchers' answers to six statements about the use of animals for research. First it should be noted that a large majority (89%) agree or strongly agree that animals have certain rights that must be respected. Despite this, none (0%) agree or strongly agree that it is wrong to use mice for experiments and only few (5%) are of this opinion in the case of dogs (see figure 33). The purpose seems to have some effect on acceptance, as 85% agree or strongly agree that it is acceptable to use animals for teaching purposes, while the same is true for just 16% when animals are used to test cosmetics. The majority disagrees that fewer animals suffering significantly is better than many animals suffering to a lesser degree, although it should be noted that a third (34%) do not have a clear opinion about this issue. Finally, a large majority (80%) agrees or strongly agrees that the legislation in Denmark adequately ensures the welfare of animals used for experiments.

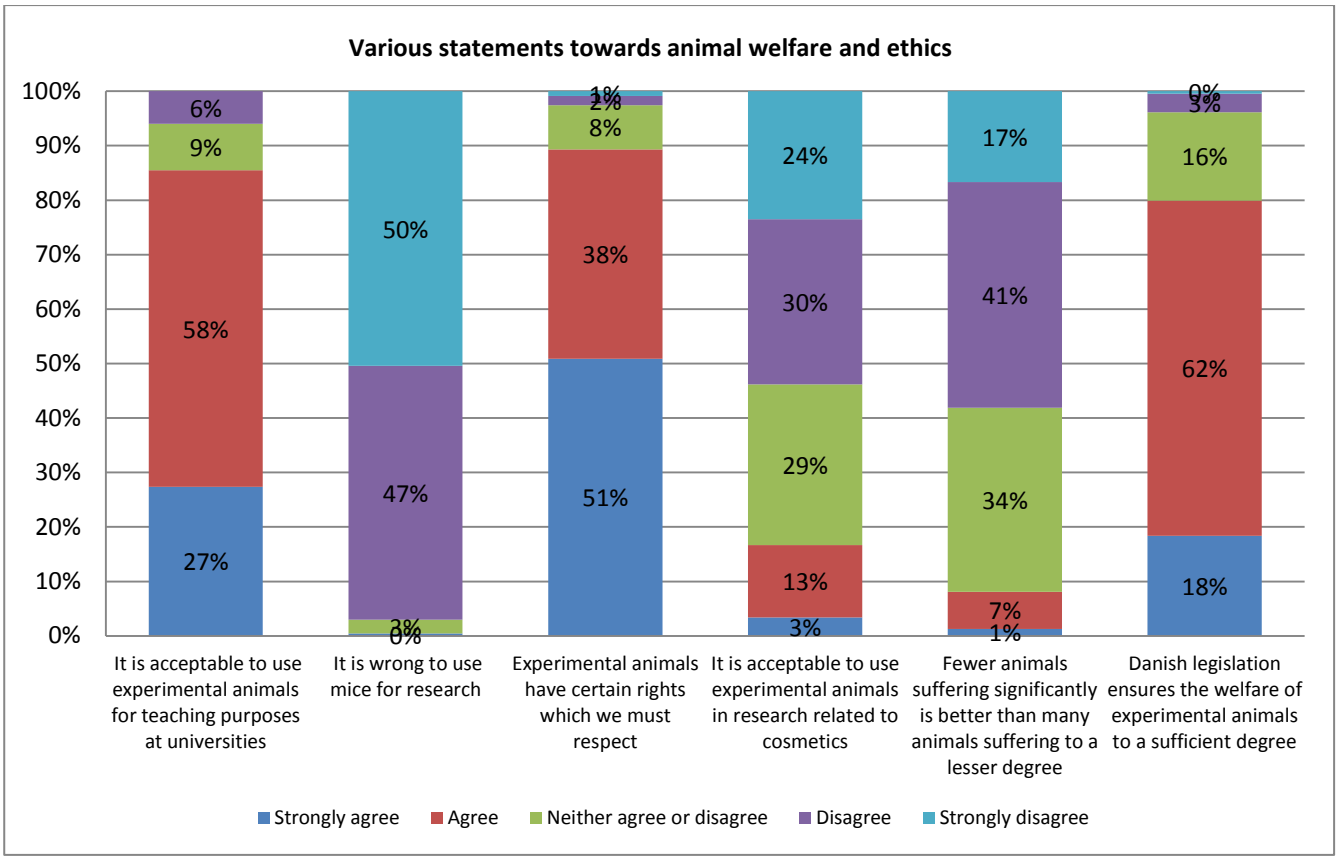

Figure 32. Researchers' attitudes towards different aspects of the use of animals for research

(The sample total is 234.)

There is no significant difference between the sectors concerning the statements reported in figure 32; by contrast, there is a significant difference between the sectors when it comes to the acceptability of using dogs for research. Figure 33 demonstrates this difference, where as many as 96% of the researchers working in private companies disagree or strongly disagree that it is wrong to use dogs for research, while the same is true for 79% of researchers in the public sector – where almost a fourth (23%) state that they neither agree nor disagree with this statement.

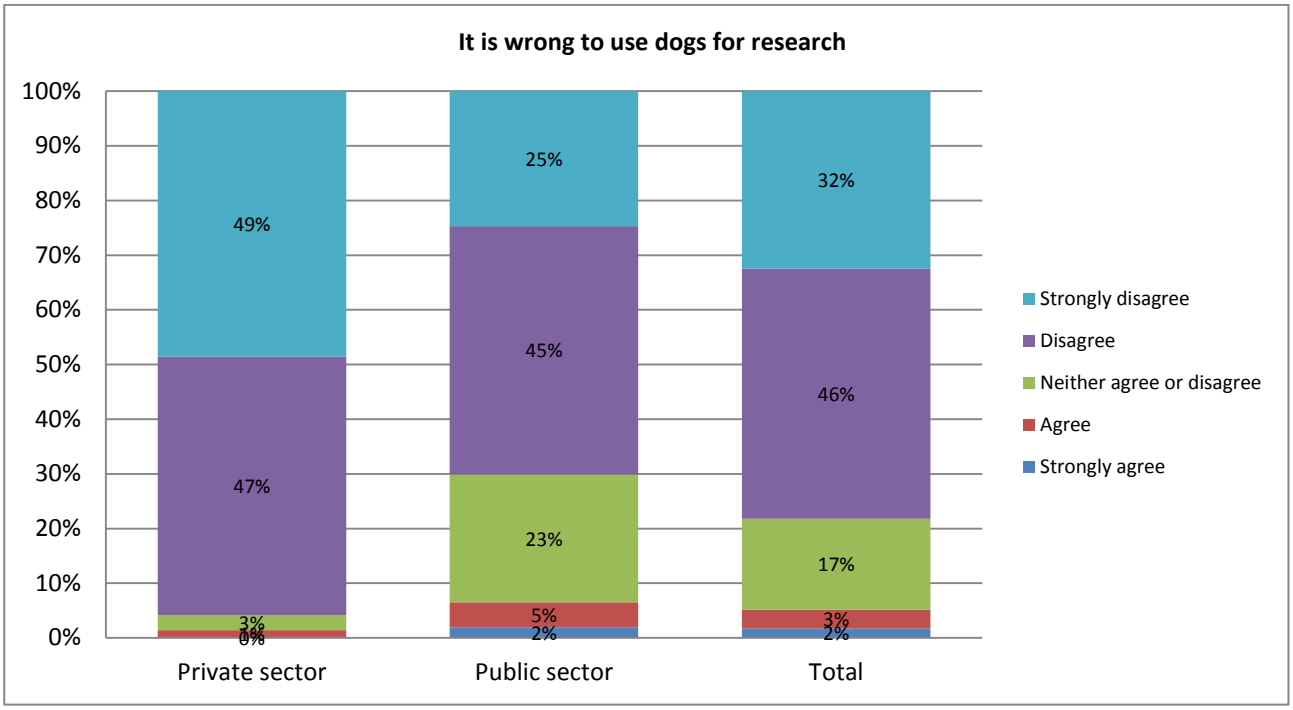

Figure 33. Attitudes towards using dogs for research

(The sample total is 234 respondents, while the category of the public and the private sector contains 226 respondents. P-value: 0.00)

The researchers were asked to report to what extent they agree that environmental enrichment may compromise their results. As can be seen in figure 34, just over half (52%) disagree or strongly disagree that this is the case, while just 15% agree or strongly agree with the statement – almost a third

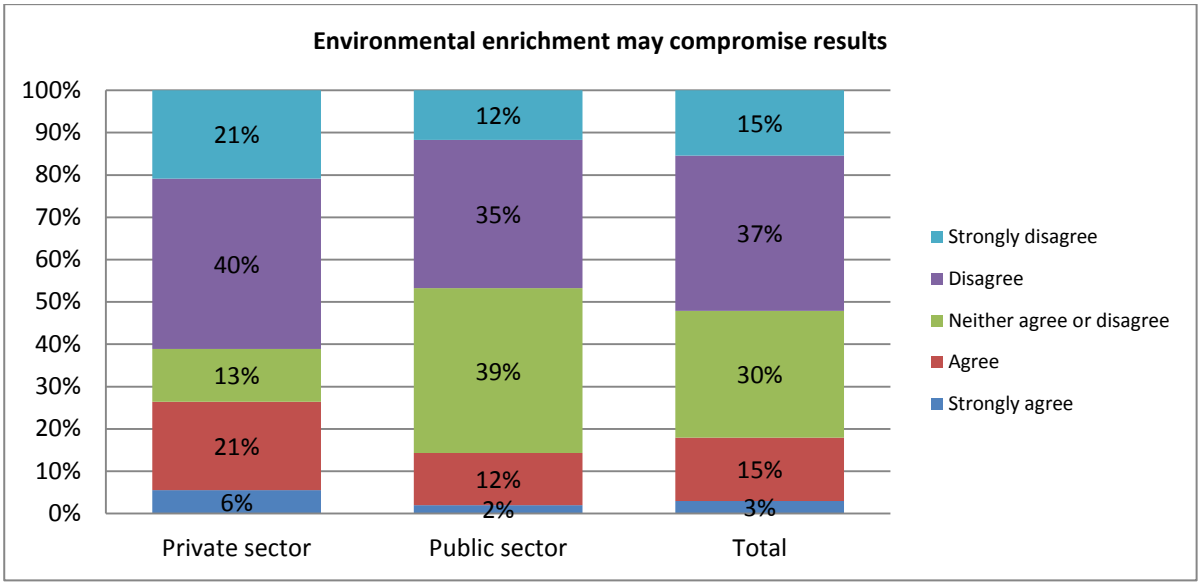

Figure 34. Environmental enrichment and the quality of results

(The sample total is 234 respondents, while the category of the public and the private sector contains 226 respondents. P-value: 0.001)

(30%) neither agree nor disagree. There is a significant difference between the sectors on this question, where more privately employed researchers think that enrichment may compromise results (27% compared to 14%) just as more privately employed researchers think that this is not the case (61% compared to 47%). By comparison, as many as 39% in the public sector are undecided on this question, while this is true for just 13% of those coming from the private sector.

The researchers' views on the quality of data produced in animal experiments can be seen in figure 35. As the figure shows, most researchers find that it is possible to generalize results from animals to humans; two thirds (66%) disagree or strongly disagree that results from animal experiments can rarely be generalized to human beings. As the figure also shows, the majority agrees that non-stressed animals yield more valid results. There are no significant differences between the two sectors on these two questions.

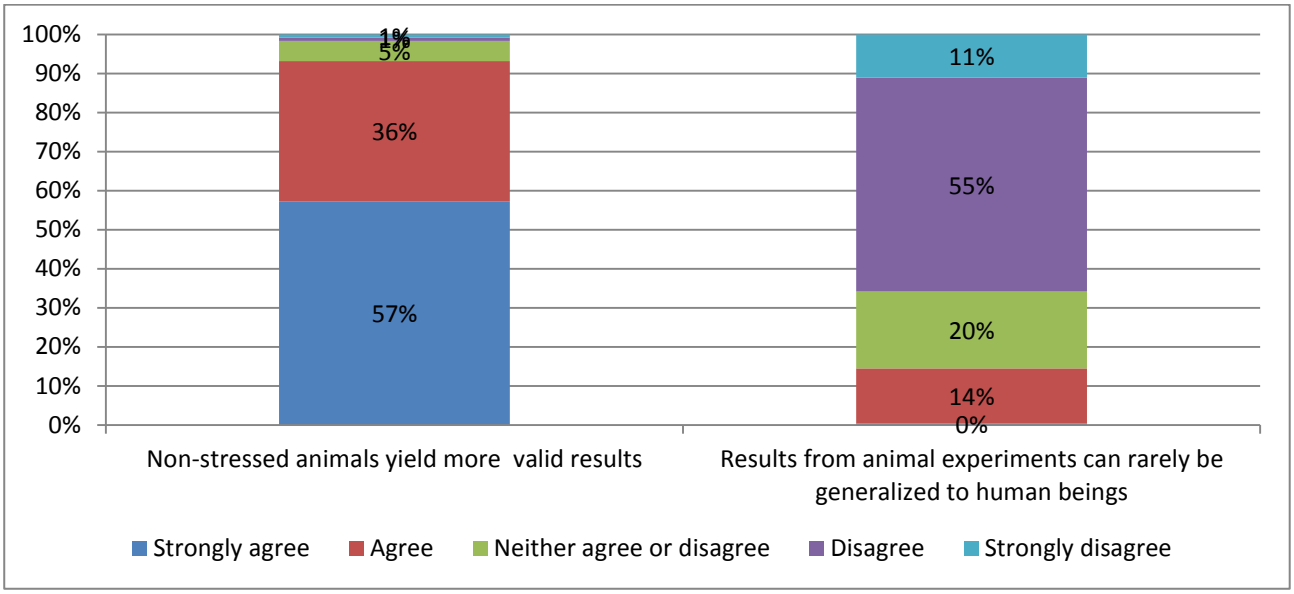

Figure 35. The quality of data produced using animals in experiments

(The sample total is 234 respondents.)

4.5 Researchers' views of the Danish 3R Center

This section reports the researchers' knowledge and awareness of the Danish 3R Center as well as their attitudes to and expectations and use of the centre.

As figure 36 shows, most researchers (73%) had heard of the Danish 3R Center two years after its establishment. There is no significant difference between the sectors regarding this point.

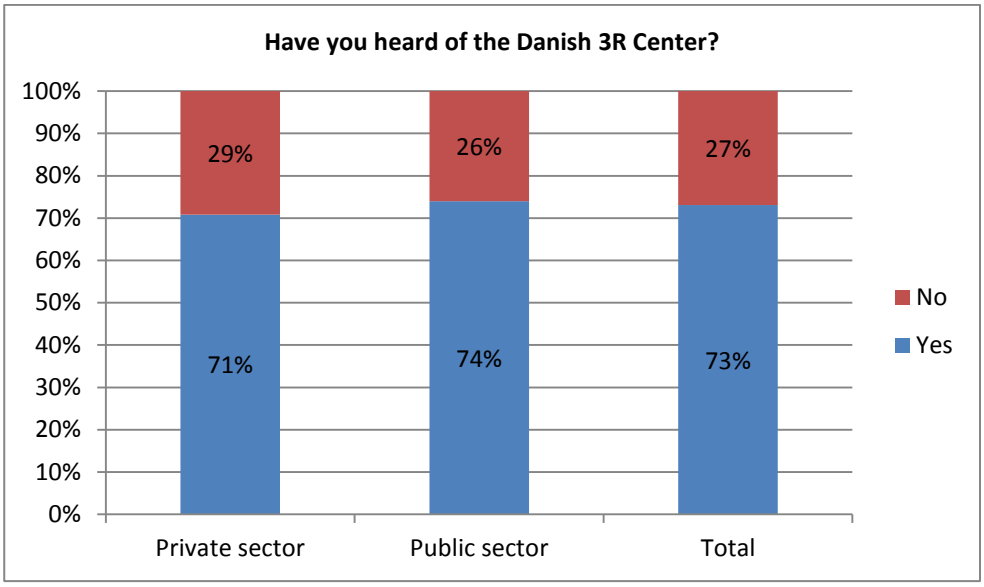

Figure 36. Researchers' awareness of the Danish 3R Center

(The sample total is 234 respondents, while the category of the public and the private sector contains 226 respondents.)

When the researchers were asked where they had heard about the center for the first time, the majority (39%) responded 'mail or Internet,' while 28% had heard about the center from their colleagues. Only few (4%) had learned about the center for first time on the center's homepage or through leaflets. See figure 37.

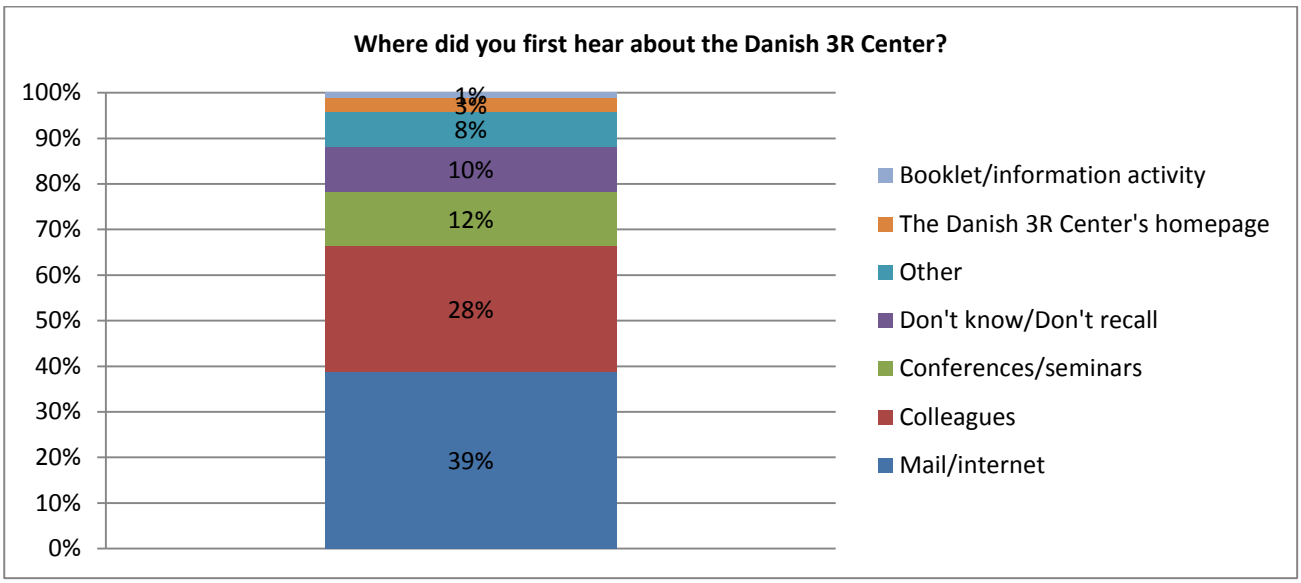

Figure 37. First source of information about the Danish 3R Center

(The sample total is 234 respondents.)

A majority of the researchers (60%) agree that the center is important for people working with experiments in Denmark, and only 5% disagree that there is a need for an institution like the 3R Center - see figure 38. A very high proportion of the respondents answered *neither agree or disagree* or *don't know* to the question which suggests that the Danish 3R Centers does a good job developing networks among researchers. A fourth of the researchers think that the center is visible and answer *disagree or strongly disagree* to the statement that the center is not visible in debates – most, however, answer neither agree or disagree (47%) or *don't know* (15%) to this question. There are no significant differences between the sectors on these questions.

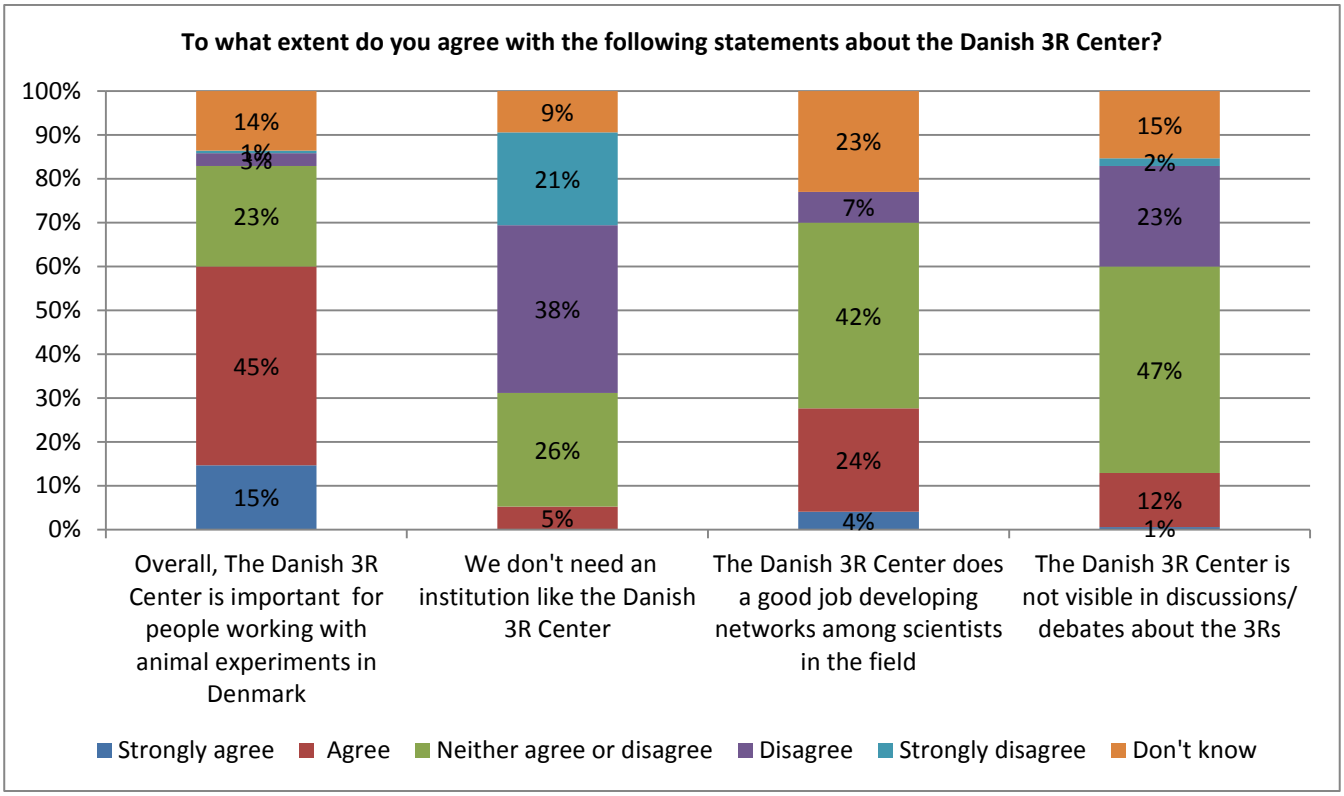

Figure 38. Attitudes to the Danish 3R Center

(The sample total is 234 respondents.)

The figures 39 and 40 display researchers' expectations regarding the Danish 3R Center. As can be seen, facilitating the establishment of networks between researchers (52%) and across the sectors (28%) is considered important activities. Also, knowledge dissemination is among the prioritized activities, where 52% state that the center should spread knowledge about the 3Rs to researchers; 26% to technical staff and 24% to the public. Organizing seminars, which may function as networking activities and knowledge dissemination, is prioritized by 42% of the researchers. Finally, few (9%) suggest that the center should play a political role to influence the public regulation of animal experiments.

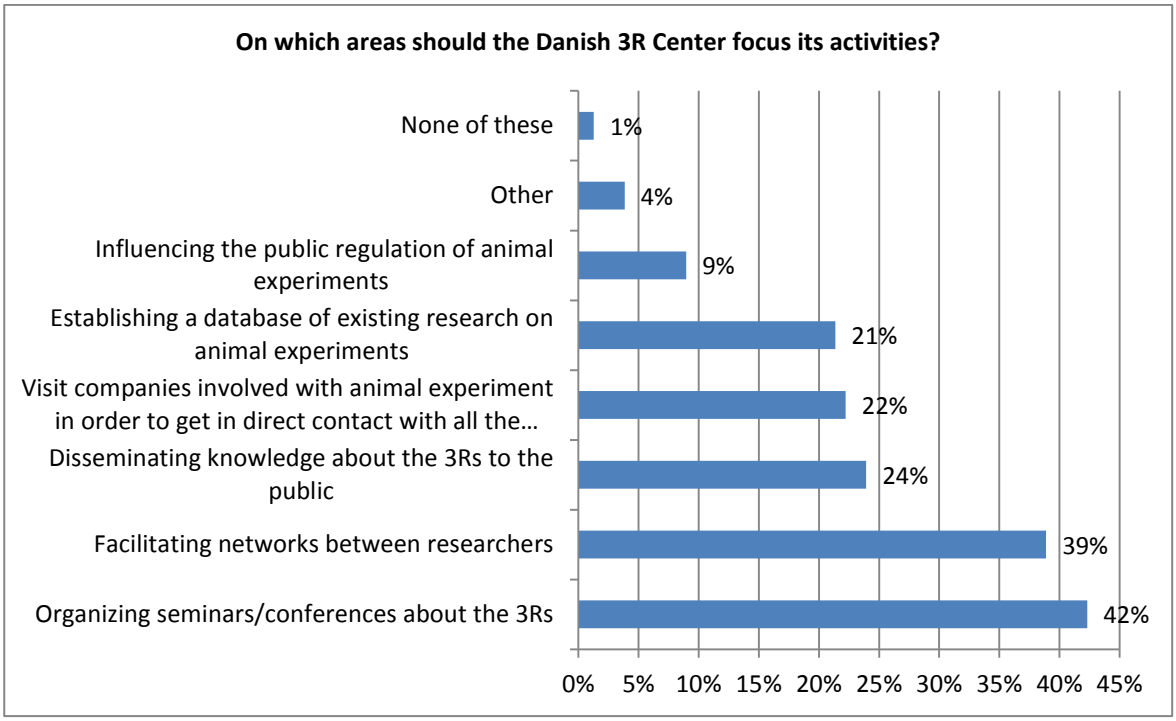

Figure 39. Expectations regarding the activities of the Danish 3R Center where there is no significant difference between sectors

(The sample total is 234 respondents. Respondents were asked to choose up to three of the areas suggested in figure 37 and figure 38. This figure only displays the suggested areas where there is no significant difference between the sectors.)

The three aspects where there is a significant difference between the sectors (see figure 40) shows that the researchers in the public sector think that the Danish 3R Center should prioritize the dissemination of knowledge about the 3Rs to researchers (58% compared to 36%) as well as to technical staff (30% compared to 15%). By contrast, more privately employed researchers want the center to prioritize activities that develop networks between the sectors than the public sector researchers (43% compared to 22%).

As figure 41 shows, there was a highly significant difference between the sectors when researchers were asked how often they have considered applying for research funding from the Danish 3R Center. The researchers from the public sector have considered this much more often than those from the private sector.

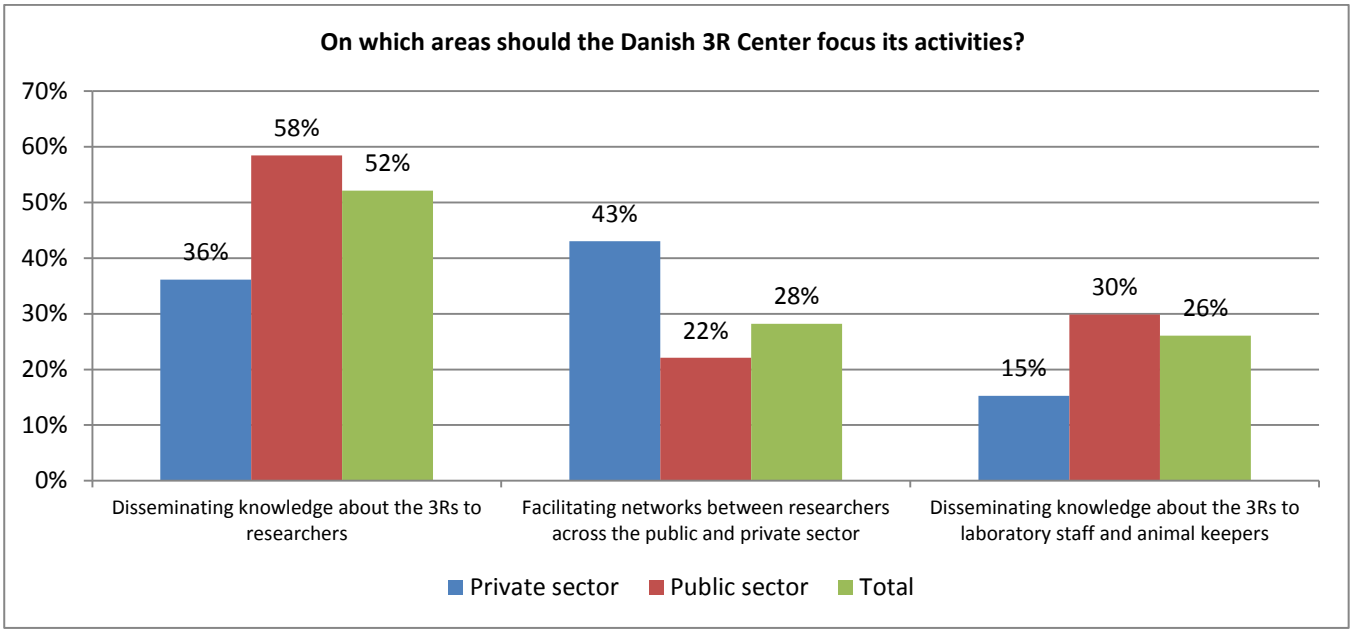

Figure 40. Expectations regarding the activities of the Danish 3R Center where there is a significant difference between sectors – total and by sector

(The sample total is 234 respondents, while the category of the public and the private sector contains 226 respondents. Respondents were asked to choose up to three of the areas suggested in figure 37 and figure 38. This figure only displays the suggested areas where there is a significant difference between the sectors' P-values: Facilitating networks between researchers across the public and private sector: 0.001; Disseminating knowledge about the 3Rs to researchers: 0.002; Disseminating knowledge about the 3Rs to laboratory staff and animal keepers: 0.019)

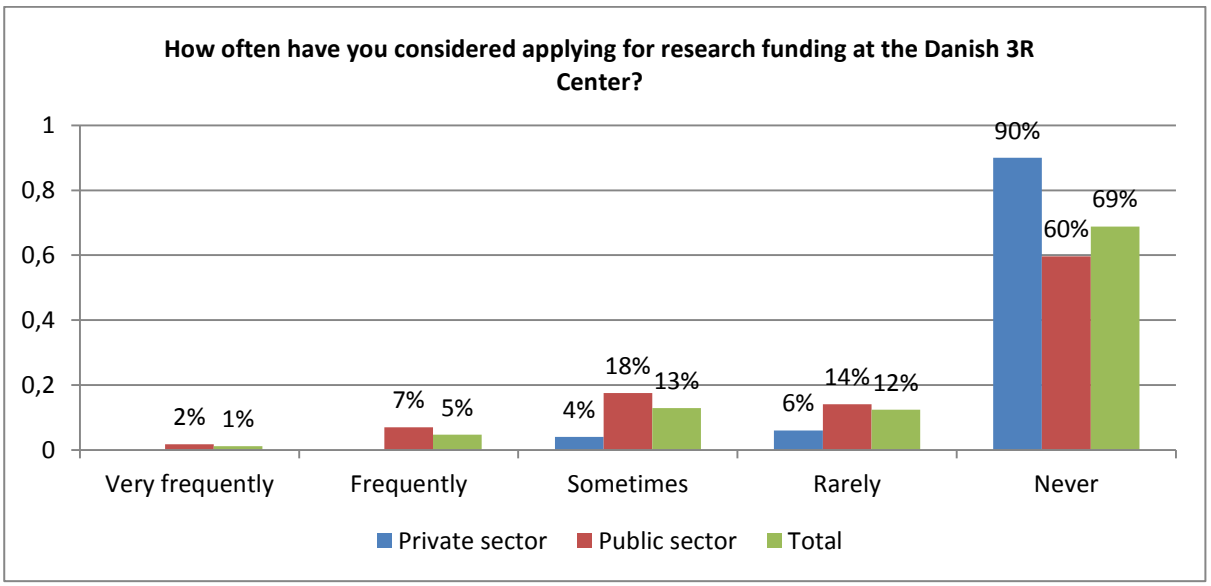

Figure 41. Researchers' thoughts about applying for funding from the Danish 3R Center

(The sample total is 234 respondents. P-value: 0.003)

4.6 Follow-up multivariate analysis of identified sector differences

The previous chapter revealed a number of differences between animal researchers employed in the public and private sector. Amongst the more pronounced differences was the fact that animal researchers from the two sectors varied with respect to the frequency with which animal welfare issues are talked about (section 4.2.3), when the 3Rs are considered in the research process (section 4.2.2), understanding the refinement component of the 3Rs (section 4.1.3), and reluctance towards the idea of implementing animal welfare concerns in animal research science (section 4.2 and section 4.4).

This raises the question of whether the differences can be explained by genuine cultural differences in the sense that animal-related concerns prevail at different levels in the two sectors. A competing explanation would be that the higher level of 3R understanding and concern for animal welfare in the private sector is determined by other circumstances such as differences in the socio-demographic profile of the researchers employed in the two sectors (nationality, age, gender, and educational background); that research objectives (basic or applied) differ in the two sectors when animals are used in experiments or that there are differences in managerial responsibility.

This chapter examines whether socio-demographic factors, different types of research activity and managerial status can explain the differences between the two sectors regarding *frequency of communication about animal welfare issues*, *understanding of refinement, when the 3Rs are considered in the research process* and *reluctance towards implementing animal welfare concerns*.

4.6.1 Dependent measures

To simplify the analysis and to construct more valid measures, all dependent variables are composite variables that are developed on the basis of several variables that are (slightly varying) indicators of the same phenomenon. These composite variables are listed and explained below.

Frequency of animal welfare communication

This variable is based on responses to three questions regarding the frequency with which the following issues are talked about: 1) Improving animal conditions in the laboratory, 2) Barriers/opportunities in terms of implementing the 3Rs, and; 3) Experience with the 3Rs. The introductory text to all these questions was: *"How often do you discuss the following themes with colleagues?",* and five response options ("never" to "very frequently") were offered to the respondents. The three questions are highly correlated, and Cronbach's alpha is 0.81, which suggests that the three questions together capture the frequency of animal welfare communication very well (variable range is 1-13).

Understanding of refinement

This variable is calculated as the number of correct responses to the five knowledge quiz questions about refinement as present in figure 6 (variable range is 0-5).

When 3Rs are considered

The results in figure 15 indicate that some researchers primarily consider the 3Rs during the application phase, while others consider them at a more practical, every day level. We conducted an initial principal component analysis (pca) to determine whether the data support this interpretation. Results from the pca indeed revealed patterns corresponding to these two dimensions. There were two components with eigenvalue >1 which are displayed in table 3.

Table 3. Results from principal component analysis (varimax rotation)

	Design phase focussed	**Everyday focussed**
When designing and carrying out an experiment	**.584**	-.026
When preparing an application for the Ethical Review Process	**.834**	-.039
When submitting project license applications	**.720**	.160
When considering a compliance perspective	.100	**.773**
All the time as part of my day-to-day work	-.088	**.653**
When coming into direct physical contact with animals	.073	**.656**
Eigenvalue (% variance)	1.675 (27.9%)	1.387 (23.12%)

(All six items in the pca were multiple response options given to the question: "When do you consider the 3Rs in your work (Tick all that apply)")

The situations that load high on the first component (highlighted in bold) all relate to considerations of the 3R during the design and application process. Thus, we label this dimension as the design focused 3R consideration. The derived variable *design phase focused 3R consideration* used in the following analysis is based on calculated factor scores (range -3.27 to 0.98). Items that imply consideration of the 3Rs at a practical/everyday level load high on the second component. Factor scores were also computed for this everyday focused dimension (range -1.09 to 2.43).

Reluctance to implement animal welfare concerns

This is a composite variable based on responses to five questions that all center on the line of thought that giving too much priority to animal welfare concerns will have some negative consequences. Three of the questions focus on general reluctance to implement animal welfare concerns *("The extensive focus on the welfare of experimental animals will hinder scientific breakthroughs", "Alternative methods will increase research costs", "Complete replacement of the use of animals in research and testing will never be achieved"*). Two questions center on the researchers own work *("Implementing the 3Rs will be detrimental to the quality of my results", "I am reluctant to change the way I work because of the need for comparability with earlier findings*"). All the question items are positively correlated, and Cronbach's alpha is 0.61, suggesting that the questions together capture reluctance satisfactorily (variable range is 3-17).

4.6.2 Multivariate analysis

Results from **Table reg.** (table 4) show that the *frequency of communication about animal welfare* is only explained by whether the scientist works in the public or private sector. The direction of this association is the same as observed in a previous part of the analysis (section 4.2.3): there is more communication about animal welfare issues in the private sector than the public sector.

The same picture emerges regarding *understanding of refinement* as only sector affiliation explains the level of understanding at the 0.05 level of significance. Similar to the findings presented in an earlier chapter, the level of understanding is lower in the public sector (section 4.1.3). It should be mentioned that age is borderline significant ($p < 0.10$) as understanding of refinement decreases with age.

A number of factors explain whether the *3Rs are considered during the design phase*. First, this focus is significantly more prevalent among scientists who work in the public sector. It is also more prevalent if scientists have managerial responsibility (i.e. if they have higher decision responsibility and are license holders). This is hardly surprising as a higher managerial status also typically implies that greater effort and more resources are put into e.g. designing and applying for funding and accreditation. Higher research activities devoted to teaching results in significantly less focus on the 3Rs during the design phases. Higher applied research activity is also associated with less focus on the design phase at the borderline significant level ($p < 0.10$). Moving on to *considerations of the 3Rs at an everyday level*, it is apparent that this everyday focus is more prevalent in the private sector. Also, researchers who, to a greater extent, work with product development/testing tend not to focus on this.

Many background factors are associated with the latter variable examined, *reluctance to implement animal welfare concerns*. Scientists working in the public sector have clearly a higher propensity to be reluctant than scientists from the private sector. Also, Danish researchers are more reluctant than non-Danish scientists and men are more reluctant than women. Reluctance also increases in tandem with responsibility for taking important decisions related to the experimentation. Finally, educational background is very highly associated with this. The most reluctant education group is the medical doctors, while the least reluctant group is the veterinarians, whilst an educational background in biology/chemistry/pharmacy occupies an intermediate attitude on this point. The combined explanatory effect of these variables is quite high (R^2 approximately 28%), suggesting that there is considerable difference across relevant backgrounds in reluctance to implement animal welfare concerns.

Table 4. Table reg. What explains frequency of animal welfare communication, understanding of refinement, when 3Rs are considered and reluctance – results from five ols regressions

	Animal welfare communication			**Understanding of refinement**			**Design phase focused 3R considerations**			**Everyday focused 3R considerations**			**Reluctance**		
	B	Wald Chi2	Sig	B	Wald Chi2	Sig	B	Wald Chi2	Sig	B	Wald Chi2	Sig	B	Wald Chi2	Sig
(Intercept)	10.579	51.570	.000	4.401	26.155	.000	1.434	6.884	.009	1.393	5.564	.018	7.191	22.653	.000
Sector affiliation (ref. private)															
Public	-1.352	7.135	.008	-.841	8.096	.004	.474	6.363	.012	-.739	13.277	.000	1.941	13.982	.000
Socio-demographic factors															
Gender (ref: women)															
Men	-.111	.101	.751	-.310	2.304	.129	.031	.058	.809	-.179	1.639	.200	.861	5.781	.016
Age (range 24-90 y)	.009	.277	.598	-.017	2.790	.095	-.001	.014	.907	.005	.420	.517	.006	.125	.723
Nationality (ref: Danish)															
Non-Danish	-.203	.232	.630	.155	.396	.529	-.101	.416	.519	.167	.975	.324	-1.155	7.154	.007
Education (ref: biological /chemist/ pharmacy degree)															
Medical doctors	-.011	.001	.982	-.299	1.172	.279	-.011	.004	.949	.257	1.835	.176	1.184	5.965	.015
Veterinarian	.497	1.556	.212	.029	.016	.901	-.177	1.428	.232	.073	.209	.648	-1.026	6.307	.012
Type of research activity															
Basic research	-.222	2.063	.151	.005	.003	.959	-.026	.211	.646	-.092	2.215	.137	.161	1.033	.309
Applied research	.094	.521	.470	.042	.307	.580	-.089	3.327	.068	.042	.651	.420	-.042	.100	.752
Product development/testing	-.182	1.916	.166	.012	.023	.880	-.037	.577	.447	-.107	4.106	.043	.200	2.202	.138
Teaching	-.165	1.281	.258	-.046	.290	.590	-.152	7.878	.005	-.062	1.117	.290	.149	.996	.318
Authorisation of animal testing protocol	-.045	.093	.760	.005	.004	.952	-.018	.113	.737	-.034	.332	.564	-.198	1.702	.192
Preparation of animal testing protocol	-.216	2.310	.129	.084	1.016	.313	.032	.374	.541	.047	.683	.408	-.012	.007	.932
Managerial status indicators															
Degree of decision responsibility regarding animal research (reference: very much)															
Somewhat/little/not at all	.316	.394	.530	.181	.378	.539	-.593	10.057	.002	.132	.426	.514	-1.050	4.121	.042
Much	-.446	1.210	.271	-.270	1.297	.255	-.007	.002	.965	-.103	.401	.526	-.902	4.713	.030
License holder (ref.:yes)															
No	.349	.674	.412	.154	.383	.536	-.559	12.577	.000	.220	1.660	.198	.344	.621	.431
Number of years working with animal experiments	.033	.128	.721	-.028	.280	.597	-.050	2.158	.142	-.048	1.693	.193	-.053	.317	.574

(N=220.The variables in the table above describing gender, nationality and sector are binary. The age variable is continuous. Education is a recoded variable derived from five variables (biology, veterinary, chemistry/biochemistry, medicine, pharmacy), see note below table 1.A, Appendix 1 for further details. The variable Type of research activity is derived from six variables asking 'how often do you work within the following area' (basic research, applied research, product development/testing, teaching, authorization of animal testing protocols and preparing animal testing protocols) with the following response options offered to the respondent: "very frequently" to "never". The variable degree of decision responsibility regarding animal research is derived from a variable asking 'to what extent are you responsible for making the important decisions concerning the protocol of the animal experiments in which you are involved?' with the following response options: very much/much/somewhat/little/not at all. The variable number of years working with animal experiments has the following response options: less than one year/1-4 years/5-10 years/11-20 years/more than 20 years.)

5 Discussion

The overall purpose of this project was to survey experiences with and perceptions and knowledge of the 3Rs among researchers involved with animal experiments in Denmark, and to survey their attitude to the use of animals in experiments and reluctance to implement animal welfare considerations. Specific attention was paid to the examination of differences between researchers working in public research institutions and private (typically medical) companies. Further, the results from this survey are also intended to provide input to the Danish 3R Center's efforts to ensure knowledge production and dissemination about the 3Rs within the research community.

In this discussion, the main findings are presented and discussed under five themes. When relevant, recommendations for the 3R Center on how to proceed with the implementation of the 3Rs are also highlighted. In the last section of the discussion a number of future actions points are recommended to the Danish 3R Center.

Knowledge and sources of knowledge

All researchers report that they have at least some knowledge of the 3Rs, while the majority assesses their knowledge of the 3Rs to be good. Researchers from the private sector are particularly confident in their own knowledge about the 3Rs and they also report to have known about the principles for longer than the public researchers; a difference that may be explained by the educational background of the researchers in the two sectors. Thus veterinarians, for whom the 3Rs constitute a natural part of their curriculum, dominate the private sector, while the public sector is dominated by researchers with an educational background in biology, chemistry or pharmacy.

The majority of the researchers turn to their network or the Internet when seeking information about the 3Rs. Further, a large proportion of the researchers employed in the private sector get their information about the 3Rs from the Ethical Committee at the workplace or colleagues. Although conferences are not among the most favoured places to seek information about the 3Rs, it should be noted that researchers working in the private sector are considerably more active when it comes to attending such activities just as they are significantly more likely to turn to conferences to get information about the 3Rs.

These differences may reflect a deeper cultural difference between the sectors, namely that there are differences in how qualifications are upgraded or maintained. This points towards a need to carefully consider the means of communication in a strategic effort to maintain and develop 3R qualifications in the two sectors, and when preparing future generations of researchers during their education.

Factual understanding

The results show a rather confident group of researchers, most of who claim that they know the 3R principles well or very well. This corresponds with the actual level of knowledge as tested in the knowledge quiz: knowledge is quite high. Although there are more correct than incorrect answers for all the 3Rs, the quiz also shows that the three principles are not equally well understood. Thus refinement stands out as the least well understood principle. Moreover, researchers from the private sector have a significantly better understanding of several aspects of refinement, even when potential alternative explanations are taken into consideration (cf. multivariate analysis in section 4.6.2).

This suggests, first, that the other results about, e.g. barriers to the implementation of and attitudes to refinement should be read and interpreted with some care. For instance, if researchers have a poor understanding of the principle, it is less likely that they will be able to identify the right obstacles and take appropriate action so as to implement refinement. Second, there is a special need to disseminate knowledge and train researchers (in particular public researchers) in the refinement principle, assuming that there is a correlation between a correct understanding and adequate practice.

There is a noticeable difference between the results of the knowledge quiz in the British NC3R survey and the Danish results regarding all 3Rs, indicating that researchers in Britain, in general, have a poorer understanding of these three principles. This result should, however, be treated with some care as the NC3R survey is seven years older than the Danish survey and thus precedes the revised EU directive that may have led to increased attention and training in the 3Rs in both countries.

Attitudes to the use of animals in research and reluctance to change research practices

The clear majority, unsurprisingly, are of the opinion that the use animals for important research endeavours, e.g. teaching purposes at the university is acceptable, and that it is acceptable to use a range of animals, from mice to dogs. Despite this, there is also considerable agreement that the welfare of animals is very important. This is both because most find that animals have some basic rights that should be respected, and because of the prevalent perception that mistreated animals cannot provide valid results.

As an extension of this finding, there is also quite a low level of reluctance towards implementing animal welfare concerns concretely in animal research practice. The clear majority disagrees that the focus on the welfare of laboratory animals hinders scientific breakthroughs and that implementing the 3Rs will be detrimental to their own work. Despite this, a clear difference in the degree of reluctance was identified between the two sectors with researchers in the public sector being more reluctant. This difference was retained after adjustment for additional explanatory factors[1]. Also medical doctors who primarily work in the public sector were considerably more reluctant than researchers with other educational backgrounds. This suggests that animal welfare issues and the 3R principles receive less attention at least in some parts of the public sector. This study cannot identify whether reluctance is specific to the culture in a subset of public institutions, or whether reluctance is lower in the sector as a whole. However, the higher reluctance in the public sector may be a cause of concern insofar as this propensity results in lower engagement in the 3Rs and animal welfare issues in general. Indeed, additional analysis shows that higher reluctance is associated with lower animal welfare communication in the work place (Pearson's r=-0.300), lower understanding of refinement (Pearson's r=-0.3330), and less everyday focus on the 3Rs (Pearson's r=-0.259). Although it cannot be ruled out that there is a qualitative difference between researches in the two sectors, these findings suggest that there is a need to target researchers in the public sector and challenge their view on the relationship between animal welfare and the quality of their research.

[1] Since the quality of results is a major concern in any research activity, the differences in reluctance may reflect the nature of research in the two sectors (more applied and drug testing, e.g. in the private sector and more basic research in the public), However, the difference in research activities did not explain the sectoral differences in the propensity to be reluctant (see section 4.6.2).

Implementing the 3Rs

According to a clear majority of the researchers, refinement and reduction play a role when planning and carrying out experiments, and many have developed techniques to refine and reduce the use of animals. Even replacement plays a role for many during planning and designing experiments, although it is less clear how this happens in practice. Going a bit deeper into this question, it appears that there are, in fact, very large differences as to when researchers from the public and private sector pay attention to the 3Rs. Researchers employed in the private sector predominantly consider the 3Rs when they are in direct contact with the animals and in their daily work. By contrast, public sector researchers predominantly consider this in the course of obligations, such as submitting project license applications, and preparing an ethical review process.

Section 4.6 examined whether these differences could be accounted for by the different profiles of the public and private researchers included in the sample. If, for instance, a higher proportion of researchers are at a high level in the public sector (such as professors, who seldom have hands on experience with animals and instead spend their time on research applications), this would result in less frequent contact with animals on a daily basis, which in turn could account for the sectoral difference observed. However, managerial responsibility, type of research activity and other socio-demographic differences do not account for the higher propensity in the public sector to consider the 3Rs during application/design phases or their lower propensity to consider the 3Rs in their daily work.

Surely, the measures examined here cannot provide a complete portrayal of the implementation of the 3Rs in the public and private sector. On the whole, though, there are striking differences between the two sectors with respect to how and to what extent the 3Rs appear to be implemented. Whether this reflects actual differences in the implementation is an open question that cannot be answered by a survey like this, but instead must be investigated by studying the actual design of the experiments themselves.

It should, however, be noted that there are differences between the Rs. While it is important to consider all Rs in the initial designing phases of research because they are heavily reliant on the final design – some adjustments to achieve refinement could be achieved when the project is running and the researcher is in direct contact with the animals. It is, though, less likely or impossible to achieve reduction and replacement when in direct contact with the animals during the experiment since these Rs require a different approach to be chosen and – in the case of replacement – maybe even the involvement of other sciences.

Although most researchers know about the ethical committee at their workplace, it is notable that about 1/3 of the public sector researchers are not aware of this committee. Further, in both sectors and especially in the public sector, a relatively large proportion does not find the committee helpful, especially when it comes to implementing the 3Rs. This point towards a further need to understanding how the committees are organized in the different sectors. For instance, does physical location of the committee have an impact on the frequency and smoothness of the communication between researcher and committee? And what role does the committee actually play in relation to the researchers and their experiments. Such insights may help to develop committees' role in relation to the 3Rs either by highlighting a possible need to revise the requirements / instructions for the committees just as it may make it possible to incorporate these sector-related difference in the way the committees are used as strategic partners to promote the implementation of the 3Rs.

The future of the 3Rs

Only a minority of the researchers believe that a complete replacement of animal experimentation will be achieved in the future. Interestingly, however, the majority were not of the opinion that alternatives were more costly, while just a third thought that alternatives were not recognized in the research community. The results, however, indicate that the limited expectations for replacement can be explained by two important factors. First a lack of technological solutions, which is reflected by the fact that few believe that the use of computer models will one day replace animals and a general call for a number of other technical solutions. Second, and much more important, is the fact that as many as 82% of the researchers do not see replacement as an option because they claim that their research demands the use of the whole animal system. This general rejection of replacement as a relevant option is in stark contrast to the finding that close to everyone (97%) agrees or strongly agrees that researchers have an obligation to check if there are alternatives before using animals.

By contrast, reduction seems to be less dependent on technological progress as GM animals, stem cells and breeding programs are only perceived to have minor importance for future reductions. Instead, the researchers point to the importance of sharing data between companies and research groups. Also here economic concerns are not a major issue, but a certain conservatism seems to prevail, since many (40%) suggest that willingness to change methods is a major obstacle.

Knowledge about and expectations of the Danish 3R Center

The Danish 3R Center can be said to be fairly well known among the researchers in this field. Most have heard about the centre through mails, the Internet or colleagues. A clear majority think that the centre is important for people working with experiments in Denmark, whereas only 5% do not think there is a need for such an institution. However, the researchers do not yet know whether the efforts of the 3R Center have an impact. Thus, 65% respond that they "don't know" or "neither disagree nor agree" that "The Danish 3R Center does a good job developing networks among scientists". Similarly, 62% "don't know" or "neither disagree nor agree" that the centre is visible in debates about the 3Rs. This very likely reflects the fact that the centre was established relatively recently, and that the respondents have not yet formed an impression of the centre's efforts or the quality of these efforts. Therefore, these responses are of limited relevance at this point.

A large proportion of the researchers believe that the centre ought to focus its activities on organizing seminars/conferences about the 3Rs. In line with this, many believe that the centre should facilitate networks between researchers, whereas few find that the 3R Center should be engaged in more political activities such as influencing public regulation of animal experiments.

The majority of researchers working in the public sector think that, in the future, the centre should focus on disseminating knowledge about the 3Rs to researchers whereas fewer think that they should address laboratory staff and animal keepers. By contrast, researchers from the private sector predominately wish the centre to focus on facilitating networks between researchers across the public and private sector.

It is noteworthy that researchers in the public sector would like the centre to disseminate knowledge about the 3Rs to researchers and additional staff, to a greater extent, while private sector scientists are

more interested in developing networks. The call for the dissemination of knowledge about the 3Rs from the public sector could reflect the fact that scientists in this sector recognize that there is a knowledge gap and perhaps an inadequate focus on 3R implementation. It, therefore, appears imperative that the centre meets this need.

Recommended action points

The identified differences between researchers working in the public and private sector, respectively, suggests that it would be relevant for the Danish 3R Center to operate with a partial dual strategy in their future efforts to disseminate knowledge about the 3Rs. Specifically, basic knowledge about the 3Rs should be targeted to the public sector. It could include four themes where the analysis suggests improvements are relevant:

1) Information about the 3R principles, in particular refinement
2) Information about the local committees and that it can facilitate the researchers with respect to animal welfare issues. In addition to this basic knowledge it is also relevant to target public scientists with information on
3) Guidance about how to make the 3Rs operational in the daily work with animal experiments
4) Informing and demonstrating that compliance with the 3R principles will not damage research.

The latter point targets the reluctance among public sector researchers to implement animal welfare considerations, and could include exemplary illustrations preferably from basic research, where it can be seen that following the 3R principles does not result in less knowledge generation or higher costs.

The four themes laid out above are of course also relevant for private sector scientists. However, it is more critical to target the public sector scientists. There are different media through which this can be done, including direct contact (mails and information from the institution's committee) but also through seminars/conferences, cf. below.

Researchers in the private sector are, generally speaking, more knowledgeable about the 3Rs, less reluctant, report to have some experience with the 3Rs and work in organizations where there is more focus on their implementation. However, a considerable portion of scientists from this sector also calls for more knowledge about the 3Rs and are positive towards the idea that the Danish 3R Center facilitates networks between public and private researchers. This underline the importance of the annual symposia already organized by the centre and suggests that there is a need for other similar and perhaps less ambitious events gathering animal researchers from both sectors. Such activities should invite the researchers to exchange experience with different aspects of the 3Rs and their implementation and could have a less formal nature as experience exchange group (ERFA groups), where e.g. researchers from public and private institutions can meet each other and exchange ideas and experience.

In addition to providing information about the four themes listed earlier where improvements can be made particularly among scientists in the public sector, the seminars/conferences should particularly address when and where replacement can be considered. Since the large majority of scientists do not expect to be able to replace their research with non-animal techniques, there is room for improvement here as well.

References

European Parliament and Council (2010). Directive 2010/63/EU of the European Parliament and of the Council of 22 September 2010 on the protection of animals used for scientific purposes. Official Journal of the European Union L 276/33.

Fenwick, Nicole, Peter Danielson & Gilly Griffin (2011). Survey of Canadian animal-based researchers' views on the three Rs: replacement, reduction and refinement. *PloS one* 6(8): e22478.

Franco, N.H. & I.A.S. Olsson (2014). Scientists and the 3Rs: attitudes to animal use in biomedical research and the effect of mandatory training in laboratory animal science. *Laboratory Animals* 48(1): 50–60.

Knight, Sarah, Aldert Vrij, Kim A. Bard & Doug Brandon (2009). Science versus human welfare? Understanding attitudes toward animal use. *Journal of Social Issues* 65(3): 463–483.

Van Luijk, Judith, Yvonne Cuijpers, Lilian van der Vaart, Tineke Coenen de Roo, Marlies Leenaars & Merel Ritskes-Hoitinga (2013). Assessing the application of the 3Rs: a survey among animal welfare officers in The Netherlands. *Laboratory Animals* 47(3): 210–219.

NC3R (2008). Views on the 3Rs: Survey Report 2008. National Centre for the Replacement, Refinement and Reduction of Animals in Research, London.

Russell, W.M.S., & R.L. Burch (1959). *The Principles of Humane Experimental Technique.* London: Methuen & Co. Ltd.

Sandøe, Peter, Nuno H. Franco, Thomas B. Lund, Daniel M. Weary & I. Anna S. Olsson. (2015). Harms to animals: can we agree on how best to limit them? *ALTEX Proceedings* 4(1): 28–32.

Schiffelers, Marie-Jeanne W. A., Bas J. Blaauboer, J. Martje Fentener van Vlissingen, Janne Kuil, René Remie, Joop W.G.M. Thuring, Manon A. Vaal & Coenraad F. M. Hendriksen (2007). Factors stimulating or obstructing the implementation of the 3Rs, in the Regulatory Process. *ALTEX – Alternativen Zu Tierexperimenten* 24(4): 271–278.

Appendix 1

Table 5. Demographic characteristics

Factor	Category	Frequency	Percentage
GENDER	Male	117	50%
	Female	117	50%
	Total	234	100%
AGE	20-34 years	50	21%
	35-44 years	85	36%
	45-54 years	55	24%
	55 years->	44	19%
	Total	234	100%
NATIONALITY	Danish	193	82%
	Other	41	18%
	Total	234	100%
LEVEL OF EDUCATION	Bachelor's degree	2	1%
	Master's degree	56	24%
	PhD. degree	152	65%
	Other	24	10%
	Total	234	100%
EDUCATIONAL BACK-GROUND	Biology/chemistry/pharmacy	129	55%
	Medical doctor	35	15%
	Veterinarian	64	27%
	Other education/not academic researcher	6	3%
	Total	234	100%
PROFESSION (Public sector)	Research Assistant	4	3%
	PhD Student	21	14%
	Post Doc	17	11%
	Assistant Professor/Junior Researcher	8	5%
	Associate Professor/Senior Researcher	53	34%
	Professor	40	26%
	Other	11	7%
	Total	154	100%
EMPLOYMENT SECTOR	The private sector	72	31%
	The public sector	154	66%
	Both private and public sector	8	3%
	Total	234	100%
STATUS OF LICENSE	Licensee	168	72%
	Non-licensee	66	28%
	Total	234	100%
WORK EXPERIENCE IN PRE-VIOUS POSITIONS	Not worked with animal experiments in pre-vious positions	63	27%
	Less than one year	15	6%
	1-4 years	61	26%
	5-10 years	53	23%
	11-20 years	30	13%
	More than 20 years	12	5%
	Total	234	100%

WORK EXPERIENCE IN CURRENT POSITION	Less than one year	24	10%
	1-4 years	81	35%
	5-10 years	44	19%
	11-20 years	49	21%
	More than 20 years	36	15%
	Total	234	100%

(Educational background is a recoded variable derived from five variables (biology, veterinary, chemistry/biochemistry, medicine, pharmacy) with the option of ticking all that apply coded into four categories; veterinary, medicine, chemistry/biology/pharmacy and other education/not academic researcher.)