

Occupational Allergy Among  
Laboratory Animal Workers Exposed to Mice:  
The Role of Respiratory Protection

By

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## **ABSTRACT**

**Problem:** Workers exposed to laboratory animal allergens develop laboratory animal allergies (LAA) (sensitization accompanied by allergic symptoms) which often progresses to occupational asthma (OA). Although public health agencies endorse using disposable particulate respirators (DPRs) as a means of primary prevention of LAA and OA, we have a poor understanding of the factors associated with their use. In addition, no research has been published verifying that DPRs are an effective form of primary prevention of the aforementioned health outcomes.

**Methods:** To address these questions, two studies were performed using data obtained from an ongoing prospective occupational cohort study of laboratory animal workers. The first was a cross-sectional study which evaluated the associations between workers' health beliefs and their use of DPRs. The second study utilized a prospective occupational cohort design and evaluated the association between DPR use and risk for becoming sensitized to mouse allergen or developing respiratory symptoms.

**Results:** We found that only fifty-five percent of participants used DPRs at least some of the time, and that participants' perceptions of their susceptibility to adverse effects of mouse allergen exposure, self-efficacy for using a DPR, and the perceived barriers to using a DPR were significantly associated with DPR use. In the second study we determined that workers who used DPRs intermittently were more likely to become sensitized and to develop LAA compared to workers who used DPRs consistently or not at all.

**Conclusions:** These findings have implications for the policies that address the use of DPRs as a means of primary prevention of LAA, as well as future research in this field. Specifically, we may need to reconsider the emphasis placed on assuring DPR use as a

means of primary prevention. With regard to future research, it will be important to evaluate the effectiveness of health-belief based interventions on DPR use and worker health outcomes, to define the mechanism by which intermittent DPR users are at the highest risk of developing allergic outcomes, and to develop methods of determining those most at risk for developing allergic outcomes as well as new means of primary prevention.

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## **PREFACE**

It is my belief that people have the right to work in an environment that will not threaten their health, and that as public health practitioners one of the biggest contributions we can make to society is to pursue this aim. This work was supported in part through a grant from the National Institute for Occupational Safety and Health through support of the Johns Hopkins Education and Research Center for Occupational Safety and Health (T42OH008428), as well as the National Institute of Environmental Health Sciences (P50ES015903, P01ES018176, P01ES018181, R01ES019560), the Environmental Protection Agency (R832139, STAR Grant RD83451501), and the National Institute of Allergy and Infectious Diseases (R01AI070630 and U01AI083238).

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*This dissertation is dedicated to my dear friend*

*Anna Miriam Kuntson*

*1976 -2013*

*and my cousin,*

*Paul Kasameyer, PhD*

*1945 – 2014.*

*You are both sorely missed and –  
–your passion for life and learning will never be forgotten.*

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## ABBREVIATIONS

APF	Assigned Protection Factor
DPR	Disposable Particulate Respirator (N95)
EU	European Union
IgE	Immunoglobulin E
IgG	Immunoglobulin G
LAA	Laboratory Animal Allergy
NIH	National Institutes for Health
NIOSH	National Institute for Occupational Safety and Health
OA	Occupational Asthma
OSHA	Occupational Safety and Health Administration
PAPR	Powered Air-Purifying Respirator
RPS	Respiratory Protection Standard (29 CFR 1910.134)
SPT	Skin Prick Test
The Guide	The Guide to the Use and Care of Laboratory Animals in Research

# CHAPTER 1: INTRODUCTION

## 1.1 Statement of the Problem

Laboratory animal workers are at high risk of developing laboratory animal allergy (LAA), which can lead to occupational asthma (OA), a permanent and disabling condition<sup>1-18</sup>. Often the only way to prevent workers who have developed LAA from developing OA is removal from exposure. LAA not only threatens workers' livelihoods, but also encumbers significant cost to employers<sup>2,17-21</sup>. Therefore, means of preventing sensitization, and thereby LAA, are needed<sup>4,5,10,13,16,17,19,21-28</sup>.

In conjunction with an occupational safety and health program aimed at exposure reduction, both the Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH) endorse disposable particulate respirators (DPRs) as a means of primary prevention of LAA based in part on two assumptions<sup>4,25,29-31</sup>. Specifically, the assumptions are that: 1) the exposure-sensitization relationship is linear; and 2) DPRs are capable of reducing the risk for developing the adverse allergy-related health outcomes associated with exposure<sup>1,5,6,8,10,11,19,22,23,31-45</sup>.

However, there is substantial controversy surrounding these assumptions<sup>14,45-59</sup>. In fact, to our knowledge, no published research has been conducted verifying the effectiveness of DPR use as a form of primary prevention of the adverse allergy-related health outcomes associated with exposure to laboratory animal allergens<sup>2,4,5,10,11,21,23,27,34,38,43,45,60-69</sup>. In addition to the uncertainty surrounding the

effectiveness of DPRs, we also have a poor understanding of the extent to which DPR-use policies are adopted and practiced in the workplace, or the factors associated with adherence to DPR use<sup>70-79</sup>.

Preliminary data, gathered as part of an ongoing prospective occupational cohort at the Jackson Laboratory in Maine, measured the primary preventative effect of DPR use, independent of an established occupational health program, on the risk for developing sensitization to mice. Analysis of these data suggests that a large proportion of workers do not use respiratory protection, and that DPR use did not result in a reduction in the risk of sensitization.

## **1.2 Research Questions**

With the evidence base and our preliminary findings in mind, we hypothesized that:

1) worker's health beliefs are associated with DPR use; and 2) workers who use respiratory protection intermittently are at a higher risk for sensitization and developing allergic outcomes than workers who do not use respiratory protection.

These hypotheses were tested using prospective occupational cohort data, thus providing a unique opportunity to examine these relationships and assumptions in ways that had not been previously possible. Two specific aims were used to structure the research:

1) Evaluate the strength of the associations between workers' health beliefs and the frequency with which they use DPRs by

characterizing: (a) the frequency of DPR use; and (b) the associations between health beliefs and frequency of DPR use.

2) Characterize the association between frequency of DPR use and the time to development of: (a) mouse-specific sensitization; and (b) allergic symptoms.

### **1.3 Study Site and the JAXCohort**

The data used in this study were collected at the Jackson Laboratory, a research and mouse-husbandry facility in Bar Harbor, Maine<sup>14,15</sup>. As one of the larger non-seasonal employers in the region, the Jackson Laboratory has a high rate of retention of its approximately 1,300 workers<sup>14,15</sup>. In addition, a robust occupational safety and health program aimed at exposure reduction is in place and mice are the only species housed at the facility, making it an ideal location for evaluating a number of different research questions regarding laboratory animal exposure-sensitization pathways, the effectiveness of primary and secondary prevention methods, and the individual and occupational factors associated with respiratory protection use. With these factors in mind, the JAXCohort was established in 2004. Data were gathered in two phases: Phase 1 (2004 to 2009), and Phase 2 (which began enrolling in 2010 and ended enrollment in 2014). A subset of the JAXCohort data (collected from 2004 until October 1, 2013) were included in this analysis.

Participants for the JAXCohort were recruited by study staff during their initial post-job offer health screening, which all newly hired employees undergo. All non-temporary, full-time workers over the age of 18 with no history of sensitization to mice who had been employed at the Jackson Laboratory for less than a month were eligible to participate in the JAXCohort<sup>14</sup>. Every six months, workers' respiratory protection use, exposure to mouse allergen, incident mouse-sensitization, and LAA were measured. Workers' health beliefs and attitudes regarding respiratory protection were assessed using a survey administered during the first six-month follow-up visits of Phase 2<sup>14</sup>.

Both phases of the JAXCohort study were approved by the Institutional Review Boards at the Jackson Laboratory and the Johns Hopkins School of Medicine. Written consent was obtained at baseline. In order to complete specific aim 1, a cross-sectional analysis of the association between workers' health beliefs and their respiratory protection use was conducted (n=90). In order to complete specific aim 2, a longitudinal analysis using Cox proportionate hazard modeling was conducted (n=222).

#### **1.4 Organization of the Dissertation**

A review of the literature salient to my research questions are presented in Chapter 2. Subsections include: hazard identification, routes of exposure, and health effects associated with exposure to laboratory animal allergens. Section 2.3 presents an overview of the regulatory agencies and their associated regulations and guidance

documents regarding the use of disposable particulate respirators as a means of primary prevention of the adverse respiratory health outcomes associated with exposure to laboratory animal allergens. The subsequent sections review the evidence base underlying these policies, specifically with regard to the exposure-response relationship, as well as the effectiveness of disposable particulate respirators as a form of primary prevention of LAA and OA. The last two sections of Chapter 2 are devoted to discussing how these policies have been implemented, as well as what is known regarding the factors that influence DPR-use practices. Specifically, the requirements regarding recordkeeping, medical monitoring, surveillance, and the evaluation of site-based respiratory protection programs are reviewed. The chapter concludes with a discussion of the current evidence regarding the role that psychosocial determinants play in the performance of health behaviors such as the use of disposable particulate respirators. Supplementary materials for this chapter are presented in Appendix 1, including OSHA's Respiratory Protection Standard (29 CFR 1910.134).

The first manuscript, entitled "Laboratory Animal Workers' Health Beliefs and their use of Disposable Particulate Respirators," is presented in Chapter 3. This cross-sectional study (n=90) evaluated the association between laboratory animal workers' health beliefs and their use of DPRs using the Health Belief Model (HBM) as a framework. Associated tables and figures are presented immediately following the conclusions section. Supplementary materials—including our conceptual framework, the associations between responses to individual questionnaire items and DPR use, and other pertinent information—are presented in Appendix 2.

The second manuscript, entitled “The Effectiveness of Disposable Particulate Respirator Use in Primary Prevention of Incident Allergic Sensitization and Laboratory Animal Allergy,” is presented in Chapter 4. This prospective occupational cohort study (n=222) evaluated the associations between laboratory animal workers’ use of DPRs and their risk for becoming sensitized to mouse allergen and developing LAA. Associated tables and figures are presented immediately following the discussion. Supplementary materials are presented in Appendix 3, including the questionnaires used to gather data.

Chapter 5 includes a discussion of the findings of both studies in the context of the evidence to date, as well as the current regulatory framework. In addition, implications for both policy and research are discussed. The bibliography of the references cited follows the appendices.

## **CHAPTER 2: BACKGROUND**

### **2.1 Hazard Identification and Routes of Exposure**

Each day, more than 125,000 laboratory animal workers are exposed to animal allergens such as Mus m 1, the major allergen associated with mice, which is found in feces, urine, dander, and blood<sup>15,19,80</sup>. Ninety percent of Mus m 1 adheres to particles between <10um in size, allowing it to penetrate into the deepest parts of the lung and to disperse throughout facilities from point sources, placing virtually every employee at a laboratory animal facility at risk for developing adverse allergy-related health outcomes associated with exposure<sup>9,14,15,21,34,38,43,50,66,81-85</sup>.

### **2.2 Health Effects of Exposure**

Within four years of initial exposure to laboratory animal allergens, as many as 50% of workers develop sensitivity, and 60% develop respiratory symptoms. Upper-respiratory symptoms include itchy/watery eyes and nasal congestion. Lower-respiratory symptoms include wheezing, shortness of breath, and coughing<sup>4,11,19,20,23,36,39,43,45,52,53,84,86-89</sup>. Over time, one in five workers exposed to laboratory animal allergens develops Laboratory Animal Allergy (LAA), sensitivity accompanied by symptoms, which often progresses to occupational asthma (OA)<sup>4,11,19,39,43,45,52,67,84</sup>. Therefore, becoming sensitized to laboratory animal allergens has serious potential ramifications for workers, including morbidity, loss of productivity, increased health care costs, and potential job loss<sup>18-22,27,39,45,59,89-94</sup>.

There are also consequences for employers, including increased worker's compensation costs and higher levels of absenteeism, as well as high rates of attrition<sup>18-20,22,27,59,89,91,92,94</sup>.

Finally, another factor that makes LAA such an insidious condition is that—unlike other occupational sensitizers that are, for the most part, confined to specific occupational locations and can, therefore, be avoided outside the workplace—the allergens produced by laboratory animals such as mice, rats, dogs, and cats are ubiquitous in the non-occupational environment<sup>19,95</sup>. Therefore, once a worker develops LAA, even the relatively low levels of the aforementioned allergens (encountered at home, or in offices or schools) are enough to cause allergic reactions in workers who develop LAA, thereby impacting not only their health, but also their quality of life<sup>17,36,95</sup>.

### **2.3 Regulations and Recommendations Applicable to Exposure**

The Occupational Safety and Health Administration (OSHA) promulgates standards in order to provide workers with the safest occupational environment feasible; whereas the National Institute for Occupational Safety and Health (NIOSH) conducts occupational health research in order to provide OSHA evidence on which to base standards, creates health-based recommendations regarding occupational exposures, and certifies the personal protective equipment (PPE) that workers are required to use in compliance with OSHA standards<sup>31</sup>. Both OSHA and NIOSH have published regulations and guidelines intended to reduce the burden of adverse

allergy-related health outcomes on workers exposed to laboratory animal allergens<sup>11,19,31,33,35,36,38,96</sup>.

In addition to OSHA and NIOSH regulations and guidance, the Animal Welfare Act (via the Public Health Service Policy on Humane Care and Use of Laboratory Animals, 2002) requires that facilities in the United States that use animals as part of their research must adhere to the “The Guide for the Care and Use of Laboratory Animals” (referred to as “The Guide”) issued by the National Research Council<sup>16</sup>. Use of The Guide is assured by the fact that every institution that uses animals for research must be certified by the Association for Assessment and Accreditation of Laboratory Care (AAALAC)<sup>16</sup>. The Guide contains specifications regarding the nature of the occupational safety and health programs that must be in place in institutions working with research animals<sup>16</sup>. These specifications, as well as their underlying assumptions, are in keeping with OSHA and NIOSH’s guidance in regard to which workers should be offered DPRs and the circumstances under which DPRs should be used<sup>16,22,25,30,31,38,63,91,97</sup>. The following sections will discuss these policies, as well as their underlying evidence base.

## **2.4 OSHA Regulations & Laboratory Animal Allergen Exposure**

There are several OSHA standards that apply to laboratory animal allergen exposure, including: the General Duty Clause (29 U.S.C. § 654, 5); the Personal Protection Equipment Standard (29 CFR 1910.132); the Approval of Respiratory Protective Devices Standard (Title 42 Part 84); and the Hazard Communication

Standard (29 CFR 1910.1200)<sup>96,98-101</sup>. The most pertinent standard, and therefore the standard which will be discussed here, is the Respiratory Protection Standard or RPS (29 CFR 1910.134), which requires employers to provide workers with specific types of respiratory protection based on their performance against categories of aerosol hazards<sup>30,31</sup>.

*i. Assigned Protection Factors and Laboratory Animal Allergens*

The RPS instructs employers to use the hierarchy of controls in order to reduce or eliminate workers exposures<sup>30</sup>. If employers determine—despite the use of engineering and administrative controls—that workers are still being exposed to hazardous levels of respiratory exposures, then employers are instructed to provide workers with PPE, including respiratory protection<sup>30</sup>. The RPS uses two metrics to guide the selection of respirators for a given occupational exposure: the Assigned Protection Factor (APF) for a given class of respirator and the exposure limit specific to the exposure<sup>30,31</sup>.

For air-purifying respirators such as DPRs, which employers at laboratory animal facilities are required to offer workers who meet the aforementioned criteria, the APF value was calculated based on controlled laboratory studies using sodium chloride (NaCl) particles, as well as workplace studies that measured the reduction in the concentration of aerosol hazard between ambient and inhalable air conferred by the DPR<sup>31,34,35,37,63,102,103</sup>. However, reliance on APF values has questionable merit with regard to the selection of effective respiratory protection against laboratory animal allergens<sup>14,31,35,102,104-109</sup>. Bioaerosols such as laboratory animal

allergens possess significantly different aerodynamic properties from the types of particles used in the aforementioned studies, and these differences negatively impact the filtration efficacy of DPRs<sup>31,34,35,65,66,102,103,105,106,108,110,111</sup>. Despite implications for worker health, no studies have evaluated the association between DPR use and risk of developing allergic outcomes. Therefore, while we cannot definitively state that DPRs are ineffective at preventing the adverse allergy-related health outcomes associated with exposure to laboratory animal allergens, there is reason to believe that DPRs may not perform as expected based on their APF values<sup>2,4,5,10,11,21,23,27,34,38,43,45,60-63,66-69,106,108,110,111</sup>.

*ii. Exposure Limits and Laboratory Animal Allergens*

A second major shortcoming is that, under the RPS, employers are directed to utilize APF values in conjunction with hazard-specific exposure limits in the choosing of an appropriate form of respiratory protection; however, no such limit has been established for laboratory animal allergens<sup>5,21,43,63,112,113</sup>. This is in part due to the lack of clarity regarding the exposure-response relationship<sup>5,10,11,21,27,28,31,35,38,40,43,47,50,59,63,65,66,114</sup>. In the absence of an exposure-specific limit, the default exposure limit for particulates applies—i.e. no more than 10mg/m<sup>3</sup> of inhalable particulates or 4mg/m<sup>3</sup> of respirable particulates in an 8h-TWA—despite the fact that increased risk for sensitization to laboratory animal allergens has been observed below 0.1ng/m<sup>3</sup><sup>14,30,31</sup>.

Therefore, until an exposure limit is established, even if workers and employers at laboratory animal facilities comply with the RPS, it cannot be assured that workers

are protected to the extent intended<sup>21,36,38,45,59,102,115</sup>. In order to address some of these issues, we evaluated the association between DPR use and risk for exposure to Mus m 1 sensitization and the development of respiratory symptoms.

## **2.5 NIOSH Recommendations and Guidelines**

NIOSH recommends that workers use DPR as a means of primary prevention of the adverse allergy-related health outcomes associated with exposure to laboratory animal allergens<sup>22,25,31</sup>. Unfortunately, the evidence base underlying this recommendation is limited, especially in key areas such as the exposure-sensitization curve, and the effectiveness of DPRs as a form of primary prevention<sup>1,4,5,10-12,14,21,23,25,27,34,38,41,42,45,50-53,59,63,68,116,117</sup>.

### *i. The Exposure-Sensitization Relationship*

Early findings regarding the relationship between exposure to laboratory animal allergens and the development of adverse allergy-related health outcomes suggested a linear response<sup>1,4,22,23,41,44,50</sup>. NIOSH's DPR recommendation was based in part on these findings, from which it was inferred that any reduction in exposure would result in an incremental reduction in risk for sensitization, LAA and OA<sup>25</sup>.

However, since these initial studies were performed, evidence has emerged in more rigorously conducted prospective studies suggesting a non-linear exposure-response relationship. Specifically that, moderate allergen exposure appears to be associated with the highest risk for developing adverse allergy-related health outcomes<sup>14,21,45-</sup>

<sup>49,51-55,57-59</sup>. Despite the fact that these studies utilized superior research designs and exposure-response assessment techniques, NIOSH has not revisited its recommendations. For example, Peng et al, published a study in 2011 using a different subset of the data collected in the JAXCohort that provides evidence of a non-linear exposure-immune response relationship with *Mus m 1*<sup>14</sup>.

At the onset of the Peng study, 179 immunologically naïve workers were recruited within one month of entering the workforce<sup>14</sup>. Participants were followed for 23 months on average<sup>14</sup>. Personal air sampling for exposure to *Mus m 1* was conducted every 6 months. Questionnaires and clinical assessments were completed coincident with air sampling, and included collection of the following data: serum levels of mouse-specific IgG1-3, IgG4, and IgE; skin prick sensitivity to mouse; mouse-associated allergic and respiratory symptoms, smoking status, and frequency of DPR use<sup>14</sup>. By 24 months, 23% of workers were sensitized to mouse allergen<sup>14</sup>. Moderate exposure was associated with the highest risk for sensitization (Figure 2.1.a)<sup>14</sup>. This finding is in keeping with not only several other studies regarding the exposure-response relationship to laboratory animal allergens, but also a large body of research in other occupational and community settings<sup>8,43,44,46-49,51,53-55,57-59,88,118-120</sup>. By 24 months, 10% and 8% of workers developed mouse-specific IgG1-3 and IgG4, respectively<sup>14</sup>. Risk increased with increasing cumulative exposure, a finding which is consistent with other studies that have shown that cumulative exposure to *Mus m 1* is positively correlated with serum levels of mouse-specific IgG ( $r_s = 0.30$ ,  $p = .0002$ , Figure 2.1.b)<sup>10,14,53</sup>.

Figure 2.1

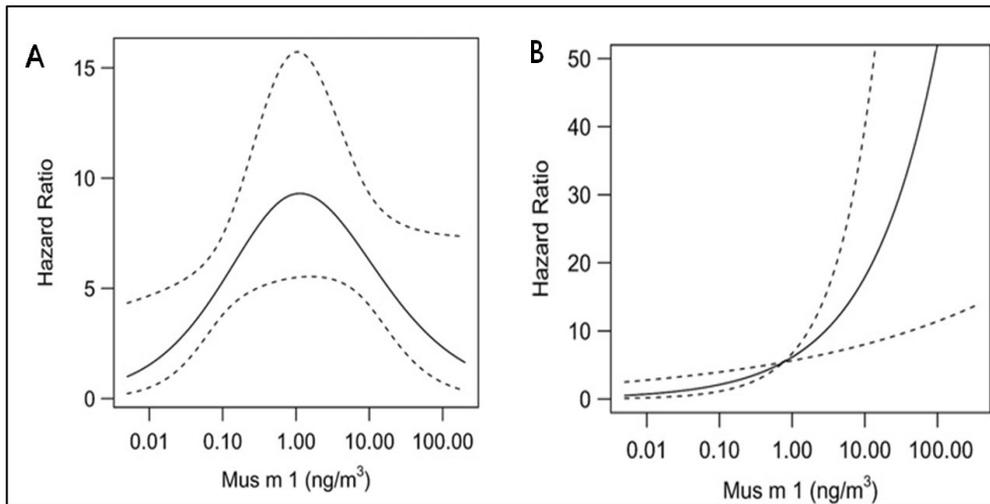


Figure 2.1 Median exposure to Mus m1 was 0.69 ng/m<sup>3</sup> (25th-75th %: 0.09-9.88 ng/m<sup>3</sup>). 1a) Risk for sensitization increased with increasing exposure until 1.2 ng/m<sup>3</sup>, thereafter it decreased with increasing exposure. 1b) Risk for developing of mouse-specific IgG4

ii. *Evidence prior to 2003 Regarding the Effectiveness of DPRs*

In 2003 NIOSH published a review of the currently available evidence-based interventions for preventing the development of occupational asthma as a result of exposure to occupational allergens<sup>25</sup>. Of the 97 articles reviewed, NIOSH cites one article, Fisher et al, 1998, as demonstrating evidence that DPRs are an effective form of primary prevention against the development of adverse allergy-related health outcomes associated with exposure to laboratory animal allergens<sup>4</sup>. However, this study has methodological limitations<sup>4</sup>. The most significant limitation is that evaluation of incidence of LAA followed the simultaneous implementation of multiple interventions including engineering and administrative controls and the

introduction of various forms of PPE such as DPRs. This limiting the ability to identify independent effects of each intervention<sup>4,25</sup>.

*iii. Evidence post-2003*

To our knowledge, the only work that has been conducted with the specific goal of evaluating the independent effectiveness of DPRs as a form of primary prevention of laboratory animal allergy-related health outcomes is a small, year-long prospective occupational cohort study conducted in 2005 at the Jackson Laboratory. The study population was drawn from the cohort studied by Peng et al. 2011. Workers were followed for one year to determine the association between frequency of DPR use and incident mouse allergen sensitivity<sup>13</sup>.

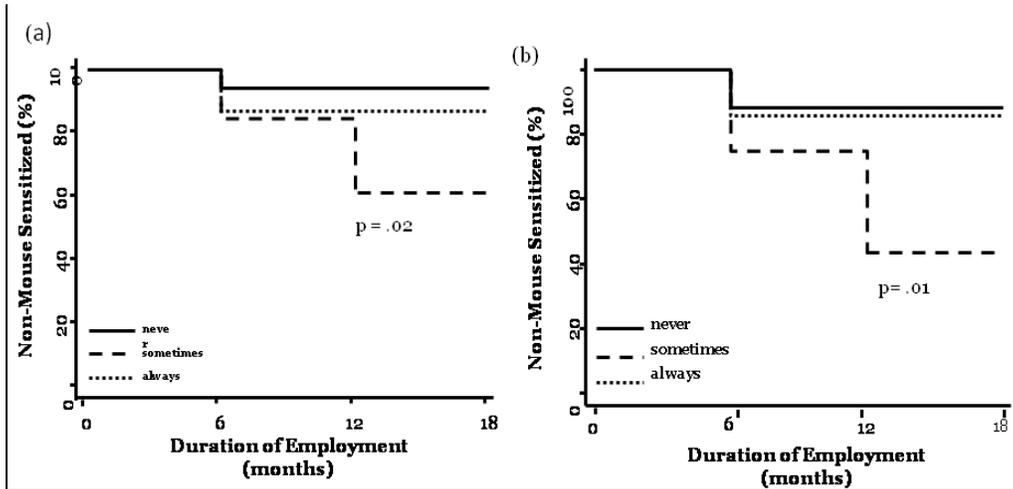
All mouse handlers as well as any other worker whom the Occupational Health and Safety staff determined was at increased risk for developing LAA, were referred for fit testing and training on proper DPR use and maintenance<sup>13</sup>. At six months, 45.4% of mouse handlers reported that they never used DPRs, whereas 18.2% and 36.4% reported intermittent and consistent use respectively (Table 2.1, data courtesy of Dr. E. Matsui) consistent with DPR use patterns observed in other industries<sup>35,61,69,70,72-74,79,85,89,93,121-127</sup>. These trends in DPR use persisted with little change at 12 months (Table 2.1).

Table 2.1 Frequency with which laboratory animal workers used DPRs

Frequency of Use	6 months (n=77)	12 months (n=49)
No DPR use	45.4%	38.8%
Intermittent use	18.2%	22.5%
Consistent use	36.4%	38.7%

By 6 months, 13% of workers became sensitized to mouse allergen, at 12 months this percentage increased to 23%<sup>13</sup>. Intermittent DPR users, including those who were atopic, were significantly more likely to develop sensitivity to mouse allergen when compared to those who used DPRs consistently or not at all, (Figures 2.2.a and 2.2.b)<sup>13</sup>. These observations are consistent with the hypothesis that intermittent DPR use may reduce internal allergen dose to a level that prevents the development of protective immunological changes associated with high levels of exposure. This was a small pilot study that did not explore factors that promote or impede DPR use or the association between frequency of DPR use and risk for exposure or respiratory symptom development.

Figure 2.2:(a) Kaplan-Meier risk estimates for sensitization by DPR use for all participants; (b) the subset of atopic workers. Statistical analysis and figure courtesy of Dr. Matsui, 2005.



Other relevant studies regarding the effectiveness of DPRs as a form of primary prevention have been performed in the agricultural industry. This work demonstrates that for workers exposed to bioaerosols, DPR use is associated with a reduced risk of lung function decline and development of respiratory symptoms<sup>61,69,73</sup>. Two additional studies from the health-care and laboratory animal industries demonstrated that DPR use reduced the concentration of latex and rodent allergens in inhaled air by 17.4 fold and 93% respectively<sup>63,64</sup>. Nasal samplers were used as the means of exposure assessment in both of these studies<sup>63,64,89,90,97</sup>. In part due to the limitation of this technique, neither study determined the effect of the reduction in exposure on either internal allergen dose or on the risk of sensitization, LAA or OA<sup>63,64,89,90,97</sup>.

## **2.6 Measuring the Effect of DPR use on Internal Dose**

No study has measured the reduction in internal dose of allergen associated with DPR use, or the effect of dose reduction on risk for developing allergy-related health outcomes associated with exposure<sup>5,10,11,38,39,45,68,102,103</sup>. Unlike other occupational exposures that can be measured directly in blood or tissue or by means of other biomarkers, internal dose of laboratory animal allergen is determined by immunological response<sup>14,42,45,49,51,53,57,59,80,82,120,128,129</sup>. Serum concentration of allergen-specific IgGs, which increase proportionately to exposure, have been used as biomarkers of exposure<sup>49,51,53,54,62,80,119,130</sup>.

## **2.7 Policy Implementation: Record Keeping and Program Evaluation**

The RPS and AAALAC task respiratory protection programs with evaluating the effectiveness their exposure control programs, but the methods for evaluation are not specified<sup>131</sup>. Although various methods were considered for tracking DPR use or health effects, none were incorporated into the final regulation<sup>30,31</sup>.

## **2.8 From Policy to Practice: DPR use and Drivers of Use**

We have a poor understanding of the extent to which DPR-use policies are adopted and practiced in the workplace or of the factors associated with adherence.

However, the RPS instructs laboratory animal workers to use DPRs because consistent DPR use may be necessary to reduce the risk of LAA and OA<sup>31,76</sup>. In

other occupational settings, only 1-62% of workers report using PPE consistently<sup>34,35,61,70-74,76-79,85,121-127,132-147</sup>.

A large body of research, using different theoretical models, has been performed regarding the factors associated with the performance of a given health behavior<sup>70,71,73,77-79,121,122,127,133,135,141,148-157</sup>. One of the most widely used models is the Health Belief Model (HBM) which posits that a combination of six factors predict the performance of a health behavior including: the perceived severity of, and susceptibility to, the health effects associated with exposure; the perceived ability to perform the health behavior (aka self-efficacy); the perceived cues to action regarding the performance of the health behavior (i.e. peer attitudes towards the behavior); and finally, the perceived costs and benefits associated with performing the health behavior, (i.e. loss of productivity or an increased sense of well-being)<sup>149</sup>. Studies demonstrate that health belief-based interventions can be used to increase worker's performance of protective-activities<sup>134,158,159</sup>.

A recent survey of 198 laboratory animal facilities in the US reported that 25% of facilities required DPR use, however this study did not report any findings regarding the regularity with which workers used DPRs<sup>13</sup>. Given the implications for worker health, it is crucial that we gain a better understanding of not only the current patterns of DPR use, but also the drivers of use, in order to create and implement effective intervention strategies.

## 2.9 Summary

Laboratory animal workers are exposed to animal allergens, resulting in an increased risk of sensitization as well as LAA and OA<sup>2,5,9,11,15,19,23,43-45,84,94,160-162</sup>. Under the RPS and the guidance put forth by NIOSH, laboratory animal workers are instructed to use DPRs to reduce the risk of LAA and OA<sup>25,31</sup>. These regulations and recommendations are based on the following assumptions: DPRs will be used consistently, and the recommended DPRs are capable of reducing the risk for developing adverse health outcomes<sup>1,5,6,8,10,11,19,22,23,31-45</sup>. However, there are gaps in the evidence underlying these assumptions, as well as new contradictory evidence<sup>2,4,5,10,11,21,23,27,34,38,43,45,60-69</sup>. In addition, we have a poor understanding of the extent to which DPR-use policies are adopted and practiced in the workplace, or the factors that predict compliance<sup>70-79</sup>. In order to shed light on both of these questions the following research was undertaken.

## **CHAPTER 3: MANUSCRIPT 1**

**Title:** Laboratory Animal Workers' Health Beliefs and their use of Respirators

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### 3.1 ABSTRACT

**Background:** U.S. public health agencies endorse the use of disposable particulate respirators (DPR) as a means of preventing Laboratory Animal Allergy (LAA) and Occupational Asthma (OA) among laboratory animal workers. However, we have a very limited understanding of the factors associated with DPR use.

**Objective:** We sought to examine the association between workers' health beliefs and their use of DPRs.

**Methods:** We conducted a cross-sectional study among laboratory animal workers who had been offered respiratory protection (n=90). A questionnaire based on the Health Belief Model was administered to capture health beliefs related to DPR use. Multivariate logistic regression was used to evaluate the associations between workers' health beliefs and their reported use of DPRs.

**Results:** Fifty-five percent of workers reported using a DPR at least some of the time. Perceived susceptibility, self-efficacy, and lack of barriers to using a DPR were all significantly associated with using a DPR.

**Conclusion:** Almost half of workers offered DPRs for primary prevention of mouse allergy never used DPRs. Several health beliefs were associated with DPR use, suggesting that interventions aimed at increasing laboratory animal workers' perceived susceptibility and self-efficacy and reducing their perceptions of the barriers to using a DPR might result in increased DPR use.

**KEY WORDS:**

Laboratory animal allergy, respiratory protection, health beliefs, occupational asthma, Health Belief Model, personal protective equipment

**ABBREVIATIONS:**

DPR	Disposable particulate respirator (N95)
SPT+	Positive skin prick test for mouse allergen
LAA	Laboratory animal allergy (sensitization accompanied by symptoms)
OA	Occupational asthma
OSHA	Occupational Safety and Health Administration
NIOSH	National Institute for Occupational Safety and Health
PPE	Personal Protective Equipment

**3.2 INTRODUCTION**

Occupational health and safety agencies in the United States and Europe endorse the use of disposable particulate respirators (DPR) as a means of primary prevention of laboratory animal allergy (LAA), which can progress to occupational asthma (OA), a disabling condition that is one of the most common occupational diseases<sup>4,10,18-20,22,30,36,91,92,94,152</sup>. However, we have little understanding of the frequency or determinants of DPR use among laboratory animal workers<sup>13,153</sup>.

An extensive body of research in other occupational settings has shown that workers' health beliefs play an important role in shaping health behaviors such as the use of personal protective equipment (PPE)<sup>78,122,146,154,155</sup>. These health beliefs include: workers' perceptions of their susceptibility to a given adverse occupational health outcome and the severity of that outcome; the degree to which they believe they are able to take the preventative action (self-efficacy); their perceived cues to take preventative action; and their perception of the barriers to, and the benefits of, taking action<sup>55,77,127,134,141</sup>.

An understanding of the role of these constructs in predicting the frequency of DPR use will inform interventions and policies aimed at increasing DPR use<sup>134,156</sup>. Therefore, we conducted a cross-sectional study of laboratory animal workers at a large mouse husbandry and research facility to identify the health beliefs that predict DPR use.

### **3.3 METHODS**

The study population was drawn from the JAXCohort Study, a prospective occupational cohort at the Jackson Laboratory in Maine, which enrolled participants from June 2004 through May 2014. New, non-temporary, full-time employees who were at least 18-years of age were eligible to participate. The questionnaire used for this analysis, "Health Beliefs and Respiratory Protection," was developed and implemented starting in 2010 (Appendix 2.9). Data for this study were drawn from the first follow-up visit at which the questionnaire was completed, and included data collected through October 2013. For participants enrolled in the study prior to

2010, this follow-up visit occurred between six and 66 months after enrollment. For participants enrolled from 2010 onward, this follow-up visit was their six-month follow-up visit. Additionally, from 2010 on, the cohort was enriched for atopic participants by limiting the number of newly recruited non-atopic participants.

Between June 2004 and October of 2013, 599 of the 894 newly hired workers at Jackson Laboratory consented to a baseline screening visit as part of the JAXCohort. Of these, 567 were eligible to participate, 475 enrolled, and 442 completed at least six months of follow-up. For the purpose of this analysis, which focused on the association between health beliefs and the use of respiratory protection, the population was further restricted to participants who: 1) were enrolled when the “Health Beliefs and Respiratory Protection” questionnaire was introduced, and who completed the questionnaire (n=221); 2) were mouse-handlers (n=148); and 3) reported being offered respiratory protection (n=90), for a total of 90 participants. The Jackson Laboratory offered respiratory protection as a means of primary prevention of mouse allergy to participants who were considered to be at risk based on their medical history or occupational exposures. Nursing personnel referred participants to the occupational health and safety office for distribution, fit testing, and training in use. The research protocol was approved by the Institutional Review Board at both the Jackson Laboratory and the Johns Hopkins School of Medicine.

*i. Frequency of Respiratory Protection Use and Health Beliefs*

Self-reported frequency of DPR use was captured by a questionnaire that included the question, “How often do you use a respirator when working with mice?” Likert-type response options included: “never”, “rarely”, “usually”, “sometimes”, and “always”. The questionnaire items used to capture participants’ health beliefs and attitudes regarding DPR use were adapted from previously validated instruments<sup>157</sup>. The constructs that were assessed included: perceived susceptibility, self-efficacy, and cues to action; as well as the barriers to and benefits of DPR use (Appendix 2.1)<sup>158</sup>. The internal reliability of the questionnaire was tested using Chronbach’s alpha (0.81 – 0.91)<sup>159</sup>.

For the purpose of this analysis, perceived susceptibility was defined as whether participants believed that they had been offered respiratory protection because of pre-existing medical conditions or because of the possibility of being exposed to respiratory hazards while working at the facility<sup>158</sup>. Eight items were used to measure susceptibility, four of which queried whether participants believed that they had been offered respiratory protection because they had a history of a medical condition (asthma, allergies, COPD, or some other medical condition) that might be a risk factor for mouse allergy (Appendix 2.3.i). The additional four items measured whether participants believed that they had been offered respiratory protection because they were exposed to respiratory hazards, including mouse allergen, dust, chemicals, or fumes. The possible responses for each of these eight items were “Yes” or “No” (Appendix 2.3.i).

Participants’ belief that they could use a DPR (self-efficacy) was measured using eight items, including the ability to use a DPR despite: a lack of knowledge of how

DPRs function; co-workers either not using DPRs or not believing that DPRs are necessary; feeling stressed or short on time; and being able to use a DPR regardless of how long it needed to be worn or the additional heat accompanying use<sup>158</sup>. For example, participants were asked to mark their response to the following statement: “I can use a respirator even if I don’t understand how they work.” Response options included: “strongly disagree,” “disagree,” “neutral,” “agree,” and “strongly agree” (Appendix 2.3.ii).

Perceived cultural norms about respirator use (cues to action) were measured using four items: knowledge of whether and how often co-workers used DPRs, and perceived support from co-workers and supervisors regarding DPR use<sup>158</sup>. The response options for the items regarding co-workers’ use patterns were based on frequency—“never,” “rarely,” “sometimes,” “usually,” “always,” and “don’t know”; whereas the response options for the statements regarding perceived support from co-workers and supervisors were the same as those for the self-efficacy items—ranging from “strongly disagree” to “strongly agree” (Appendix 2.3.iii).

Perceived barriers to using a DPR (barriers to use) were measured using seven items, including whether using a DPR would negatively impact productivity, job satisfaction, ease of work, or relationships with colleagues<sup>158</sup>. The same response options used to measure self-efficacy were used to measure barriers to use (Appendix 2.3.iv).

The perceived benefits of using a DPR (benefits of use) were measured using eight items, including the overall perceived benefit of using a DPR, the perceived

effectiveness of DPRs as a form of primary prevention of developing allergies to mice, and the extent to which using a DPR would positively impact job satisfaction, productivity, ease of work, and participants' relationships with their colleagues<sup>158</sup>. Response options for overall perceived benefits of use included “not beneficial,” “slightly beneficial,” “somewhat beneficial,” “very beneficial,” and “extremely beneficial,” whereas the response options for the remaining seven items were the same as those used for measuring self-efficacy (Appendix 2.3.v).

The questionnaire was also used to obtain socio-demographic information as well as participants' medical and occupational histories, including how many times a week they handled mice. Potential responses included: <1 week, 1-2 times/week, 3-4 times/week, and 5 or more times/week (Appendix 2.8).

### *ii. Skin Prick Testing*

Skin prick testing (SPT) was conducted during the baseline study visit using a Multitest device with full-strength glycerinated extracts for 14 major aeroallergens, including: mouse, rat, hamster, guinea pig, rabbit, cat, dog, ragweed, grass, oak, *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae*, *Alternaria*, and *Aspergillus*<sup>14</sup>. A worker was considered atopic if he/she exhibited at least one positive skin prick test, defined as net orthogonal wheal 3 mm<sup>14</sup>.

### *iii. Statistical Analysis*

Descriptive and exploratory data analysis techniques were used to examine the distributions of self-reported respiratory protection use and *a priori* potential predictors of DPR use, including age, gender, job type, education, history of

asthma, atopy, hay fever, smoking, and time spent handling mice<sup>167,168</sup>. For the purposes of this analysis, we were interested in characterizing the differences in health beliefs between participants who reported using DPRs and participants who reported that they did not use DPRs. Therefore, the five ordinal responses used to measure DPR use were collapsed into two categories: “DPR users,” which included participants who reported “sometimes”, “usually,” and “always” using DPRs; and the “No DPR use” category, which included participants who reported “rarely” and “never” using DPRs<sup>70</sup>. All subsequent analyses were performed using this dichotomous DPR-use outcome variable. We evaluated the associations between the aforementioned covariates of interest and DPR use using bivariate inferential statistical tests, including rank-sum, chi-squared tests, and Students’ t-tests<sup>168</sup>.

#### *iv. Associations between DPR Use and Health Beliefs*

The associations between health beliefs and DPR use were assessed in several ways. First, the association between DPR use and the responses to each questionnaire item was evaluated using parametric and non-parametric exploratory techniques<sup>161</sup>. Points were assigned to each item’s responses, and summated scales were created by summing these points for each construct<sup>162,163</sup>. Each summated scale was dichotomized, using the median score as the cut point, to create a “high score” and a “low score” category for each health belief construct<sup>70,162</sup>. Crude and multivariate logistic regression models were used to estimate the associations between the dichotomized health belief constructs and DPR use<sup>70,162</sup>.

#### *v. Summated Scales*

Susceptibility was measured using eight “yes” or “no” items. Negative responses were assigned zero points and positive responses were assigned one point, for a potential total of eight points. The higher the score, the greater number of susceptibility factors the participant was told he/she had<sup>163</sup>. Self-efficacy was measured using eight items with Likert-type responses. Ascending point values were assigned for each response, starting with a value of zero for “strongly disagree,” and up to four points for “strongly agree”. The total possible score on the self-efficacy scale was 32; the higher the score, the more capable of using a DPR the participant felt. Cues to action were measured using four items, including three items with Likert-type responses, and one item with a yes-or-no response. Points were assigned to the Likert-type responses in the same manner as they were for the self-efficacy construct. One point was assigned to the “yes” response for the yes-or-no item. The total possible score on the cues to action scale was 13. The higher the score, the more cues to use a DPR the participant perceived.

Barriers to use were measured using seven items with Likert-type responses. The points for the Likert-type responses were assigned in reverse order, as compared to the other Likert-type responses for the other health belief constructs. This approach for scoring the barriers to use construct resulted in a directionality of score that can be interpreted similarly to the other health belief constructs; i.e. a higher score indicates health beliefs that are favorable for using DPRs. For example, if a worker “strongly disagreed” with the statement that using a DPR would reduce productivity, four points were awarded, whereas if they “strongly

agreed” that using a DPR would reduce their productivity, no points were awarded. A total of 28 points were possible.

The benefits of DPR use were measured using eight items with Likert-type responses. The points were assigned in the same manner as they were for the Likert-type responses used to measure self-efficacy. The total possible score on the perceived benefits of use scale was 32; the higher the score, the more benefits to use a worker perceived.

*v. Exploratory Analysis of Summated Scales*

Exploratory analysis techniques were used to characterize the distributions of each health belief construct’s summated scale<sup>161,162</sup>. Parametric and non-parametric techniques were used to determine if any of the potential confounders were predictors of a given health belief construct, including: age; gender; level of education; job type; years of employment; amount of time spent handling mice; atopy; smoking status; and the primary outcome, frequency of DPR use (Appendix 2.1)<sup>71,73,77,79,121,127,143,161,162,164,165</sup>.

*vii. Associations between Health Belief Constructs and DPR Use*

As previously mentioned, we divided each summated scale into two categories of scores, using the median as a cut-point. For example, the median score on the self-efficacy scale was 22; therefore, workers who scored 22 or below were included in the “low self-efficacy” score category, and the remainder were included in the “high self-efficacy” score category<sup>70</sup>. Using these dichotomous health belief variables, the crude associations between each individual health construct and DPR use were

estimated using univariate logistic regression models<sup>70</sup>. These dichotomized health belief constructs were also used to estimate the associations between health beliefs and DPR use in two multivariate logistic models. Model 1 estimated the association between all five health beliefs and DPR use, and Model 2 estimated the association between all five health beliefs and DPR use and was adjusted for age, gender, job type, years of experience, and amount of time spent handling mice. Selection of these covariates was based on the evidence to date, our conceptual model, and the results of our exploratory analyses (Appendix 2.1, Appendices 2.4.i – 2.4.v, 2.5, 2.6)<sup>71,73,77,79,121,127,143,161,162,164,165</sup>. The model’s goodness-of-fit was evaluated using Hosmer-Lemeshow’s goodness-of-fit-test, and pregibon residuals were to make sure that the model assumptions had not been violated<sup>161,166</sup>.

Additionally, we evaluated our definition of DPR use. We re-categorized participants who reported using DPRs “sometimes” as non-users, in contrast to our previous designation of this group as DPR users, and repeated the analyses performed under Model 2 (Appendix 2.7). The results were similar. Data analyses were performed using STATA 11 (StataCorp, College Station, TX)<sup>166</sup>.

### **3.4 RESULTS**

#### *i. Characteristics of the Study Population*

The majority of the study population was Caucasian (95%) and male (51%), with a mean age of 29 years (Table 3.1). Most participants were employed as animal caretakers (71.1%), followed by laboratory technicians (13%), and scientists (8%). Eighty-one percent of participants handled mice every day. The majority of

participants were atopic (61%), and approximately 28% reported having hay fever. Approximately a quarter of the population had been told by a health care provider that they had asthma, and 14% reported current asthma. A majority (57%) of participants believed DPR use was an effective means of primary prevention of mouse allergy. Forty-six percent of participants reported that they were offered DPRs because of at least one medical condition, including a history of allergies (37%) or asthma (14%).

*i. Respiratory Protection Use*

Fifty-five percent of participants reported using DPRs. Participants tended to be more likely to use a DPR if they had been employed for more than a year (47% vs. 67%, respectively;  $p=0.07$ ), or if they had a history of hay fever (49% vs. 68%, respectively;  $p=0.11$ ), whereas participants were significantly less likely to use a DPR if they had obtained at least some post-baccalaureate education (60% vs. 11%, respectively;  $p<0.006$ ). There were no other associations between DPR use and age, gender, job type, amount of time spent handling mice, smoking status, atopy, or asthma.

*iii. Overview of Health Belief Construct Scores*

Several items were used to measure each health belief construct, and points were assigned to the responses to each item and added in order to create an overall score for each health belief construct. For example, the median overall score on the susceptibility scale was 1.5 [IQR:1-2] out of a total possible 8, suggesting that participants tended to perceive that they had a low level of susceptibility to the

adverse respiratory health outcomes associated with exposure to mice (Table 3.2). Participants' responses to the self-efficacy items suggested that participants tended to feel confident that they could use a DPR (median score 21 [IQR: 21-27] out of a total possible 32). Overall, the cues to action scores suggested that participants tended to perceive that using a DPR was in keeping with the social norms of their workplace, as the median score was 11 [IQR:8-13] out of a possible 13. However, a sub-group of participants did not share this belief, as evidenced by approximately 30% of the population clustering at the lower end of the scale, around a score of 5. The median score for perceived barriers to use was 18 [IQR:16 - 21] out of a possible 24 points, suggesting that, in general, participants did not perceive that there were barriers to using a DPR. The median score for perceived benefits was 14 [IQR:11 - 17] out of a total possible 32, suggesting that, in general, participants felt that using a DPR would neither be helpful nor harmful.

*i.v. Individual Items used to Measure Constructs*

*a. Susceptibility:*

Perceived susceptibility was measured using eight items, including whether participants believed that they had been offered respiratory protection because of pre-existing medical conditions or because of the hazards that they could be exposed to while working at the facility. In regard to pre-existing medical conditions, 38 percent of participants believed that they were offered respiratory protection because of at least one medical condition, the most common being a history of allergies, and 8% reported being offered a DPR because of more than one

underlying medical condition. Participants who reported being offered a DPR because of a history of allergies were significantly more likely to use a DPR than those who did not report history of allergies as a reason for being offered a DPR (75% vs. 43%;  $p=0.01$ ). In contrast, participants who reported that they had been offered a DPR because of a history of asthma were no more likely to use a DPR than those who did not (62% vs. 53%;  $p=0.58$ ). Participants who believed that they had been offered a respirator because of an underlying medical condition(s) were approximately twice as likely to use a respirator as participants who believed that their medical history had not played a role in them being offered a respirator (75% vs 37%,  $p=0.02$ ).

Perceived susceptibility was also measured by asking participants if they had been offered respiratory protection because of occupational exposures. The majority of participants believed that they had been offered a respirator because they were exposed to at least one respiratory hazard (85%)—the most common being mouse allergen (78%), followed by dust (17%), chemicals (7%), and fumes (6%). Participants who reported being offered a DPR because they were exposed to mouse allergen were more likely to use a DPR than participants who did not report mouse allergen exposure as the reason for being offered a DPR, but this difference was not significant (60% vs 37%;  $p=0.07$ ), and there were no other differences in DPR use by type of exposure. In contrast to the number of pre-existing medical conditions, participants who believed that they had been offered respiratory protection because they were exposed to more than one respiratory hazard were no more likely to use a DPR than participants who believed that they had been offered

a DPR because they were exposed to only one respiratory hazard (60% vs. 53%, respectively;  $p=0.58$ ) (Appendix 2.3.i).

*b. Self-Efficacy:*

Perceived ability to use a DPR (self-efficacy) was measured using eight items, and the distributions of the responses to the items were similar to each other.

Participants were significantly more likely to use a DPR if they believed that they could use a DPR despite their co-workers' disagreement that DPRs were necessary, with 61% of the workers who agreed with the statement reporting DPR use, as compared to 25% of those who disagreed with the statement ( $p=0.02$ , Appendix 2.3.ii). They were also significantly more likely to use a DPR if they believed that they could use a DPR even if they did not know how it worked or if they had to use a DPR for a short period of time, with 62% and 60% of workers who agreed with these statements reporting DPR use, respectively, as opposed to only 18% and 0% of those who disagreed with these statements reporting DPR use, ( $p=0.03$  and  $p=0.02$ , respectively; Appendix 2.3.ii). Participants who felt capable of using a DPR even when they felt stressed or short on time, if they had to use a DPR all day, or if their co-workers did not use a DPR, were no more likely to use a DPR than those who did not feel capable of using it under these conditions.

*c. Cues to Action*

Participants' perceptions of whether DPR use was in keeping with the social norms of the facility (cues to action) were measured using four items. While the majority of participants believed that both their co-workers and supervisors supported DPR

use (51% and 73%, respectively), a minority believed that their co-workers and supervisors did not support DPR use (8% and 9%, respectively); the remainder believed that their co-workers and supervisors were impartial (41% and 17%, respectively). Participants were significantly more likely to use a DPR if they felt supported by their supervisor; for example, 57% of the workers who agreed that their supervisor supported DPR use reported using a DPR, whereas only 13% of the workers who believed that their supervisor did not support DPR use reported using a DPR ( $p=0.03$ ). Although a similar pattern was apparent for the association between perceived support from co-workers and DPR use, this difference was not statistically significant; with 53% of workers who believed that their co-workers supported DPR use reporting DPRs use, and only 14% of workers who believed that their co-workers did not support using a DPR reporting DPR use ( $p=0.06$ ). Participants' knowledge of whether, or how often, ones' co-workers used a DPR was not associated with DPR use (54% and 57% reported DPR use among those who did and did not have knowledge of co-workers' DPR use, respectively;  $p=0.89$ —and 54%, 57%, and 50% reporting DPR use among those who believed that their co-workers always, sometimes, or never use DPRs, respectively;  $p=0.96$ ) (Appendix 2.3.iii).

*d. Barriers to using DPRs:*

Perceived barriers to DPR use were measured using seven items, the responses to which were similarly distributed. Participants were more likely to use a DPR if they believed that DPR use would not reduce their productivity, increase their work load, or negatively impact their relationships with their co-workers and supervisors;

however, none of these differences was statistically significant (Appendix 2.3.iv). Belief that using a DPR would negatively impact job satisfaction was not associated with using a DPR.

*e. Benefits of use:*

Participants' perceptions of the benefits of using DPRs were measured using 8 items, the responses to all of which were similarly distributed. There were no statistically significant associations between the responses to these eight items and participants' use of DPRs (Appendix 2.3.v).

*v. Logistic Regression Models*

*a. Overview:*

Two categories of scores were created for each health belief construct: a “low” and a “high” score were defined using the median as the cut point (see methods)<sup>70</sup>. These dichotomized health belief construct variables were used for the remainder of the analysis including: i) the univariate models which estimated the association between each individual health belief construct and DPR use; ii) Models 1 and 2, which were multivariate logistic models used to estimate the associations between all five of the health belief models and DPR use.

*b. Crude Logistic Regression Models:*

Unadjusted logistic regression models of the association between each health belief construct and DPR use demonstrated that “high” susceptibility scores and “low” barriers to use scores were associated with DPR use (OR [95%CI]: 3.5[1.6 – 2.8]

and 2.5 [1.1 – 6.0], respectively, table 3.3). A “high” cues to action score was also associated with DPR use, however, this association was not statistically significant (OR [95%CI]: 1.9 [0.9 – 1.6], table 3.3). There were no associations between self-efficacy or benefits of DPR use scores and DPR use (OR [95%CI]: 1.4 [0.6 – 3.2] and 1.0 [0.4 – 2.4], respectively).

c. *Multivariate Logistic Regression Models:*

In Model 1, a multivariate logistic model that included all five health belief constructs, high scores for perceived susceptibility and low barriers to use were both independently associated with DPR use, whereas high self-efficacy, cues to action, and perceived benefits scores were not. Specifically, participants with scores in the “high” susceptibility and “low” barriers to use categories were significantly more likely to use a DPR than participants who had scores in the “low” susceptibility and “high” barriers to use categories, and these associations were independent of the other health belief constructs (OR [95%CI]: 3.9[1.5 – 10.7] and 4.1 [1.3 – 13.2] respectively, table 3.3). Although a high self-efficacy score was associated with DPR use, this association was not statistically significant (OR [95%CI]: 2.8 [0.9 -7.9], table 3.3).

In the fully adjusted multivariate logistic model of the association between all five of the health belief constructs and DPR use (Model 2), high scores for susceptibility and low barriers to use remained independent predictors of DPR use. Specifically, participants with high scores for susceptibility and low barriers to use were 10-fold- and 8-fold more likely to use a DPR, respectively, and these associations were independent of age, sex, exposure to mice, job, and length of

employment (OR [95%CI] 10.5 [2.3 – 47.9] and 8.0 [1.1 – 60.8], respectively, table 3.3). A high self-efficacy score was also a significant predictor of DPR use, with participants with a high self-efficacy score being almost 5-fold more likely to use a DPR than participants with a low self-efficacy scores (OR [95%CI]: 4.9 [1.1 – 22.3] table 3.3). There was no significant association between cues to action or the perceived benefits of using a DPR and DPR use in any of the models that included all five health belief constructs (table 3.3). Sensitivity analyses that classified participants who reported intermittent use of DPRs as non-users rather than users yielded similar results (Appendix 2.7).

### **3.5 DISCUSSION**

#### *i. Findings in Context*

This is the first study to assess the association between laboratory animal workers' health beliefs and their reported use of disposable particulate respirators.

Approximately half of the participants (55%) reported using respiratory protection at least some of the time and participants' health beliefs were significantly associated with DPR use. Specifically, workers who perceived that they had been offered a DPR because of their medical history or because of an occupational exposure (susceptibility), or who perceived that they were capable of using a DPR (self-efficacy) were significantly more likely to use a DPR. Workers who perceived a lack of barriers to using a DPR were also more likely to use a DPR. These findings

provide an evidence-base for future initiatives aimed at reducing the burden of LAA and OA on laboratory animal workers<sup>134,141,167-169</sup>.

While neither the of the overall constructs used to measure either cues to action or the benefits of DPR use were associated with DPR use, there were significant associations between the responses to several of the individual items on those scales. Specifically, some participants believed that their supervisors did not support DPR use, and that DPR use was not in keeping with laboratory policies. These participants were significantly less likely to use a DPR. These findings may reflect the content or the manner in which respiratory protection use policies were communicated to staff<sup>69</sup>.

Our findings that only 55% of participants used DPRs at least some of the time, and that susceptibility, self-efficacy and barriers to use were significantly associated with DPR use are in keeping with other research in the field<sup>71,73,77-</sup>

<sup>79,121,122,127,134,135,137,141,143,146,155,156,164,165,168,170-172</sup>. Specifically, others have reported that a low proportion of workers (1 to 62%) use PPE, and that the same three health belief constructs are most strongly associated with the performance of protective behaviors in other occupational groups<sup>70,71,73,78,121,122,134</sup>.

In contrast to other work, we did not find age, gender or job type to be independent predictors of PPE use<sup>70,71,73,78,121,122,134</sup>. In our study, the only predictor of respiratory protection use in addition to health beliefs was increasing number of years of employment at the facility. One explanation for this observation is that only the most experienced participants qualify to work in the more complex mouse-housing

facilities which require DPR use; therefore, the longer a worker has been employed the more likely he or she is to be required to use DPR. Another possibility is that participants who used respiratory protection were more likely to remain at the facility due to healthy worker effects; however, there were no differences in attrition between DPR users and non-users.

*ii. Strengths and Limitations*

This study's cross-sectional design precludes conclusions regarding temporality<sup>54,64,162</sup>. However, the design does allow us to examine associations between participants' health beliefs and their use of DPRs. These findings are also important because although the influence of workers' health beliefs on their use of PPE has been studied in other occupational settings; there are unique aspects of this occupational environment; therefore it could not be assumed that these associations would be the same<sup>132,140,141</sup>.

A number of precautions were taken to prevent desirability bias which would introduce the potential for misclassification of reported DPR use<sup>162</sup>. For example, participants were informed that no data about DPR use would be shared with their employer, and study staff worked exclusively on the study and not as a part of the employee health, human resources or safety departments. Furthermore, there is no facility-wide mandatory DPR use policy. An indication that these steps may have been at least somewhat successful is the majority of our participants reported that they did not use DPRs consistently.

The majority of our study population was Caucasian, and the study was conducted at a single site, potentially limiting the generalizability of our findings. However, our study population was similar to the general US working population in prevalence of asthma, atopy, and hay fever (table 3.1)<sup>162,173</sup>. Finally, our questionnaire was adapted from a previously validated questionnaire, and we observed that it had a high level of internal consistency, suggesting that our results are both valid and accurate<sup>157,159</sup>.

*iii. Implications for Policy and Research:*

None of the educational materials or guidance documents published by public health agencies discuss the role that worker's health beliefs play in the likelihood that they will use a DPR, or how these associations can be used to maximize DPR use<sup>22,25,29-31,33,37,63,96,174,175</sup>. Our findings suggest that interventions aimed at increasing workers' perceptions of their susceptibility and self-efficacy, as well as decreasing their perceptions of the barriers to DPR use, might increase DPR use<sup>134,167</sup>. It will be important to evaluate the effect of health-belief based interventions on DPR use as well as worker's health outcomes, and integrate these findings into the policy framework surrounding the use of DPRs as a means of primary prevention of LAA<sup>134,167</sup>.

*iv. Conclusions:*

A number of questions remain regarding the extent to which DPR use policies are adopted and practiced. This study provides the first insight into the factors that are associated with DPR use in a laboratory animal worker population. However, in order to improve the effectiveness of respiratory health programming, and

ultimately, laboratory animal workers' health outcomes, it will be important to conduct research with the aim of determining whether interventions aimed at increasing perceptions of susceptibility and self-efficacy, as well as decreasing perceived barriers to use, result in laboratory animal workers using DPRs more frequently.

## TABLES

Table 3.1 Population Characteristics (n=90)

	Overall (n=90)	Non-user (n=41)	DPR User <sup>‡</sup> (n=49)	p-value <sup>α</sup>
<b>Age (y), mean ±SD</b>	28.9±8.5	29.5 ± 8.6	28.6 ± 8.5	0.92
<b>Sex</b>				
Female	44 (48.9)	18(43.9)	26(53.1)	0.38
Male	46(51.1)	23(56.1)	23(46.9)	
<b>Race</b>				
White	85(94.5)	38(92.7)	47(95.8)	0.75
Asian	3(3.3)	1(2.4)	1(2.1)	
Black	2(2.2)	2(4.9)	1(2.1)	
<b>Smoking status</b>				
Never	54(60.7)	23(56.1)	31(64.6)	0.23
Former	17(19.1)	11(26.8)	6(12.5)	
Current	18(20.2)	7(17.1)	11(22.9)	
<b>Education</b>				
High School	18(20.1)	6(14.6)	12(26.7)	0.19
Some College	23(26.7)	11(26.8)	12(26.7)	
College Graduate	36(41.8)	17(41.5)	19(42.2)	
Post Graduate	9(10.5)	7(17.1)	2(4.4)	
<b>Job Category</b>				
Animal caretaker	64(71.1)	27(65.9)	37(75.5)	0.52
Scientist	7(7.8)	3(7.3)	4(8.2)	
Lab. Technician	12(13.3)	6(14.6)	6(12.2)	
Other*	7(7.8)	5(12.2)	2(4.1)	
<b>Frequency of mouse handling</b>				
<1 day /week	5(6.5)	2(4.8)	3(6.1)	0.38
1-2 days/week	4(5.0)	3(7.3)	1(2.0)	
3-4 days/week	6(7.5)	3(7.3)	3(6.1)	
5 or more days/week	65(81.3)	26(63.4)	39(79.6)	
<b>Years of Employment</b>				
<2 years	53(58.8)	28(68.3)	25(51.0)	0.11
2-3 years	14(15.5)	3(7.3)	11(22.5)	
4 or more years	19(21.1)	8(19.5)	11(22.5)	
<b>Medical History</b>				
Hay fever	25(27.8)	8(19.5)	17(34.7)	0.11
Asthma: Never	65(73.8)	33(80.5)	33(68.8)	0.36
Former	11(12.5)	3(7.3)	8(16.7)	
Current	12(13.6)	5(12.2)	7(14.6)	
Atopic (≥1 positive SPT)	55(61.1)	23(56.1)	32(65.3)	0.38

<sup>‡</sup> Includes intermittent DPR users and consistent DPR users

<sup>α</sup> Kruskal-Wallis test

Table 3.2 Crude Associations between the Health Belief Constructs and DPR use<sup>o</sup> (n=90)

Construct:	# of items	Range	Median (IQR)	Median score		p-value <sup>□</sup>
				No DPR Use (IQR) <sup>§</sup>	DPR Use (IQR) <sup>¥</sup>	
Susceptibility	8	0-8	1.5 (1 - 2)	1 (1 - 2)	2 (1 - 2)	<b>&lt;0.01</b>
Self-efficacy	8	0-32	22 (21 - 27)	22 (19 - 26)	24 (22 - 27)	0.07
Cues to action	4	0-13	11 (8 - 13)	10 (7 - 13)	11 (8 - 13)	0.25
Barriers to use	6	0-24	18 (16 - 21)	20 (16 - 24)	18 (16 - 20)	0.21
Benefits of use	8	0-32	14 (11-17)	14 (9-18)	14 (12 - 17)	0.73

<sup>o</sup>DPR = comparing participants who used DPRs to those who did not

<sup>§</sup> n=39      <sup>¥</sup> n=47      <sup>□</sup> Chi-squared test

Table 3.3 Logistic Regression Models of the Associations between Health Beliefs and DPR use<sup>1</sup> (n=90)

Construct <sup>2</sup>	Crude <sup>o</sup>		Model 1 <sup>•</sup>		Model 2 <sup>€</sup>	
	OR	95%CI	OR	95%CI	OR	95%CI
Susceptibility	<b>3.5</b>	<b>(1.45 – 8.62)</b>	<b>3.9</b>	<b>(1.48 – 10.69)</b>	<b>10.5</b>	<b>(2.28 – 47.92)*</b>
Self-Efficacy	1.4	(0.58 – 3.17)	2.8	(0.95 – 7.91)	<b>4.9</b>	<b>(1.07 - 22.31)</b>
Cues to Action	2.0	(0.84 – 4.70)	2.1	(0.75 – 6.53)	4.7	(0.83 – 26.49)
Barriers to use	<b>2.5</b>	<b>(1.05 – 6.01)</b>	<b>4.1</b>	<b>(1.25 – 13.24)</b>	<b>8.0</b>	<b>(1.06 – 60.78)</b>
Benefits of use	1.02	(0.44 – 2.41)	0.9	(0.28 – 3.35)	4.2	(0.48 – 36.46)

<sup>1</sup> Respiratory protection use modeled as dichotomous variable: no DPR use, DPR use

<sup>2</sup> Constructs were modeled as dichotomous variables, e.g. “high” vs. “low” susceptibility

<sup>o</sup> Crude: univariate logistic models of the association between each health belief construct and DPR use

<sup>•</sup> Model 1 includes all five health beliefs included together in one multivariate logistic model

<sup>€</sup> Model 2 includes all five health belief constructs in one multivariate logistic model adjusted for age, gender, job type, years of employment, amount of time spent handling mice.

**Bold= p<0.05**      \* p<0.005

## **CHAPTER 4: MANUSCRIPT 2**

**Title: The Effectiveness of Disposable Particulate Respirator Use in Primary Prevention of Incident Allergic Sensitization and Laboratory Animal Allergy**

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#### **4.1 ABSTRACT**

**Background:** Disposable particulate respirators (DPRs) are used to reduce upper and lower airway symptoms among workers with laboratory animal allergy (LAA), but whether they are effective in the primary prevention of laboratory animal allergy is unknown.

**Objective:** We examined the association between DPR use and incident sensitization and mouse-associated upper and lower respiratory symptoms.

**Methods:** New employees (n=222) at a mouse facility were enrolled in a prospective cohort study and underwent repeat assessment of mouse allergen exposure, mouse skin test sensitivity, and mouse-associated upper and lower respiratory symptoms every six months. Demographic information, DPR use and upper and lower respiratory symptoms were assessed by questionnaire. Cox proportionate hazard modeling was used to examine the relationships between DPR use and time to development of mouse skin test sensitivity and mouse-associated upper and lower respiratory symptoms.

**Results:** Intermittent DPR users were at a significantly higher risk for sensitization than workers who either did not use DPRs or used them consistently. Similar

patterns were observed for LAA, however, there was no association between frequency of DPR use and risk of onset of respiratory symptoms.

**Conclusion:** There is a non-linear relationship between DPR use and incident sensitization to mouse allergen. While DPRs may continue to be useful as a means of secondary prevention of respiratory symptoms associated with exposure to mouse allergen, we may need to reconsider their role in primary prevention.

**Key words:** occupational health, laboratory animal allergy, respirator, primary prevention, occupational asthma, sensitization

#### **ABBREVIATIONS**

DPR	Disposable particulate respirator (N95)
SPT	Positive skin prick test for mouse allergen
LAA	Laboratory animal allergy (sensitization accompanied by symptoms)
OA	Occupational asthma
OSHA	Occupational Safety and Health Agency
PAPR	Powered Air-Purifying Respirator
NIOSH	National Institute for Occupational Safety and Health

## 4.2 INTRODUCTION

Laboratory animal allergy (LAA) affects as many as 1 in 5 laboratory animal workers, and often progresses to occupational asthma (OA)<sup>1,5,6</sup>. The current approach to managing LAA is to treat symptoms and reduce exposure to the offending allergen<sup>2,3</sup>. Typically the latter requires a change of job<sup>2,3</sup>. Because treatment options are limited and often ineffective, methods of preventing the development of LAA are needed.

Although the best means of primary prevention is unclear, NIOSH and OSHA endorse the use of disposable particulate respirators (DPRs)<sup>22,25,29-31,35,91,97,177,179</sup>. The longstanding rationale underlying this recommendation is that DPR use should reduce the amount of allergen that is inhaled, and that this reduction in respiratory exposure should decrease the risk of LAA<sup>131</sup>. However, the extent to which DPR use reduces either internal allergen dose, or risk of developing LAA, is unknown<sup>14,53,66,120</sup>. Moreover, it is becoming increasingly clear that the allergen exposure-sensitization relationship is nonlinear, with moderate, rather than high, animal allergen exposure conferring the greatest risk of sensitization<sup>14,49,52,57,120</sup>. With these factors in mind, we hypothesized that intermittent DPR use would be associated with a higher risk for LAA than either consistent DPR use or no DPR use. To address this hypothesis, we examined the association between DPR use and (1) risk of incident sensitization, and (2) risk of incident mouse-associated respiratory symptoms in a prospective occupational cohort study of newly employed laboratory animal workers at a mouse research and production facility.

## **METHODS**

### *i. Study Design and Population*

Data were drawn from a prospective cohort study (JAXCohort) at The Jackson Laboratory, a mouse production and research facility. Workers were recruited to the cohort in two phases, 2004 – 2009 and 2010 – 2013. Data collected between June of 2004 to August of 2013 were included in this analysis. In both phases newly employed workers were enrolled and followed over time, using the same data collection protocols with repeated assessment of mouse-specific immunoglobulin responses, skin test sensitivity, mouse allergen exposure, and DPR use conducted every 6 months. Written informed consent was obtained from all participants and the protocol was approved by the Institutional Review Boards at both The Jackson Laboratory and the Johns Hopkins School of Medicine.

### *ii. Recruitment and Eligibility Criteria*

Study staff approached new employees during their post-job offer occupational health screening to determine if they were interested in participating<sup>54</sup>. JAXCohort eligibility criteria included: full time employees over 18 years of age who were not sensitized to mouse allergen. Of 475 participants who were enrolled in the JAX Cohort, 222 participants qualified for this analysis based on these additional criteria: 1) handled mice, 2) employed as an animal caretaker, laboratory technician or scientist, and 3) completed of at least 6 months of follow-up. Workers who were determined to be at high risk of developing LAA or OA were referred to the Occupational Safety and Health program for fit testing for the appropriate forms of respiratory protection. Ninety-six percent of workers who used respiratory

protection used N95 DPRs whereas 4% used Powered Air-Supplying Respirators (PAPR).

*iii. Baseline Characteristics, Allergic Symptoms and DPR Use*

Questionnaires were administered at baseline and subsequently every six months. The baseline questionnaire captured socio-demographic information, smoking and allergic history. Follow-up questionnaires captured interval occupational, allergic and respiratory disease history, and DPR use. The questionnaires were adapted from the previously validated American Thoracic Society's Respiratory Symptom Questionnaire and the Collaborative Study on the Genetics of Asthma questionnaire<sup>180,181</sup>.

Participants were asked if they had been offered respiratory protection and those that responded that they had were then asked how often they had used respiratory protection in the interval since they were last seen: "How often do you use respiratory protection when you are near mice", with a 5 point Likert-type scale as the response options "never", "rarely", "sometimes", "usually", "always" (Appendix 3.5 – 3.7). The questionnaire also included questions regarding both previous and new-onset allergic symptoms including: itchy/ watery eyes, sneezing, coughing, shortness of breath, wheezing, hives, and rash. For each symptom, the question was "Have you experienced (sic) symptom in the last six months while being exposed to mice?" Potential responses included: "not exposed", "no", "uncertain", and "yes". Participants were considered to have acquired a symptom only if they answered "yes".

iv. *Sensitization to Mouse Allergen*

Sensitization to mouse allergen was determined using skin prick testing and measurement of mouse-specific IgE in serum. Skin prick testing was performed at baseline and every six months and was conducted using a Multitest device (Lincoln Diagnostics, Decatur, IL). At baseline, skin testing was performed to 14 aeroallergens: mouse epithelia, cat, dog, rat, pine, birch, oak, orchard grass, ragweed, *Dermatophagoides farina*, *Dermatophagoides pternoyssinus*, *Aspergillus* species, *Penicillium* species, and *Alternaria* species<sup>14,119</sup>. At follow-up visits, skin testing was performed to a subset of 6 aeroallergens: mouse, cat, dog, rat, dust mite and pine<sup>14</sup>. A worker was considered atopic if they exhibited at least one positive skin prick test at the baseline visit, defined as net orthogonal wheal 3mm greater than the negative control (glycerin)<sup>14,119</sup>. Mouse-specific IgE was measured using the ImmunoCap system and the mouse urine CAP (Phadia, Uppsala, Sweden)<sup>54,125,126</sup>. A positive result was defined as a mouse urine IgE of at least 0.35 kUa/L<sup>14,119</sup>.

v. *Exposure Assessment*

Exposure to mouse allergen was measured using personal air samplers<sup>14,15,21,50,51,61,119,161,163,182-187</sup>. Two eight-hour shifts of personal air sampling were performed according to standard techniques within 2 weeks of the clinical follow-up visits (Buck VSS-12 personal air sampling pump, 2L/min, 35 mm Teflon filter)<sup>14</sup>. Protein was extracted from the filters using standard techniques and Mus m 1 was quantified using sandwich ELISA<sup>14</sup>. Airborne Mus m 1 concentrations were calculated using the total ng of Mus m 1 from each filter and the volume of air sampled for the filter, resulting in a concentration expressed in ng/m<sup>3</sup><sup>14</sup>.

vi. *Statistical Analysis*

Exploratory data analysis techniques were used to examine bivariate relationships and to assess the normality of distributions. The respiratory protection use responses were collapsed into three categories including: “Non-user” “Intermittent user” and “Consistent user” with intermittent users representing the intermediate scores. There were concerns that development of mouse-related respiratory symptoms might alter participants’ DPR use, therefore, 6-month lagged versions of the respiratory protection variables were used in these models.

Survival analysis techniques including: life tables, Kaplan Meier curves and Cox proportionate hazard models were used to examine the relationship between DPR use and time to development of each outcome. The outcomes were: time to development of a positive skin prick test to mouse allergen (SPT+), a positive mouse-specific IgE, mouse-related respiratory symptoms, and LAA<sup>188,189</sup>. A worker was considered to have developed LAA if they became sensitized to mouse allergy (SPT+ or mouse-specific IgE) and they reported at least one respiratory symptom<sup>3,5</sup>. Models were adjusted for tertiles of mean-log personal Mus m 1 exposure<sup>14</sup>.

In order to assess for confounding between the covariates and outcomes, rank sum, chi-squared and Kruskal-Wallis tests were used in combination with visual inspection<sup>190</sup>. The most parsimonious model with the best fit was identified using likelihood ratio testing and Aikiakes Information Criterion (AIC). Model assumptions were tested using Schoenfeld residuals<sup>189</sup>.

## 4.4 RESULTS

### *i. Study Population and DPR Use*

The majority of the 222 participants were white (89.2%) and female (57.7%), with an mean age of 30 yrs. Current smokers represented 23.8% of the population and workers who reported current asthma accounted for 8.6%, similar to the general US population<sup>176,191</sup>. Animal caretakers made up the largest group of workers (67.6%), followed by scientists (17.6%) and laboratory technicians (14.8%, Table 4.1). Median total IgE was 14 kU/L (IQR: 1.19-34.32 kU/L), and 59% of workers had a positive skin prick test to at least one aeroallergen at baseline (Table 4.1). On average workers completed 3 follow up visits for a median follow up time of 18 months (IQR: 12-30 months, Table 4.1). 116 participants left the Jackson Laboratory over the course of the study, but there were no major differences between participants who exited and those who remained. Ninety-two percent of those who left the study completed an exit interview, and only one of these participants reported that they developed mouse allergy, but this was not cited as the reason for leaving the Jackson Laboratory.

The majority of workers reported that they never used respiratory protection (58.6%) whereas 8.1% and 33.3% reported intermittent and consistent DPR use respectively. Approximately half of animal caretakers did not use respiratory protection (51%) and 43% reported consistently using respiratory protection. The majority of scientists and laboratory technicians also did not use respiratory protection (75%) and only 13% reported consistently using respiratory protection. Scientists and laboratory technicians were twice as likely to report using respirators

intermittently as compared to animal caretakers (13% vs. 6%, Table 4.1).

Intermittent users were significantly more likely to report current asthma (12.5%) as compared to either participants who consistently used DPRs or participants who did not use DPRs (4.4% and 13.7%, respectively,  $p=0.001$ , Table 4.1). Consistent DPR users were exposed to significantly higher levels of mouse allergen ( $12.0 \text{ ng/m}^3$  [IQR:  $5.7 - 40.8 \text{ ng/m}^3$ ]), as compared to either intermittent DPR users or workers who did not use DPRs ( $7.9 \text{ ng/m}^3$  [IQR:  $0.65 - 12.6 \text{ ng/m}^3$ ] and  $7.8 \text{ ng/m}^3$  [IQR:  $0.46 - 34.27$ ] respectively,  $p=0.03$ , Table 4.1).

*ii. Median Time to Outcomes*

The median time to sensitization as measured by skin prick test was 22 months (IQR: 18 – 30 months) whereas a median of 24 months (IQR: 18 – 42 months) elapsed before mouse-specific IgE was detected in serum. The incidence rate for SPT+ was 89.6 per 1000 worker-years (95% CI: 64.6 – 124.2 per 1000 worker-years) and 31.9 per 1000 worker-years (95% CI: 18.9 – 53.9 per 1000 worker-years) for detection of mouse-specific IgE in serum (Appendix 3.1 – 3.3). Median time to development of any respiratory symptoms was 27 months (IQR: 18 – 54 months). Median time to onset of rhinoconjunctival symptoms was the same, whereas the median time to onset of lower respiratory symptoms (wheezing, coughing, shortness of breath) was longer: 36 months (IQR: 18 – 60 months). Finally, median time to development of LAA (sensitization accompanied by respiratory symptoms) was 24 months (IQR: 18 – 60 months). The incidence rate for any mouse-related allergic respiratory symptom was 197.3 per 1000 worker-years (95% CI: 156.7 – 247.2 per 1000 worker-years). Workers were more likely to

develop rhino-conjunctivitis than lower respiratory symptoms (176.6 per 1000 worker-years [95% CI: 138.9 – 223.4 per 1000 worker-years] versus 111.8 per 1000 worker-years [95% CI: 83.5 – 149.7 per 1000 worker-years]). Laboratory animal allergy was the least common outcome, with an incidence rate 37.5 per 1000 worker-years (95% CI: 21.9 – 58.5 per 1000 worker-years).

*iii. DPR Use and Mouse Sensitization*

Onset of sensitization to mice was measured using both skin prick testing (SPT+) and mouse-specific IgE in serum<sup>14</sup>. Intermittent DPR users were significantly more likely to become sensitized to mouse allergen as compared to workers who either did not use DPRs or consistent DPR users, in unadjusted Cox proportionate hazard models: (4.0 HR [95% CI: 1.8-9.0]  $p < 0.001$ ; Table 4.2) (Figure 4.1). This difference continued to be significant after adjusting for age, sex, race, job type, atopic status at baseline, and mean exposure to *Mus m 1*, (3.9 HR [95% CI: 1.6-9.3],  $p < 0.001$ , Table 4.2) (Figure 4.2). Atopic status at baseline was the only other independent predictor of sensitization. Intermittent DPR users were also at significantly greater risk of developing mouse-specific IgE in serum than workers who either did not use DPRs or consistent DPR users, in both unadjusted and adjusted Cox proportionate models (8.8HR [95% CI: 2.3-33.5] and 8.6 HR [95% CI: 2.2 – 34.1], Table 4.2) (Figure 4.2).

*iv. DPR Use and Mouse-Associated Respiratory Symptoms and LAA*

There was no significant association between frequency of DPR use and risk of developing mouse-related respiratory symptoms in either unadjusted Cox proportionate hazard models, (Table A22). However, when the analysis was restricted to workers who did not have current asthma, intermittent DPR users were significantly more likely to develop mouse-related itchy / watery eyes or wheezing as compared to workers who either did not use a DPR or those who used DPRs consistently after adjusting for age, sex, job, atopic status, Mus m 1 concentration, and smoking (3.7 HR [95% CI: 1.1-11.8] and 14.8 HR [95% CI: 1.2 – 178.5] respectively, Table A23).

Intermittent DPR users were also more likely to develop LAA than workers who did not use DPRs and workers who used them consistently, however this difference was not statistically significant in either unadjusted or adjusted models (2.7 HR[ 95% CI 0.8 – 9.4], and 3.1 HR[95% CI: 0.8 – 12.3] respectively, Table 4.2). However, among participants who did not have asthma, intermittent users were at a significantly higher risk of developing LAA compared to workers who did not use DPRs and workers who used DPRs consistently in both unadjusted and adjusted models (3.7 HR[95% CI:1.0-13.7] and 6.0 HR[95% CI: 1.3 – 27.3], respectively, Table A23).

## 4.5 DISCUSSION:

### *i. Findings in Context*

The results of this prospective occupational cohort study demonstrate that among laboratory animal workers, intermittent DPR use is associated with a significantly higher risk of sensitization than either not using a DPR or using DPRs consistently. Similar patterns were observed for the risk of developing LAA.

In contrast to our study, previous studies have concluded that DPR use was positively associated with a reduction in LAA incidence<sup>4,23,41</sup>. However these studies either used cross-sectional designs or were unable to measure the independent effect of DPR use on LAA incidence because they evaluated the effect of DPR use as one component in a multi-modal intervention<sup>4,23,41</sup>. Our study overcomes the limitations of these previous studies because it was a prospective, rather than cross-sectional study, and the effect of DPR use as a single intervention on risk of allergic outcomes was examined. In addition, the frequency of DPR use was evaluated across a range of frequencies instead of simply comparing use to non-use, allowing us to examine the potential for a dose effect or non-linear effect of DPR use on allergic outcomes.

There are several plausible explanations of our findings that are based on the underlying biology and mechanics of the exposure and respiratory protection use. One explanation for the increased risk of sensitization among workers who used DPRs intermittently is that the intermittent use could have reduced the internal dose of allergen exposure from a tolerizing high dose to a pro-allergic moderate

dose<sup>14,49,52,53,119,192</sup>. In a study of relationships between mouse allergen exposure and allergic sensitization done in this same cohort, moderate levels of allergen exposure conferred the greatest risk of mouse sensitization and high levels of exposure conferred a lower risk of sensitization<sup>14</sup>. Specifically, as allergen exposure increased from low to moderate, risk for sensitization increased<sup>14</sup>. However, as allergen exposure increased from moderate to high levels, protective immunologic changes occur, shifting the immune response from sensitization to tolerance<sup>14,49,53,192</sup>. This phenomenon has been observed in other studies and with other animal allergens as well<sup>14,49,53,192</sup>. If we consider our results in this context, it is possible that when workers use DPRs intermittently, their internal dose remains above the level associated with increased risk for sensitization, but below the level associated with the shift from sensitization to tolerance. In this instance, we would observe, as we do here, that intermittent users would be at a significantly higher risk of becoming sensitized, and potentially of LAA as well, given that sensitization is the key step in the pathogenesis of LAA<sup>6,10,21,24</sup>.

Alternative explanations as to why intermittent users were at a higher risk becoming sensitized than workers who did not use respirators, or workers who used them consistently include the possibility that intermittent DPR use may be a surrogate measure of other factors that have a causal relationship with sensitization. It is also possible that the bell-shaped relationship between risk for sensitization and DPR use is related to the type of work that intermittent users are more likely to perform. For instance, perhaps intermittent users are more likely to perform tasks which are accompanied by exposure to other aerosol hazards that influence the risk of

developing allergic sensitization. However, models were adjusted for job type, and relationships between DPR use and incident sensitization and LAA were independent of job type.

*ii. Strengths and Limitations:*

One limitation of this study is that DPR use was assessed via self-report raising the possibility that our findings may be the result of recall bias<sup>169</sup>. However, given that DPR use was assessed prospectively, it is unlikely that participants would have reported DPR use in a way that was biased by an event which had yet to occur; i.e. incident sensitization. Instead, it is more likely that non-differential misclassification would occur and our findings would be biased towards the null<sup>169</sup>. Nevertheless, future studies that either validate self-reported DPR use or objectively measure DPR use would be beneficial.

Another potential limitation is that the vast majority (89%) of our cohort were Caucasian. Therefore these results may not be generalizable to other worker populations of different racial/ethnic backgrounds. However, in other respects our study population is similar to the US working population specifically regarding prevalence of risk factors for sensitization, smoking and occupational asthma and allergy<sup>176</sup>.

This study's strengths outweigh its limitations. For example, to our knowledge all of the other studies in this field have examined the association between risk of sensitization and DPR use when DPR use was part of a group of interventions with the aim of reducing exposure<sup>4,23,41</sup>. However, the Jackson Laboratory has always

maintained an occupational safety and health program aimed at exposure reduction, making this the first prospective occupational cohort study to be able to examine the independent effect of DPR use on risk of sensitization. The strength of our conclusions are bolstered by the fact that incidence of clinical outcomes was assessed at the same time as DPR use, within 2 weeks of personal air sampling for mouse allergen exposure, and in most instances we have several years of repeated measurements on participants. In addition, it is also the only study in which DPR use has been evaluated as a behavior that occurs along a continuum as opposed to as a binary outcome<sup>4,23,41</sup>. Classification of DPR use as an ordinal variable that captures reported frequency of use allows the evaluation of the association between frequency of DPR use and our outcomes of interest in a manner which more closely approximates actual use, and the evaluation of non-linear relationships. Finally, only one worker who left the study became sensitized, therefore our results cannot be explained by healthy worker bias. As such this study provides unique insight into the primary preventative role that respiratory protection may play, especially in regard to the development of sensitization which is a risk factor for developing LAA.

*iii. Implications for Policy and Research:*

Intermittent DPR use may be associated with a significantly higher risk for sensitization to mouse allergen than either consistent DPR use, or no DPR use. Because the link between intermittent DPR use and incident sensitization suggests that intermittent use may also be a risk factor for the progression from sensitization to laboratory animal allergy, additional research validating our findings using

observed rather than self-reported measures of DPR use, measurement of immunologically-active aerosol hazards in addition to *Mus m 1*, and a larger, more ethnically diverse cohort population is merited<sup>10,53,54,109</sup>. In addition, it will be important to determine if the bell-shaped association between DPR use and incident sensitization also applies to LAA and OA. These findings have policy implications as well, namely that it may be time to reconsider the role of DPRs in the primary prevention of LAA<sup>14,25,30,31,34,38,63,68,102,104-108,110,111,131,193-198</sup>.

*iv. Conclusions:*

The evidence base underlying the policy framework regarding the use of DPRs as a means of primary prevention for LAA is limited<sup>22,25,29-31,35,91,97,177,179</sup>. Prior to this study no research had verified DPRs are an effective means of primary prevention of developing LAA. Our study overcomes previous study design weaknesses which prevented the evaluation of the independent effect of DPRs on risk for becoming sensitized or developing LAA<sup>4,23,41</sup>. Our findings suggest that intermittent DPR users are at the greatest risk for developing LAA as compared to workers who use DPRs consistently and those who do not use DPRs. This finding is consistent with new evidence regarding bell-shaped exposure-responses for laboratory animal allergens<sup>22,25,29-31,35,91,97,177,179</sup>. In the future it will be important to define the mechanisms underlying these phenomena; identify those workers at the greatest risk of developing allergic disease; and develop new means of primary prevention. Finally, given that DPRs may not be as effective as previously thought, an evaluation of the policies surrounding their use as a form of primary prevention of LAA is merited<sup>25,30,31,102,105,111,131,195,196,199-204</sup>.

**TABLES**

**Table 4.1 Characteristics of the Study Population ( n=222)**

	Overall n=198 n (%)	Respiratory Protection Use			p-value
		Non-user (n=116) n (%)	Intermittent (n=16) n (%)	Consistent (n=66) n (%)	
<b>Follow-up time</b> (mo), median (IQR) <sup>‡</sup>	18(12-30)	18(12-30)	33(24-60)	18(12-30)	0.04
<b>Age</b> (y), mean ±SD	30.2±8.6	30.4±8.6	31.4±11.2	28.5±7.6	0.32
<b>Sex</b>					
Female	112 (57.7)	60(51.7)	13(81.2)	39(59.1)	0.07
Male	86(42.2)	56(48.2)	3(18.7)	27(40.1)	
<b>Race</b>					
White	198(89.5)	93(86.2)	50(100.0)	55(95.5)	0.34
Asian	4(3.2)	3(2.5)	-	1(1.5)	
Other	15(7.2)	13(8.3)	-	1(3.1)	
<b>Smoking status</b>					
Never smoker	113(55.9)	64(58.6)	11(68.8)	34(51.5)	0.23
Former smoker	41(20.4)	24(20.1)	4(25.1)	13(19.7)	
Current smoker	44(23.6)	24(20.7)	1(6.3)	19(28.8)	
<b>Job Category</b>					
Animal caretaker	135(67.3)	69(59.5)	8(50.0)	58(87.8)	<0.001
Scientist	33(17.7)	24(20.6)	4(25.0)	5(7.6)	
Lab. Technician	30(15.0)	23(19.8)	4(25.0)	3(4.5)	
<b>Mus m 1 Concentration</b>					
Median (ng/m <sup>3</sup> ) (IQR)	9.82 (1.19-34.32)	7.79 (0.46-34.27)	7.98 (0.65-12.61)	12.03 (5.71-40.87)	0.03
<b>Allergic History</b>					
Hay fever	44(20.0)	19(16.4)	3(18.8)	18(27.3)	0.21
Asthma: Never	162(83.1)	107(93.0)	11(68.8)	44(19.7)	<0.001
Former	19(9.1)	3(2.6)	3(18.8)	13(19.7)	
Current	16(7.8)	5(4.4)	2(12.5)	9(13.7)	
<b>Atopy</b>					
Total IgE (kU/L), median, (IQR)	14.1 (6.6- 39.5)	14.9 (7.6-36.9)	13.0 (5.1-31.9)	17.7 (6.2- 56.6)	0.67
Atopic (≥1 positive SPT)	126(61.4)	68(58.6)	11(68.8)	47(71.2)	0.21
<b>Skin Test Sensitivity</b>					
Dust mite	92(43.2)	46(39.6)	8(50.0)	38(57.6)	0.06
Pollen	70(35.0)	34(29.3)	9(56.3)	27(40.9)	0.06
Mold	24(11.8)	13(11.2)	3(18.8)	8(12.1)	0.69
Cat	23(13.6)	12(10.3)	3(18.8)	8(12.1)	0.61
Dog	4(1.8)	1(1.0)	1(6.7)	2(3.1)	0.26

Workers compared across categories of self-reported respiratory protection use at first 6 month follow-up visit

<sup>‡</sup>IQR Inter-Quartile Range (25-75%)

\*Other race: Hispanic, Black, Native American, East Indian

Table 4.2 Cox Proportional Hazards Models of the Associations between DPR use and Incident Sensitization and LAA (n=221)

Outcome	DPR Use	Crude HR (95% CI)	Adjusted HR (95% CI)
	Never	-ref-	-ref-
Mouse-Specific SPT+	<b>Intermittent</b>	<b>5.9 (2.33-14.76)</b>	<b>4.4 (1.69–11.41)</b>
	Consistent	<b>2.27 (1.04-4.96)</b>	1.63 (0.67-3.95)
	Never	-ref-	-ref-
Mus m 1-Specific IgE	<b>Intermittent</b>	<b>8.8 (2.32-33.47)</b>	<b>8.6(2.18-34.14)</b>
	Consistent	1.54 (0.44-5.33)	0.99 (0.25–3.92)
	Never	-ref-	-ref-
LAA <sup>‡</sup>	Intermittent	2.7 (0.76 – 9.41)	3.1 (0.82 – 12.3)
	Consistent	1.43 (0.48-4.24)	1.19 (0.34-4.21)

Models were adjusted for gender, age, job type, atopy and mean Mus m 1 exposure

<sup>‡</sup>Additionally adjusted for asthma and smoking

Bold indicates a significant (p<0.05)

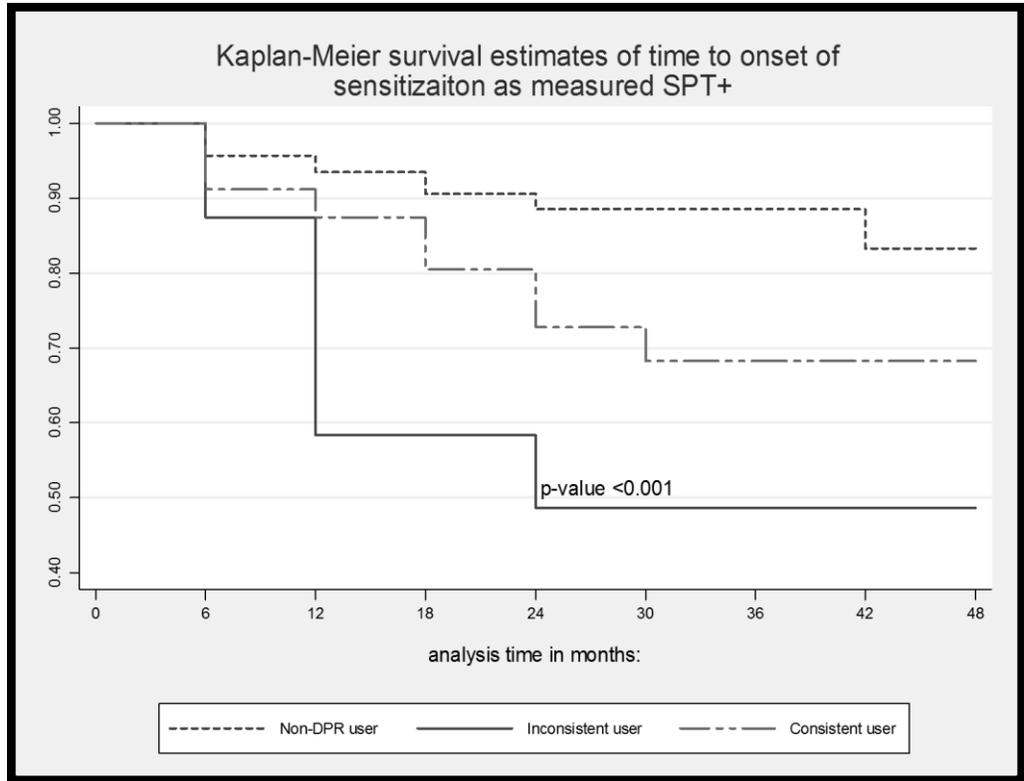
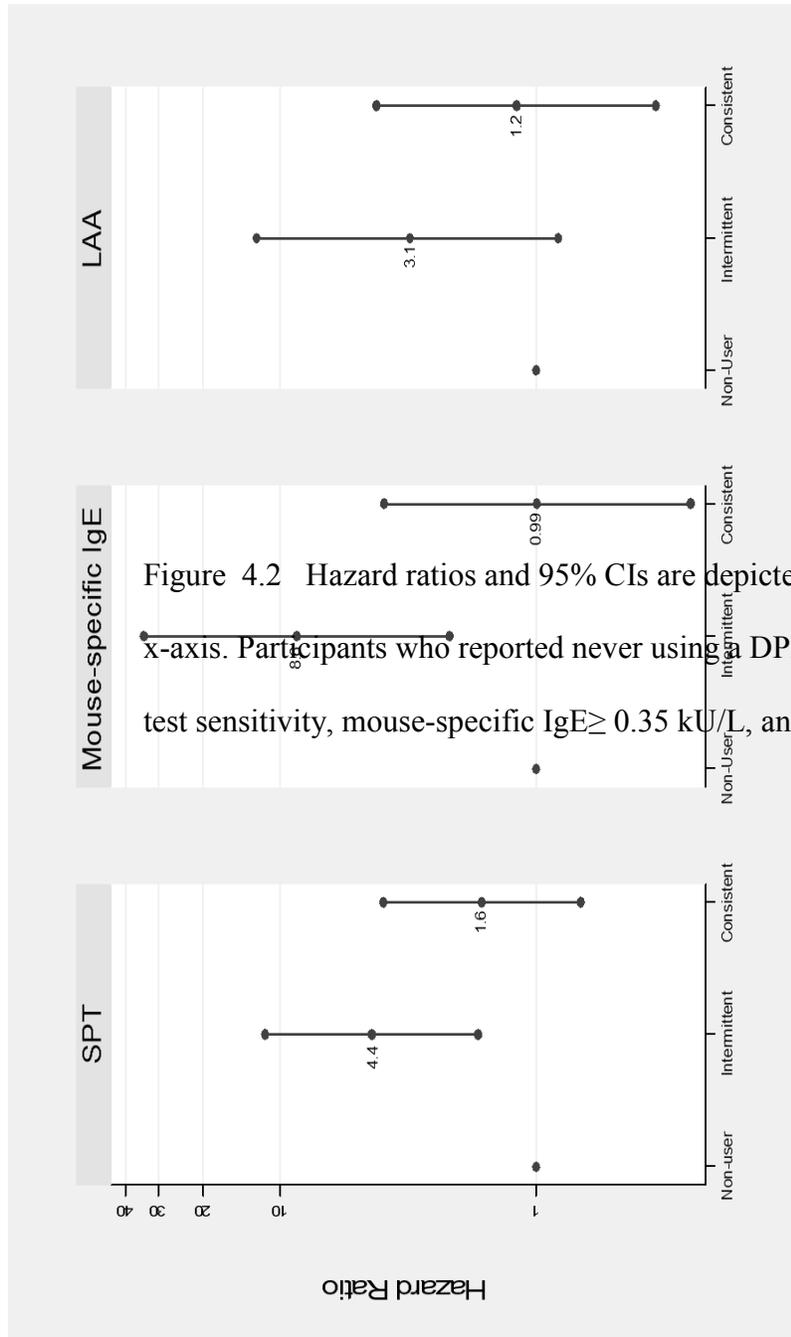


Figure 4.1 Kaplan Meier survival plot of time to sensitization to mouse allergen as measured by skin prick test, by frequency of respiratory protection use (n=222). Intermittent DPR users were significantly more likely to become sensitized than either workers who did not use DPRs, or workers who used DPRs consistently.



## CHAPTER 5: DISCUSSION

### 5.1 Introduction

Laboratory animal allergens have been considered an occupational hazard for more than 80 years, and have been regulated as an occupational exposure for more than 40 years<sup>50,98,131</sup>. However, laboratory animal workers continue to develop Laboratory Animal Allergy (LAA) and occupational asthma (OA)<sup>3,5,19,21</sup>. Since 1989, public health agencies have endorsed the use of disposable particulate respirators (DPRs) as a means of primary prevention of LAA in conjunction with an occupational safety and health program aimed at exposure reduction<sup>22,25,30,31,91,131,202</sup>. However, prior to this study, there was a dearth of knowledge regarding the frequency with which laboratory animal workers use DPRs, the factors associated with DPR use, as well as the effectiveness of DPRs as a means of primary prevention of the aforementioned health outcomes<sup>4,24,25,44,66,102,131,177</sup>.

Based on the evidence to date and our preliminary findings, we hypothesized that: 1) workers' health beliefs are associated with DPR use; and 2) workers who use respiratory protection intermittently are at higher risk of allergic outcomes compared to workers who do not use DPRs or who use them consistently. The first hypothesis reflects the findings of previous work, which demonstrates that workers' health beliefs play an important role in the frequency with which workers use PPE<sup>73,77,79,127,133,135,137,146,155-158,164,165,170,172,203,204</sup>. The latter is based on evidence suggesting that the exposure-response to laboratory animal allergens is bell-

shaped<sup>14,49,52,57,120</sup>. These hypotheses were tested using prospective occupational cohort data, thereby providing a unique opportunity to examine these relationships and assumptions in ways that had not been previously possible<sup>4,23,41</sup>.

Two specific aims were used to structure the research:

- 1) Evaluate the strength of the associations between workers' health beliefs and the frequency with which they use DPRs by characterizing: (a) the frequency and temporal trends of DPR use in this population; and (b) the associations between health beliefs and frequency of DPR use.
  
- 2) Characterize the association between frequency of DPR use and the time to development of: (a) mouse-specific sensitization; and (b) allergic symptoms.

## **5.2 Associations between Individual Factors and DPR use:**

Two studies nested in a long-standing prospective cohort study at the Jackson Laboratory in Maine were performed in pursuit of these aims. The first was cross-sectional in design and examined the associations between workers' health beliefs and their use of DPRs. The study population was drawn from the JAXCohort, described in chapter 2, and was composed of mouse-handlers who had been offered a DPR and had completed at least six months of follow-up (n=90). Data were

obtained using a self-reported questionnaire based on the Health Belief Model<sup>73,142,146,158,164</sup>.

Only 55% of the participants reported using DPRs at least some of the time; 10% percent of the population reported using DPRs intermittently; and 45% reported using them consistently. Participants' health beliefs were associated with frequency of DPR use. Specifically, those participants who perceived that they had been offered respiratory protection because of either their medical history or because of exposures to respiratory hazards (susceptibility) were more likely to use DPRs. Those who felt capable of using a DPR (self-efficacy) or who perceived a lack of barriers to using a DPR (barriers to use) were also more likely to use a DPR. These associations are consistent with those identified by other research, which has shown poor worker compliance with organizational policies requiring PPE use across a number of occupational settings, including: healthcare, construction, agriculture, and manufacturing<sup>71,73,77-79,121,122,127,134,135,137,141,143,146,155,156,164,165,168,170-172</sup>. Our findings are consistent with the body of work that demonstrates that these same three health belief constructs—perceived susceptibility, self-efficacy, and barriers to use—are significantly associated with a worker's use of PPE<sup>70,71,73,78,121,122,134</sup>. The variability in individual factors such as health beliefs differentially influences workers' willingness to engage in protective actions. This illustrates the principle of the hierarchy of controls, wherein reliance on PPE is the last line of defense for primary prevention because it requires conscious action on the part of the user<sup>205</sup>.

This is the first study to characterize the frequency with which laboratory animal workers use DPRs and the individual factors, such as health beliefs, that are

associated with use. These findings can be used to inform strategies aimed at maximizing DPR use<sup>22,25,29-31,33,37,63,96,174,175</sup>. Specifically, increasing perceived susceptibility and self-efficacy, as well as reducing barriers to use, may enhance the effectiveness of interventions aimed increasing the proportion of laboratory animal workers who use DPRs consistently<sup>22,25,29-31,33,37,63,96,174,175</sup>. In the future, it will be important to conduct research evaluating the effect of such interventions on DPR use, as well as on worker health outcomes<sup>188,189,192-197</sup>.

### **5.3 Effectiveness of DPRs as a Form of Primary Prevention:**

We performed a prospective occupational cohort study to identify the associations between DPR use and risk of becoming sensitized to mouse allergen or developing LAA. The study population (n=221) was also drawn from the JAXCohort and was composed of mouse handlers who had been offered respiratory protection, completed at least six-months of follow-up, and were not sensitized to mice.

There were no differences in risk of becoming sensitized to mouse allergen or of developing LAA between participants who always used DPRs and those who never used DPRs. However, participants who reported using DPRs intermittently were significantly more likely to become sensitized to mouse allergen and to develop LAA than participants who either always or never used DPRs.

In contrast to our study, previous studies concluded that DPR use was positively associated with a reduction in LAA incidence<sup>4,23,41</sup>. However, these studies were either cross-sectional in design, or were unable to measure the independent effect of

DPR use on LAA incidence<sup>4,23,41</sup>. Our study overcomes these limitations because it was prospective in design, and we examined the effect of DPR use, independent of an existing occupational safety and health program, on risk for developing allergic outcomes. In addition, the frequency of DPR use was evaluated across a range of frequencies, allowing us to examine the potential for a dose effect of DPR use on allergic outcomes.

One explanation for our findings is that workers who use DPRs intermittently may be maintaining their internal allergen dose below the level associated with tolerization, thereby increasing their risk for sensitization and LA<sup>25,30,31,98,101,107,127,188,189,192-197</sup>. Although our findings are not consistent with previous assumptions, they are in keeping conceptually with a growing body of evidence regarding exposure-response relationships for animal allergens<sup>6,10,21,24</sup>.

## **5.4 Implications for Research and Policy**

### *i. Research Recommendations:*

Our first study suggests that a majority of laboratory animal workers do not use DPRs in the recommended fashion and that individual factors such as workers' health beliefs influence the likelihood that workers will use a DPR. Additional research should be undertaken to determine whether interventions based on increasing workers' perceptions of susceptibility and self-efficacy, as well as decreasing barriers to use, will increase the proportion of workers who use DPRs consistently<sup>22,25,29-31,33,37,63,96,174,175</sup>.

Our second study suggests that intermittent DPR users were at the greatest risk for developing adverse respiratory health outcomes, as compared to participants who did not use DPRs or who used them at all times. It will be important to define the mechanisms underlying these observations. We also need to be able to identify those workers who are at the greatest risk of becoming sensitized and developing LAA. It is also clear that we need to develop effective methods of primary prevention of LAA. In developing these methods, we may need to focus on mechanisms of inhibiting the disease process, in addition to reducing exposure<sup>14,53,68,81,95</sup>.

#### *ii. Implications for Policy*

It would be premature to recommend changes to the regulatory policies regarding the use of DPRs as a means of primary prevention of the allergic outcomes associated with exposure to laboratory animal allergens<sup>206</sup>. However, our findings suggest that we need to evaluate the effectiveness of these policies and identify steps to improve them<sup>25,30,31,102,105,111,131,192,193,196-201</sup>. To our knowledge, NIOSH has no plans to support additional research into the effectiveness of DPRs as a means of primary prevention of LAA. Yet, given the implications of our findings for worker's health, it may be time to revisit this position and to appeal to NIOSH to pursue the research outlined herein.

## **5.5 Conclusion**

The majority of laboratory animal workers we studied did not report consistent use of DPRs, and their likelihood of wearing DPRs was associated with individual

factors such as health beliefs. In addition, contrary to previous assumptions, our research suggests that intermittent DPR users are at the highest risk of developing allergic outcomes when compared to those who do not use DPRs or who use them consistently<sup>4,23,25,41,131</sup>. Health belief-based interventions may prove effective in increasing the proportion of workers who use DPRs consistently<sup>22,25,29-31,33,37,63,96,174,175</sup>. However, further research is needed to understand the mechanisms underlying the association between intermittent DPR use and greater risk of developing allergic outcomes<sup>14,49,52,53,119,189,207</sup>. We also need to develop ways to identify workers who are at the greatest risk for developing allergic outcomes, as well as new methods of primary prevention<sup>9-11,21,23,41,80,95,114,120,136,149,207,208</sup>. Finally, we should undertake an evaluation of the policy framework surrounding the use of DPRs as a means of primary prevention of LAA, and determine ways in which these policies could be improved<sup>25,30,31,102,105,111,131,192,193,196-201</sup>.

## APPENDICES

### Appendix 1: The Respiratory Protection Standard (29 CFR 1910.134)

This section applies to General Industry (part 1910), Shipyards (part 1915), Marine Terminals (part 1917), Longshoring (part 1918), and Construction (part 1926).

#### **1910.134(a)**

***Permissible practice.***

#### **1910.134(a)(1)**

In the control of those occupational diseases caused by breathing air contaminated with harmful dusts<sup>1</sup>, fogs, fumes, mists, gases, smokes, sprays, or vapors, the primary objective shall be to prevent atmospheric contamination. **This shall be accomplished as far as feasible by accepted engineering control measures (for example, enclosure or confinement of the operation, general and local ventilation, and substitution of less toxic materials). When effective engineering controls are not feasible, or while they are being instituted, appropriate respirators shall be used pursuant to this section.**<sup>2</sup>

#### **1910.134(a)(2)**

A respirator shall be provided to each employee when such equipment is necessary to protect the health of such employee. **The employer shall provide the respirators which are applicable and suitable for the purpose intended.**<sup>3</sup> The employer shall be responsible for the establishment and maintenance of a respiratory protection program, which shall include the requirements outlined in paragraph (c) of this section. **The program shall cover each employee**

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<sup>1</sup> Laboratory animal allergens are classified as "harmful dusts" i.e. particulates.

<sup>2</sup> Denotes that respirators are to be used only when other higher control measures fail to reduce exposure. Section states "shall be used" in contrast to the majority of the document which focuses on employers offering and providing workers with respirators but does not specifically discuss mandatory use policies or enforcement of use.

<sup>3</sup> Assigned protection factors and exposure limits are used to determine the respirator that is "applicable and suitable". However, the studies used to calculate these values poorly represent laboratory animal allergen exposures, therefore, respirators selected based on these values may not provide the level of protection intended by the standard.

## required by this section to use a respirator.<sup>4</sup>

### 1910.134(b)

**Definitions.** The following definitions are important terms used in the respiratory protection standard in this section.

***Air-purifying respirator*** means a respirator with an air-purifying filter, cartridge, or canister that removes specific air contaminants by passing ambient air through the air-purifying element.

***Assigned protection factor (APF)*** means the workplace level of respiratory protection that a respirator or class of respirators is expected to provide to employees when the employer implements a continuing, effective respiratory protection program as specified by this section.

***Atmosphere-supplying respirator*** means a respirator that supplies the respirator user with breathing air from a source independent of the ambient atmosphere, and includes supplied-air respirators (SARs) and self-contained breathing apparatus (SCBA) units.

***Canister or cartridge*** means a container with a filter, sorbent, or catalyst, or combination of these items, which removes specific contaminants from the air passed through the container.

***Demand respirator*** means an atmosphere-supplying respirator that admits breathing air to the facepiece only when a negative pressure is created inside the facepiece by inhalation.

***Emergency situation*** means any occurrence such as, but not limited to, equipment failure, rupture of containers, or failure of control equipment that may or does result in an uncontrolled significant release of an airborne contaminant.

***Employee exposure*** means exposure to a concentration of an airborne contaminant that would occur if the employee were not using respiratory protection.

***End-of-service-life indicator (ESLI)*** means a system that warns the respirator user of the approach of the end of adequate respiratory protection, for example, that the sorbent is approaching saturation or is no longer effective.

***Escape-only respirator*** means a respirator intended to be used only for emergency exit.

***Filter or air purifying element*** means a component used in respirators to remove solid or liquid aerosols from the inspired air.

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<sup>4</sup> Because there is no hazard specific exposure limit it may be difficult for employers to determine if workers exposed to laboratory animal allergens are required to use respirators for several reasons. For example: laboratory animal workers are typically exposed to allergen levels 10,000 - 100,000-fold lower than the exposure limit for respirable particulates (4mg/m<sup>3</sup>). This means that employers could legitimately conclude that workers do not require respiratory protection.

**Filtering facepiece (dust mask)** means a negative pressure particulate respirator with a filter as an integral part of the facepiece or with the entire facepiece composed of the filtering medium.

**Fit factor** means a quantitative estimate of the fit of a particular respirator to a specific individual, and typically estimates the ratio of the concentration of a substance in ambient air to its concentration inside the respirator when worn.

**Fit test** means the use of a protocol to qualitatively or quantitatively evaluate the fit of a respirator on an individual. (See also Qualitative fit test QLFT and Quantitative fit test QNFT.)

**Helmet** means a rigid respiratory inlet covering that also provides head protection against impact and penetration.

**High efficiency particulate air (HEPA) filter** means a filter that is at least 99.97% efficient in removing monodisperse particles of 0.3 micrometers in diameter. The equivalent NIOSH 42 CFR 84 particulate filters are the N100, R100, and P100 filters.

**Hood** means a respiratory inlet covering that completely covers the head and neck and may also cover portions of the shoulders and torso.

**Immediately dangerous to life or health (IDLH)** means an atmosphere that poses an immediate threat to life, would cause irreversible adverse health effects, or would impair an individual's ability to escape from a dangerous atmosphere.

**Interior structural firefighting** means the physical activity of fire suppression, rescue or both, inside of buildings or enclosed structures which are involved in a fire situation beyond the incipient stage. (See 29 CFR 1910.155)

**Loose-fitting facepiece** means a respiratory inlet covering that is designed to form a partial seal with the face.

**Maximum use concentration (MUC)** means the maximum atmospheric concentration of a hazardous substance from which an employee can be expected to be protected when wearing a respirator, and is determined by the assigned protection factor of the respirator or class of respirators and the exposure limit of the hazardous substance. The MUC can be determined mathematically by multiplying the assigned protection factor specified for a respirator by the required OSHA permissible exposure limit, short-term exposure limit, or ceiling limit.<sup>5</sup> When no OSHA exposure limit is available for a

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<sup>5</sup> Based on the default exposure limit for respirable particles of 4mg/m<sup>3</sup>, a worker using a disposable particulate respirator should expect to be protected from developing adverse health

hazardous substance, an employer must determine an MUC on the basis of relevant available information and informed professional judgment.<sup>6</sup>

**Negative pressure respirator (tight fitting)** means a respirator in which the air pressure inside the facepiece is negative during inhalation with respect to the ambient air pressure outside the respirator.

**Oxygen deficient atmosphere** means an atmosphere with an oxygen content below 19.5% by volume.

**Physician or other licensed health care professional (PLHCP)** means an individual whose legally permitted scope of practice (i.e., license, registration, or certification) allows him or her to independently provide, or be delegated the responsibility to provide, some or all of the health care services required by paragraph (e) of this section.

**Positive pressure respirator** means a respirator in which the pressure inside the respiratory inlet covering exceeds the ambient air pressure outside the respirator.

**Powered air-purifying respirator (PAPR)** means an air-purifying respirator that uses a blower to force the ambient air through air-purifying elements to the inlet covering.

**Pressure demand respirator** means a positive pressure atmosphere-supplying respirator that admits breathing air to the facepiece when the positive pressure is reduced inside the facepiece by inhalation.

**Qualitative fit test (QLFT)** means a pass/fail fit test to assess the adequacy of respirator fit that relies on the individual's response to the test agent.

**Quantitative fit test (QNFT)** means an assessment of the adequacy of respirator fit by numerically measuring the amount of leakage into the respirator.

**Respiratory inlet covering** means that portion of a respirator that forms the protective barrier between the user's respiratory tract and an air-purifying device or breathing air source, or both. It may be a facepiece, helmet, hood, suit, or a mouthpiece respirator with nose clamp.

**Self-contained breathing apparatus (SCBA)** means an atmosphere-supplying respirator for which the breathing air source is designed to be carried by the user.

**Service life** means the period of time that a respirator, filter or sorbent, or other respiratory equipment provides adequate protection to the

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outcomes associated with exposure to laboratory animal allergens such as Mus m 1 at 40mg/m<sup>3</sup>.

<sup>6</sup> Setting such a level has been a subject of intense debate, especially given the uncertainties regarding the shape of the exposure-response relationship and the inter-individual variability in response to laboratory animal allergens.

wearer.

**Supplied-air respirator (SAR) or airline respirator** means an atmosphere-supplying respirator for which the source of breathing air is not designed to be carried by the user.

**This section** means this respiratory protection standard.

**Tight-fitting facepiece** means a respiratory inlet covering that forms a complete seal with the face.

**User seal check** means an action conducted by the respirator user to determine if the respirator is properly seated to the face.

**1910.134(c)**

**Respiratory protection program.** This paragraph requires the employer to develop and implement a written respiratory protection program with required worksite-specific procedures and elements for required respirator use. The program must be administered by a suitably trained program administrator. In addition, certain program elements may be required for voluntary use to prevent potential hazards associated with the use of the respirator. The Small Entity Compliance Guide contains criteria for the selection of a program administrator and a sample program that meets the requirements of this paragraph. Copies of the Small Entity Compliance Guide will be available on or about April 8, 1998 from the Occupational Safety and Health Administration's Office of Publications, Room N 3101, 200 Constitution Avenue, NW, Washington, DC, 20210 (202-219-4667).

**1910.134(c)(1)**

In any workplace where respirators are necessary to protect the health of the employee or whenever respirators are required by the employer, the employer shall establish and implement a written respiratory protection program with worksite-specific procedures. The program shall be updated as necessary to reflect those changes in workplace conditions that affect respirator use. The employer shall include in the program the following provisions of this section, as applicable:

**1910.134(c)(1)(i)**

Procedures for selecting respirators for use in the workplace;

**1910.134(c)(1)(ii)**

Medical evaluations of employees required to use respirators;

**1910.134(c)(1)(iii)**

Fit testing procedures for tight-fitting respirators;

**1910.134(c)(1)(iv)**

Procedures for proper use of respirators in routine and reasonably foreseeable emergency situations;

**1910.134(c)(1)(v)**

Procedures and schedules for cleaning, disinfecting, storing, inspecting, repairing, discarding, and otherwise maintaining respirators;

**1910.134(c)(1)(vi)**

Procedures to ensure adequate air quality, quantity, and flow of breathing air for atmosphere-supplying respirators;

**1910.134(c)(1)(vii)**

Training of employees in the respiratory hazards to which they are potentially exposed during routine and emergency situations;

**1910.134(c)(1)(viii)**

Training of employees in the proper use of respirators, including putting on and removing them, any limitations on their use, and their maintenance; and

**1910.134(c)(1)(ix)**

Procedures for regularly evaluating the effectiveness of the program.

**1910.134(c)(2)**

Where respirator use is not required:

**1910.134(c)(2)(i)**

An employer may provide respirators at the request of employees or permit employees to use their own respirators, if the employer determines that such respirator use will not in itself create a hazard. If the employer determines that any voluntary respirator use is permissible, the employer shall provide the respirator users with the information contained in Appendix D to this section ("Information for Employees Using Respirators When Not Required Under the Standard"); and

**1910.134(c)(2)(ii)**

In addition, the employer must establish and implement those elements of a written respiratory protection program necessary to ensure that any employee using a respirator voluntarily is medically able to use that respirator, and that the respirator is cleaned, stored, and maintained so that its use does not present a health hazard to the user. Exception: Employers are not required to include in a written respiratory protection program those employees whose only use of respirators involves the voluntary use of filtering facepieces (dust masks).

**1910.134(c)(3)**

The employer shall designate a program administrator who is qualified by appropriate training or experience that is commensurate with the complexity of the program to administer or oversee the respiratory protection program and conduct the required evaluations of program effectiveness.

**1910.134(c)(4)**

The employer shall provide respirators, training, and medical evaluations at no cost to the employee.

**1910.134(d)**

***Selection of respirators.*** This paragraph requires the employer to evaluate respiratory hazard(s) in the workplace, identify relevant workplace and user factors, and base respirator selection on these factors. The paragraph also specifies appropriately protective respirators for use in IDLH atmospheres, and limits the selection and use of air-purifying respirators.

**1910.134(d)(1)**

***General requirements.***

**1910.134(d)(1)(i)**

The employer shall select and provide an appropriate respirator based on the respiratory hazard(s) to which the worker is exposed and workplace and user factors that affect respirator performance and reliability.

**1910.134(d)(1)(ii)**

The employer shall select a NIOSH-certified respirator. The respirator shall be used in compliance with the conditions of its certification.

**1910.134(d)(1)(iii)**

The employer shall identify and evaluate the respiratory hazard(s) in the workplace; this evaluation shall include a reasonable estimate of employee exposures to respiratory hazard(s) and an identification of the contaminant's chemical state and physical form. Where the employer cannot identify or reasonably estimate the employee exposure, the employer shall consider the atmosphere to be IDLH.

**1910.134(d)(1)(iv)**

The employer shall select respirators from a sufficient number of respirator models and sizes so that the respirator is acceptable to, and correctly fits, the user.

**1910.134(d)(2)**

***Respirators for IDLH atmospheres.***

**1910.134(d)(2)(i)**

The employer shall provide the following respirators for employee use in IDLH atmospheres:

**1910.134(d)(2)(i)(A)**

A full facepiece pressure demand SCBA certified by NIOSH for a minimum service life of thirty minutes, or

**1910.134(d)(2)(i)(B)**

A combination full facepiece pressure demand supplied-air respirator (SAR) with auxiliary self-contained air supply.

**1910.134(d)(2)(ii)**

Respirators provided only for escape from IDLH atmospheres shall be NIOSH-certified for escape from the atmosphere in which they will be used.

**1910.134(d)(2)(iii)**

All oxygen-deficient atmospheres shall be considered IDLH. Exception: If the employer demonstrates that, under all foreseeable conditions, the oxygen concentration can be maintained within the ranges specified in Table II of this section (i.e., for the altitudes set out in the table), then any atmosphere-supplying respirator may be used.

**1910.134(d)(3)**

***Respirators for atmospheres that are not IDLH.***

**1910.134(d)(3)(i)**

The employer shall provide a respirator that is adequate to protect the health of the employee and ensure compliance with all other OSHA statutory and regulatory requirements, under routine and reasonably foreseeable emergency situations.

**1910.134(d)(3)(i)(A)**

**Assigned Protection Factors (APFs)** Employers must use the assigned protection factors listed in Table 1 to select a respirator that meets or exceeds the required level of employee protection. When using a combination respirator (e.g., airline respirators with an air-purifying filter), employers must ensure that the assigned protection factor is appropriate to the mode of operation in which the respirator is being used.

Table 1. -- Assigned Protection Factors<sup>5</sup>

Type of respirator <sup>1, 2</sup>	Quarter	Half mask	Full Face piece	Helmet	
<b>1. Air-Purifying Respirator</b>	<b>5</b>	<b><sup>3</sup>10<sup>7</sup></b>	<b>50</b>	.....	.....

**Notes:**

<sup>1</sup>Employers may select respirators assigned for use in higher workplace concentrations of a hazardous substance for use at lower concentrations of that substance, or when required respirator use is independent of concentration.

<sup>2</sup>The assigned protection factors in Table 1 are only effective when the employer implements a continuing, effective respirator program as required by this section (29 CFR 1910.134), including training, fit testing, maintenance, and use requirements.

<sup>7</sup> As laboratory animal allergens are regulated as particulates, air-purifying respirators with an APF value of 10, is the minimal level of respiratory protection that should be offered to laboratory animal workers.

<sup>3</sup>This APF category includes filtering facepieces, and half masks with elastomeric facepieces.

<sup>4</sup>The employer must have evidence provided by the respirator manufacturer that testing of these respirators demonstrates performance at a level of protection of 1,000 or greater to receive an APF of 1,000. This level of performance can best be demonstrated by performing a WPF or SWPF study or equivalent testing. Absent such testing, all other PAPRs and SARs with helmets/hoods are to be treated as loose-fitting facepiece respirators, and receive an APF of 25.

<sup>5</sup>These APFs do not apply to respirators used solely for escape. For escape respirators used in association with specific substances covered by 29 CFR 1910 subpart Z, employers must refer to the appropriate substance-specific standards in that subpart. Escape respirators for other IDLH atmospheres are specified by 29 CFR 1910.134 (d)(2)(ii).

**1910.134(d)(3)(i)(B)**

***Maximum Use Concentration (MUC)***

**1910.134(d)(3)(i)(B)(1)**

The employer must select a respirator for employee use that maintains the employee's exposure to the hazardous substance, when measured outside the respirator, at or below the MUC.

**1910.134(d)(3)(i)(B)(2)**

Employers must not apply MUCs to conditions that are immediately dangerous to life or health (IDLH); instead, they must use respirators listed for IDLH conditions in paragraph (d)(2) of this standard.

**1910.134(d)(3)(i)(B)(3)**

When the calculated MUC exceeds the IDLH level for a hazardous substance, or the performance limits of the cartridge or canister, then employers must set the maximum MUC at that lower limit.

**1910.134(d)(3)(ii)**

The respirator selected shall be appropriate for the chemical state and physical form of the contaminant.

**1910.134(d)(3)(iii)**

For protection against gases and vapors, the employer shall provide:

**1910.134(d)(3)(iii)(A)**

An atmosphere-supplying respirator, or

**1910.134(d)(3)(iii)(B)**

An air-purifying respirator, provided that:

**1910.134(d)(3)(iii)(B)(1)**

The respirator is equipped with an end-of-service-life indicator (ESLI) certified by NIOSH for the contaminant; or

**1910.134(d)(3)(iii)(B)(2)**

If there is no ESLI appropriate for conditions in the employer's workplace, the employer implements a change schedule for canisters and cartridges that is based on objective information or data that will ensure that canisters and cartridges are changed before the end of their service life. The employer shall describe in the respirator program the information and data relied upon and the basis for the canister and cartridge change schedule and the basis for reliance on the data.

**1910.134(d)(3)(iv)**

For protection against particulates, the employer shall provide:

**1910.134(d)(3)(iv)(A)**

An atmosphere-supplying respirator; or

**1910.134(d)(3)(iv)(B)**

An air-purifying respirator equipped with a filter certified by NIOSH under 30 CFR part 11 as a high efficiency particulate air (HEPA) filter, or an air-purifying respirator equipped with a filter certified for particulates by NIOSH under 42 CFR part 84; or

### **1910.134(d)(3)(iv)(C)**

For contaminants consisting primarily of particles with mass median aerodynamic diameters (MMAD) of at least 2 micrometers, an air-purifying respirator equipped with any filter certified for particulates by NIOSH.<sup>8</sup>

### **1910.134(e)<sup>9</sup>**

**Medical evaluation.** Using a respirator may place a physiological burden on employees that varies with the type of respirator worn, the job and workplace conditions in which the respirator is used, and the medical status of the employee. Accordingly, this paragraph specifies the minimum requirements for medical evaluation that employers must implement to determine the employee's ability to use a respirator.

### **1910.134(e)(1)**

**General.** The employer shall provide a medical evaluation to determine the employee's ability to use a respirator, before the employee is fit tested or required to use the respirator in the workplace. The employer may discontinue an employee's medical evaluations when the employee is no longer required to use a respirator.

### **1910.134(e)(2)**

**Medical evaluation procedures.**

#### **1910.134(e)(2)(i)**

The employer shall identify a physician or other licensed health care professional (PLHCP) to perform medical evaluations using a medical questionnaire or an initial medical examination that obtains the same information as the medical questionnaire.

#### **1910.134(e)(2)(ii)**

The medical evaluation shall obtain the information requested by the questionnaire in Sections 1 and 2, Part A of Appendix C of this section.

#### **1910.134(e)(3)**

**Follow-up medical examination.**

#### **1910.134(e)(3)(i)**

The employer shall ensure that a follow-up medical examination is provided for an employee who gives a positive response to any question among questions 1 through 8 in Section 2, Part A of Appendix C or whose initial medical examination demonstrates the need for a follow-up medical examination.

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<sup>8</sup> Laboratory animal allergens are regulated as a member of the general class of particulate exposures. The default exposure limit is 10mg/m<sup>3</sup> for inhalable particles and 4mg/m<sup>3</sup> for respirable particles. However, we have observed increased risk for developing adverse health outcomes associated with exposure to mice below 0.01 ng/m<sup>3</sup> of Mus m 1 from an 8hr TWA.

<sup>9</sup> The medical evaluation is used to determine IF a worker is capable of using a respirator. One of the reasons that we have such a poor understanding of the effectiveness of DPRs as a means of primary prevention of LAA and OA is employers are not required to determine if laboratory animal workers are sensitized to laboratory animal allergens at the start of employment, or in fact at any time thereafter, unless they develop allergic symptoms.

**1910.134(e)(3)(ii)**

The follow-up medical examination shall include any medical tests, consultations, or diagnostic procedures that the PLHCP deems necessary to make a final determination.

**1910.134(e)(4)**

***Administration of the medical questionnaire and examinations.***

**1910.134(e)(4)(i)**

The medical questionnaire and examinations shall be administered confidentially during the employee's normal working hours or at a time and place convenient to the employee. The medical questionnaire shall be administered in a manner that ensures that the employee understands its content.

**1910.134(e)(4)(ii)**

The employer shall provide the employee with an opportunity to discuss the questionnaire and examination results with the PLHCP.

**1910.134(e)(5)**

***Supplemental information for the PLHCP.***

**1910.134(e)(5)(i)**

The following information must be provided to the PLHCP before the PLHCP makes a recommendation concerning an employee's ability to use a respirator:

**1910.134(e)(5)(i)(A)**

(A) The type and weight of the respirator to be used by the employee;

**1910.134(e)(5)(i)(B)**

The duration and frequency of respirator use (including use for rescue and escape);

**1910.134(e)(5)(i)(C)**

The expected physical work effort;

**1910.134(e)(5)(i)(D)**

Additional protective clothing and equipment to be worn; and

**1910.134(e)(5)(i)(E)**

Temperature and humidity extremes that may be encountered.

**1910.134(e)(5)(ii)**

Any supplemental information provided previously to the PLHCP regarding an employee need not be provided for a subsequent medical evaluation if the information and the PLHCP remain the same.

**1910.134(e)(5)(iii)**

The employer shall provide the PLHCP with a copy of the written respiratory protection program and a copy of this section.

**Note to Paragraph (e)(5)(iii):** When the employer replaces a PLHCP, the employer must ensure that the new PLHCP obtains this information, either by providing the documents directly to the PLHCP or having the documents transferred from the former PLHCP to the new PLHCP. However, OSHA does not expect employers to have employees medically reevaluated solely because a new PLHCP has been selected.

**1910.134(e)(6)**

***Medical determination.*** In determining the employee's ability to use a respirator, the employer shall:

**1910.134(e)(6)(i)**

Obtain a written recommendation regarding the employee's ability to use the respirator from the PLHCP. The recommendation shall provide only the following information:

**1910.134(e)(6)(i)(A)**

Any limitations on respirator use related to the medical condition of the employee, or relating to the workplace conditions in which the respirator will be used, including whether or not the employee is medically able to use the respirator;

**1910.134(e)(6)(i)(B)**

The need, if any, for follow-up medical evaluations; and

**1910.134(e)(6)(i)(C)**

A statement that the PLHCP has provided the employee with a copy of the PLHCP's written recommendation.

**1910.134(e)(6)(ii)**

If the respirator is a negative pressure respirator and the PLHCP finds a medical condition that may place the employee's health at increased risk if the respirator is used, the employer shall provide a PAPR if the PLHCP's medical evaluation finds that the employee can use such a respirator; if a subsequent medical evaluation finds that the employee is medically able to use a negative pressure respirator, then the employer is no longer required to provide a PAPR.

**1910.134(e)(7)**

**Additional medical evaluations.** At a minimum, the employer shall provide additional medical evaluations that comply with the requirements of this section if:

**1910.134(e)(7)(i)**

An employee reports medical signs or symptoms that are related to ability to use a respirator;

**1910.134(e)(7)(ii)**

A PLHCP, supervisor, or the respirator program administrator informs the employer that an employee needs to be reevaluated;

**1910.134(e)(7)(iii)**

Information from the respiratory protection program, including observations made during fit testing and program evaluation, indicates a need for employee reevaluation; or

**1910.134(e)(7)(iv)**

A change occurs in workplace conditions (e.g., physical work effort, protective clothing, temperature) that may result in a substantial increase in the physiological burden placed on an employee.

**1910.134(f)**

**Fit testing.** This paragraph requires that, before an employee may be required to use any respirator with a negative or positive pressure tight-fitting facepiece, the employee must be fit tested with the same make, model, style, and size of respirator that will be used. This paragraph specifies the kinds of fit tests allowed, the procedures for conducting them, and how the results of the fit tests must be used.

**1910.134(f)(1)**

The employer shall ensure that employees using a tight-fitting facepiece respirator pass an appropriate qualitative fit test (QLFT) or quantitative fit test (QNFT) as stated in this paragraph.

**1910.134(f)(2)**

The employer shall ensure that an employee using a tight-fitting facepiece respirator is fit tested prior to initial use of the respirator, whenever a different respirator facepiece (size, style, model or make) is used, and at least annually thereafter.

**1910.134(f)(3)**

The employer shall conduct an additional fit test whenever the employee reports, or the employer, PLHCP, supervisor, or program administrator makes visual observations of, changes in the employee's physical condition that could affect respirator fit. Such conditions include, but are not limited to, facial scarring, dental changes, cosmetic surgery, or an obvious change in body weight.

**1910.134(f)(4)**

If after passing a QLFT or QNFT, the employee subsequently notifies the employer, program administrator, supervisor, or PLHCP that the fit of the respirator is

unacceptable, the employee shall be given a reasonable opportunity to select a different respirator facepiece and to be retested.

**1910.134(f)(5)**

The fit test shall be administered using an OSHA-accepted QLFT or QNFT protocol. The OSHA-accepted QLFT and QNFT protocols and procedures are contained in Appendix A of this section.

**1910.134(f)(6)**

QLFT may only be used to fit test negative pressure air-purifying respirators that must achieve a fit factor of 100 or less.

**1910.134(f)(7)**

If the fit factor, as determined through an OSHA-accepted QNFT protocol, is equal to or greater than 100 for tight-fitting half facepieces, or equal to or greater than 500 for tight-fitting full facepieces, the QNFT has been passed with that respirator.

**1910.134(f)(8)**

Fit testing of tight-fitting atmosphere-supplying respirators and tight-fitting powered air-purifying respirators shall be accomplished by performing quantitative or qualitative fit testing in the negative pressure mode, regardless of the mode of operation (negative or positive pressure) that is used for respiratory protection.

**1910.134(f)(8)(i)**

Qualitative fit testing of these respirators shall be accomplished by temporarily converting the respirator user's actual facepiece into a negative pressure respirator with appropriate filters, or by using an identical negative pressure air-purifying respirator facepiece with the same sealing surfaces as a surrogate for the atmosphere-supplying or powered air-purifying respirator facepiece.

**1910.134(f)(8)(ii)**

Quantitative fit testing of these respirators shall be accomplished by modifying the facepiece to allow sampling inside the facepiece in the breathing zone of the user, midway between the nose and mouth. This requirement shall be accomplished by installing a permanent sampling probe onto a surrogate facepiece, or by using a sampling adapter designed to temporarily provide a means of sampling air from inside the facepiece.

**1910.134(f)(8)(iii)**

Any modifications to the respirator facepiece for fit testing shall be completely removed, and the facepiece restored to NIOSH-approved configuration, before that facepiece can be used in the workplace.

**1910.134(g)**

***Use of respirators.*** This paragraph requires employers to establish and implement procedures for the proper use of respirators. These requirements include prohibiting conditions that may result in facepiece seal leakage, preventing employees from removing respirators in hazardous environments, taking actions to ensure continued effective respirator operation throughout the work shift, and establishing procedures for the use of respirators in IDLH atmospheres or in interior structural firefighting situations.

**1910.134(g)(1)**

***Facepiece seal protection.***

**1910.134(g)(1)(i)**

The employer shall not permit respirators with tight-fitting facepieces to be worn by employees who have:

**1910.134(g)(1)(i)(A)**

Facial hair that comes between the sealing surface of the facepiece and the face or that interferes with valve function; or

**1910.134(g)(1)(i)(B)**

Any condition that interferes with the face-to-facepiece seal or valve function.

**1910.134(g)(1)(ii)**

If an employee wears corrective glasses or goggles or other personal protective equipment, the employer shall ensure that such equipment is worn in a manner that does not interfere with the seal of the facepiece to the face of the user.

**1910.134(g)(1)(iii)**

For all tight-fitting respirators, the employer shall ensure that employees perform a user seal check each time they put on the respirator using the procedures in Appendix B-1 or procedures recommended by the respirator manufacturer that the employer demonstrates are as effective as those in Appendix B-1 of this section.

**1910.134(g)(2)**

***Continuing respirator effectiveness.***

**1910.134(g)(2)(i)<sup>10</sup>**

Appropriate surveillance shall be maintained of work area conditions and degree of employee exposure or stress. When there is a change in work area conditions or degree of employee exposure or stress that may affect respirator effectiveness, the employer shall reevaluate the continued effectiveness of the respirator.

**1910.134(g)(2)(ii)**

The employer shall ensure that employees leave the respirator use area:

**1910.134(g)(2)(ii)(A)**

To wash their faces and respirator facepieces as necessary to prevent eye or skin irritation associated with respirator use; or

**1910.134(g)(2)(ii)(B)**

If they detect vapor or gas breakthrough, changes in breathing resistance, or leakage of the facepiece; or

**1910.134(g)(2)(ii)(C)**

To replace the respirator or the filter, cartridge, or canister elements.

**1910.134(g)(2)(iii)**

If the employee detects vapor or gas breakthrough, changes in breathing resistance, or leakage of the facepiece, the employer must replace or repair the respirator before allowing the employee to return to the work area.

**1910.134(g)(3)**

***Procedures for IDLH atmospheres.*** For all IDLH atmospheres, the employer shall ensure that:

**1910.134(g)(3)(i)**

One employee or, when needed, more than one employee is located outside the IDLH atmosphere;

**1910.134(g)(3)(ii)**

Visual, voice, or signal line communication is maintained between the employee(s) in the IDLH atmosphere and the employee(s) located outside the IDLH atmosphere;

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<sup>10</sup> Meant to create a feedback loop to protect workers' health by assuring that the respiratory protection program is continuously re-evaluated, allowing for flexibility and adaptation to changing exposures in the workplace. However, under the standard, "respirator effectiveness" is defined as the capacity of the respirator to reduce workers exposure to a set level, not the capacity of a respirator to reduce workers' risk for developing adverse health outcomes to a certain level. Therefore, for exposure such as laboratory animal allergens, wherein the exposure reduction provided by DPRs does not necessarily translate into reduction in risk for developing adverse health outcomes, the intent of this section fails to be realized.

**1910.134(g)(3)(iii)**

The employee(s) located outside the IDLH atmosphere are trained and equipped to provide effective emergency rescue;

**1910.134(g)(3)(iv)**

The employer or designee is notified before the employee(s) located outside the IDLH atmosphere enter the IDLH atmosphere to provide emergency rescue;

**1910.134(g)(3)(v)**

The employer or designee authorized to do so by the employer, once notified, provides necessary assistance appropriate to the situation;

**1910.134(g)(3)(vi)**

Employee(s) located outside the IDLH atmospheres are equipped with:

**1910.134(g)(3)(vi)(A)**

Pressure demand or other positive pressure SCBAs, or a pressure demand or other positive pressure supplied-air respirator with auxiliary SCBA; and either

**1910.134(g)(3)(vi)(B)**

Appropriate retrieval equipment for removing the employee(s) who enter(s) these hazardous atmospheres where retrieval equipment would contribute to the rescue of the employee(s) and would not increase the overall risk resulting from entry; or

**1910.134(g)(3)(vi)(C)**

Equivalent means for rescue where retrieval equipment is not required under paragraph (g)(3)(vi)(B).

**1910.134(g)(4)**

***Procedures for interior structural firefighting.*** In addition to the requirements set forth under paragraph (g)(3), in interior structural fires, the employer shall ensure that:

**1910.134(g)(4)(i)**

At least two employees enter the IDLH atmosphere and remain in visual or voice contact with one another at all times;

**1910.134(g)(4)(ii)**

At least two employees are located outside the IDLH atmosphere; and

**1910.134(g)(4)(iii)**

All employees engaged in interior structural firefighting use SCBAs.

**Note 1 to paragraph (g):** One of the two individuals located outside the IDLH atmosphere may be assigned to an additional role, such as incident commander in charge of the emergency or safety officer, so long as this individual is able to perform assistance or rescue activities without jeopardizing the safety or health of any firefighter working at the incident.

**Note 2 to paragraph (g):** Nothing in this section is meant to preclude firefighters from performing emergency rescue activities before an entire team has assembled.

**1910.134(h)**

***Maintenance and care of respirators.*** This paragraph requires the employer to provide for the cleaning and disinfecting, storage, inspection, and repair of respirators used by employees.

**1910.134(h)(1)**

***Cleaning and disinfecting.*** The employer shall provide each respirator user with a respirator that is clean, sanitary, and in good working order. The employer shall ensure that respirators are cleaned and disinfected using the procedures in Appendix B-2 of this section, or procedures recommended by the respirator manufacturer, provided that such procedures are of equivalent effectiveness. The respirators shall be cleaned and disinfected at the following intervals:

**1910.134(h)(1)(i)**

Respirators issued for the exclusive use of an employee shall be cleaned and disinfected as

often as necessary to be maintained in a sanitary condition;

**1910.134(h)(1)(ii)**

Respirators issued to more than one employee shall be cleaned and disinfected before being worn by different individuals;

**1910.134(h)(1)(iii)**

Respirators maintained for emergency use shall be cleaned and disinfected after each use; and

**1910.134(h)(1)(iv)**

Respirators used in fit testing and training shall be cleaned and disinfected after each use.

**1910.134(h)(2)**

**Storage.** The employer shall ensure that respirators are stored as follows:

**1910.134(h)(2)(i)**

All respirators shall be stored to protect them from damage, contamination, dust, sunlight, extreme temperatures, excessive moisture, and damaging chemicals, and they shall be packed or stored to prevent deformation of the facepiece and exhalation valve.

**1910.134(h)(2)(ii)**

In addition to the requirements of paragraph (h)(2)(i) of this section, emergency respirators shall be:

**1910.134(h)(2)(ii)(A)**

Kept accessible to the work area;

**1910.134(h)(2)(ii)(B)**

Stored in compartments or in covers that are clearly marked as containing emergency respirators; and

**1910.134(h)(2)(ii)(C)**

Stored in accordance with any applicable manufacturer instructions.

**1910.134(h)(3)**

**Inspection.**

**1910.134(h)(3)(i)**

The employer shall ensure that respirators are inspected as follows:

**1910.134(h)(3)(i)(A)**

All respirators used in routine situations shall be inspected before each use and during cleaning;

**1910.134(h)(3)(i)(B)**

All respirators maintained for use in emergency situations shall be inspected at least monthly and in accordance with the manufacturer's recommendations, and shall be checked for proper function before and after each use; and

**1910.134(h)(3)(i)(C)**

Emergency escape-only respirators shall be inspected before being carried into the workplace for use.

**1910.134(h)(3)(ii)**

The employer shall ensure that respirator inspections include the following:

**1910.134(h)(3)(ii)(A)**

A check of respirator function, tightness of connections, and the condition of the various parts including, but not limited to, the facepiece, head straps, valves, connecting tube, and cartridges, canisters or filters; and

**1910.134(h)(3)(ii)(B)**

A check of elastomeric parts for pliability and signs of deterioration.

**1910.134(h)(3)(iii)**

In addition to the requirements of paragraphs (h)(3)(i) and (ii) of this section, self-contained breathing apparatus shall be inspected monthly. Air and oxygen cylinders shall be maintained in a fully charged state and shall be recharged when the pressure falls to 90% of the manufacturer's recommended pressure level. The employer shall determine that the regulator and warning devices function properly.

**1910.134(h)(3)(iv)**

For respirators maintained for emergency use, the employer shall:

**1910.134(h)(3)(iv)(A)**

Certify the respirator by documenting the date the inspection was performed, the name (or signature) of the person who made the inspection, the findings, required remedial action, and a serial number or other means of identifying the inspected respirator; and

**1910.134(h)(3)(iv)(B)**

Provide this information on a tag or label that is attached to the storage compartment for the respirator, is kept with the respirator, or is included in inspection reports stored as paper or electronic files. This information shall be maintained until replaced following a subsequent certification.

**1910.134(h)(4)**

**Repairs.** The employer shall ensure that respirators that fail an inspection or are otherwise found to be defective are removed from service, and are discarded or repaired or adjusted in accordance with the following procedures:

**1910.134(h)(4)(i)**

Repairs or adjustments to respirators are to be made only by persons appropriately trained to perform such operations and shall use only the respirator manufacturer's NIOSH-approved parts designed for the respirator;

**1910.134(h)(4)(ii)**

Repairs shall be made according to the manufacturer's recommendations and specifications for the type and extent of repairs to be performed; and

**1910.134(h)(4)(iii)**

Reducing and admission valves, regulators, and alarms shall be adjusted or repaired only by the manufacturer or a technician trained by the manufacturer.

**1910.134(i)**

**Breathing air quality and use.** This paragraph requires the employer to provide employees using atmosphere-supplying respirators (supplied-air and SCBA) with breathing gases of high purity.

**1910.134(i)(1)**

The employer shall ensure that compressed air, compressed oxygen, liquid air, and liquid oxygen used for respiration accords with the following specifications:

**1910.134(i)(1)(i)**

Compressed and liquid oxygen shall meet the United States Pharmacopoeia requirements for medical or breathing oxygen; and

**1910.134(i)(1)(ii)**

Compressed breathing air shall meet at least the requirements for Grade D breathing air described in ANSI/Compressed Gas Association Commodity Specification for Air, G-7.1-1989, to include:

**1910.134(i)(1)(ii)(A)**

Oxygen content (v/v) of 19.5-23.5%;

**1910.134(i)(1)(ii)(B)**

Hydrocarbon (condensed) content of 5 milligrams per cubic meter of air or less;

**1910.134(i)(1)(ii)(C)**

Carbon monoxide (CO) content of 10 ppm or less;

**1910.134(i)(1)(ii)(D)**

Carbon dioxide content of 1,000 ppm or less; and

**1910.134(i)(1)(ii)(E)**

Lack of noticeable odor.

**1910.134(i)(2)**

The employer shall ensure that compressed oxygen is not used in atmosphere-supplying respirators that have previously used compressed air.

**1910.134(i)(3)**

The employer shall ensure that oxygen concentrations greater than 23.5% are used only in equipment designed for oxygen service or distribution.

**1910.134(i)(4)**

The employer shall ensure that cylinders used to supply breathing air to respirators meet the following requirements:

**1910.134(i)(4)(i)**

Cylinders are tested and maintained as prescribed in the Shipping Container Specification

Regulations of the Department of Transportation (49 CFR part 180);

**1910.134(i)(4)(ii)**

Cylinders of purchased breathing air have a certificate of analysis from the supplier that the breathing air meets the requirements for Grade D breathing air; and

**1910.134(i)(4)(iii)**

The moisture content in the cylinder does not exceed a dew point of -50 deg.F (-45.6 deg.C) at 1 atmosphere pressure.

**1910.134(i)(5)**

The employer shall ensure that compressors used to supply breathing air to respirators are constructed and situated so as to:

**1910.134(i)(5)(i)**

Prevent entry of contaminated air into the air-supply system;

**1910.134(i)(5)(ii)**

Minimize moisture content so that the dew point at 1 atmosphere pressure is 10 degrees F (5.56 deg.C) below the ambient temperature;

**1910.134(i)(5)(iii)**

Have suitable in-line air-purifying sorbent beds and filters to further ensure breathing air quality. Sorbent beds and filters shall be maintained and replaced or refurbished periodically following the manufacturer's instructions.

**1910.134(i)(5)(iv)**

Have a tag containing the most recent change date and the signature of the person authorized by the employer to perform the change. The tag shall be maintained at the compressor.

**1910.134(i)(6)**

For compressors that are not oil-lubricated, the employer shall ensure that carbon monoxide levels in the breathing air do not exceed 10 ppm.

**1910.134(i)(7)**

For oil-lubricated compressors, the employer shall use a high-temperature or carbon monoxide alarm, or both, to monitor carbon monoxide levels. If only high-temperature alarms are used, the air supply shall be monitored at intervals sufficient to prevent carbon monoxide in the breathing air from exceeding 10 ppm.

**1910.134(i)(8)**

The employer shall ensure that breathing air couplings are incompatible with outlets for nonrespirable worksite air or other gas systems. No asphyxiating substance shall be introduced into breathing air lines.

**1910.134(i)(9)**

The employer shall use only the respirator manufacturer's NIOSH-approved breathing-gas containers, marked and maintained in accordance with the Quality Assurance provisions of the NIOSH approval for the SCBA as issued in accordance with the NIOSH respirator-certification standard at 42 CFR part 84.

**1910.134(j)**

***Identification of filters, cartridges, and canisters.*** The employer shall ensure that all filters, cartridges and canisters used in the workplace are labeled and color coded with the NIOSH approval label and that the label is not removed and remains legible.

**1910.134(k)**

***Training and information.*** This paragraph requires the employer to provide effective training to employees who are required to use respirators. The training must be comprehensive, understandable, and recur annually, and more often if necessary. This paragraph also requires the employer to provide the basic information on respirators in Appendix D of this section to employees who wear respirators when not required by this section or by the employer to do so.

**1910.134(k)(1)**

The employer shall ensure that each employee can demonstrate knowledge of at least the

following:

**1910.134(k)(1)(i)**

Why the respirator is necessary and how improper fit, usage, or maintenance can compromise the protective effect of the respirator;

**1910.134(k)(1)(ii)**

What the limitations and capabilities of the respirator are;

**1910.134(k)(1)(iii)**

How to use the respirator effectively in emergency situations, including situations in which the respirator malfunctions;

**1910.134(k)(1)(iv)**

How to inspect, put on and remove, use, and check the seals of the respirator;

**1910.134(k)(1)(v)**

What the procedures are for maintenance and storage of the respirator;

**1910.134(k)(1)(vi)**

How to recognize medical signs and symptoms that may limit or prevent the effective use of respirators; and

**1910.134(k)(1)(vii)**

The general requirements of this section.

**1910.134(k)(2)**

The training shall be conducted in a manner that is understandable to the employee.

**1910.134(k)(3)**

The employer shall provide the training prior to requiring the employee to use a respirator in the workplace.

**1910.134(k)(4)**

An employer who is able to demonstrate that a new employee has received training within the last 12 months that addresses the elements specified in paragraph (k)(1)(i) through (vii) is not required to repeat such training provided that, as required by paragraph (k)(1), the employee can demonstrate knowledge of those element(s). Previous training not repeated initially by the employer must be provided no later than 12 months from the date of the previous training.

**1910.134(k)(5)**

Retraining shall be administered annually, and when the following situations occur:

**1910.134(k)(5)(i)**

Changes in the workplace or the type of respirator render previous training obsolete;

**1910.134(k)(5)(ii)**

Inadequacies in the employee's knowledge or use of the respirator indicate that the employee has not retained the requisite understanding or skill; or

**1910.134(k)(5)(iii)**

Any other situation arises in which retraining appears necessary to ensure safe respirator use.

**1910.134(k)(6)**

The basic advisory information on respirators, as presented in Appendix D of this section, shall be provided by the employer in any written or oral format, to employees who wear respirators when such use is not required by this section or by the employer.

**1910.134(l)**

***Program evaluation.***<sup>11</sup> This section requires the employer to conduct evaluations of the workplace to ensure that the written

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<sup>11</sup> Although this mechanism should ensure that each respiratory protection program is regularly evaluated, the level of evaluation possible is compromised in the instance of laboratory animal facilities because employers are not required to keep track of how many workers use respirators or whether respirator use reduces risk for becoming sensitized to laboratory animal allergens, the first step in the pathogenesis of LAA and OA.

respiratory protection program is being properly implemented, and to consult employees to ensure that they are using the respirators properly.

**1910.134(I)(1)**

The employer shall conduct evaluations of the workplace as necessary to ensure that the provisions of the current written program are being effectively implemented and that it continues to be effective.

**1910.134(I)(2)**

The employer shall regularly consult employees required to use respirators to assess the employees' views on program effectiveness and to identify any problems. Any problems that are identified during this assessment shall be corrected. Factors to be assessed include, but are not limited to:

**1910.134(I)(2)(i)**

Respirator fit (including the ability to use the respirator without interfering with effective workplace performance);

**1910.134(I)(2)(ii)**

Appropriate respirator selection for the hazards to which the employee is exposed;

**1910.134(I)(2)(iii)**

Proper respirator use under the workplace conditions the employee encounters; and

**1910.134(I)(2)(iv)**

Proper respirator maintenance.

**1910.134(m)**

***Recordkeeping.*** This section requires the employer to establish and retain written information regarding medical evaluations, fit testing, and the respirator program. This information will facilitate employee involvement in the respirator program, assist the employer in auditing the adequacy of the program, and provide a record for compliance determinations by OSHA.

**1910.134(m)(1)**

***Medical evaluation.*** Records of medical evaluations required by this section must be retained and made available in accordance with 29 CFR 1910.1020.

**1910.134(m)(2)**

***Fit testing.***

**1910.134(m)(2)(i)**

The employer shall establish a record of the qualitative and quantitative fit tests administered to an employee including:

**1910.134(m)(2)(i)(A)**

The name or identification of the employee tested;

**1910.134(m)(2)(i)(B)**

Type of fit test performed;

**1910.134(m)(2)(i)(C)**

Specific make, model, style, and size of respirator tested;

**1910.134(m)(2)(i)(D)**

Date of test; and

**1910.134(m)(2)(i)(E)**

The pass/fail results for QLFTs or the fit factor and strip chart recording or other recording

of the test results for QNFTs.

**1910.134(m)(2)(ii)**

Fit test records shall be retained for respirator users until the next fit test is administered.

**1910.134(m)(3)**

A written copy of the current respirator program shall be retained by the employer.

**1910.134(m)(4)**

Written materials required to be retained under this paragraph shall be made available upon request to affected employees and to the Assistant Secretary or designee for examination and copying.

**1910.134(n)**

**Effective date.** Paragraphs (d)(3)(i)(A) and (d)(3)(i)(B) of this section become effective November 22, 2006.

**1910.134(o)**

Appendices. Compliance with Appendix A, Appendix B-1, Appendix B-2, Appendix C, and Appendix D to this section are mandatory.

[63 FR 1152, Jan. 8, 1998; 63 FR 20098, April 23, 1998; 71 FR 16672, April 3, 2006; 71 FR 50187, August 24, 2006; 73 FR 75584, Dec. 12, 2008; 76 FR 33606, June 8, 2011]

## Appendix 2: Supplemental material for Manuscript 1

### A2.1 Conceptual model of the association between workers' health beliefs and DPR use

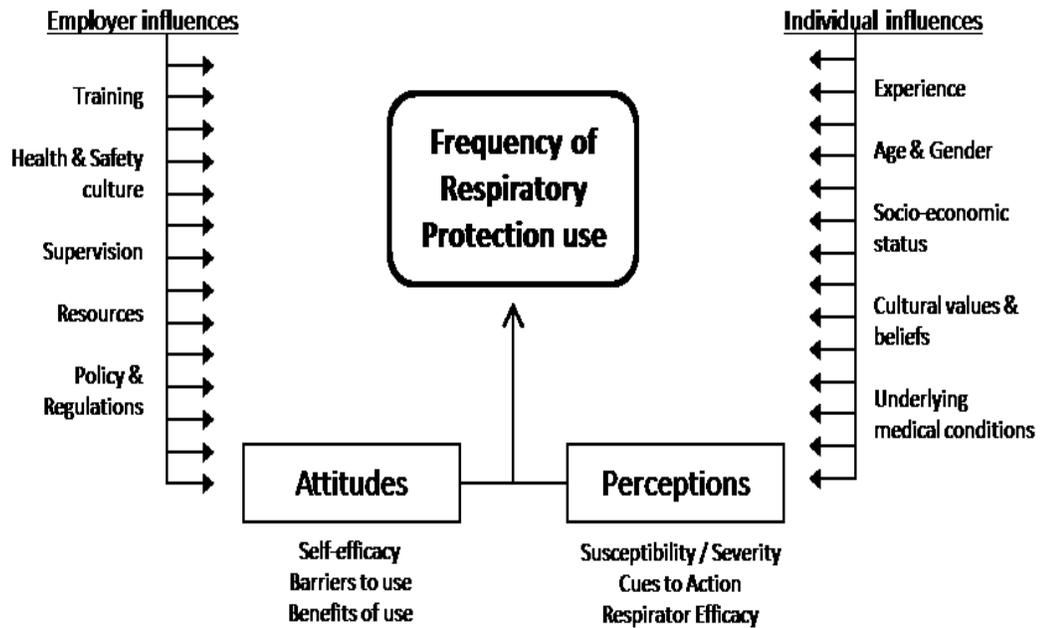


Figure A1: Conceptual framework was adapted from Geer. et al., 2006, postulates that laboratory animal workers' health beliefs are informed by both employer and individual level influences, and that worker's health beliefs inform the regularity with which workers use respirators.

## A2.2 Characteristics of the study population by three categories of DPR use frequency

Table A1: Characteristics of the Study Population by Three Categories of DPR use (n=90)

	Overall n=90	Respiratory Protection Use			p-value
		Non-user (n=41)	Intermittent (n=8)	Consistent (n=41)	
<b>Age (y), mean ±SD</b>	28.9±8.5	29.5±8.6	34±7.9	27.5±8.2	0.07
<b>Sex</b>					
Female	44 (48.9)	18(43.9)	4(50.0)	22(53.6)	0.68
Male	46(51.1)	23(56.1)	4(50.0)	19(46.4)	
<b>Race</b>					
White	85(94.5)	38(92.7)	8(100)	39(95.1)	0.69
Asian	3(3.3)	2(4.9)	-	2(2.4)	
Black	2(2.2)	1(2.4)	-	1(2.4)	
<b>Smoking status</b>					
Never	54(60.7)	23(56.1)	6(75.0)	25(62.5)	0.68
Former	17(19.1)	11(26.8)	1(12.5)	5(12.5)	
Current	18(20.2)	7(17.1)	1(12.5)	10(25.0)	
<b>Education</b>					
High School	18(20.1)	6(14.6)	1(14.3)	11(28.9)	0.21
Some College	23(26.7)	11(26.9)	3(42.8)	9(23.7)	
College Graduate	36(41.8)	17(41.5)	2(28.6)	17(44.7)	
Post Graduate	9(10.5)	7(17.1)	1(14.3)	1(2.6)	
<b>Job Category</b>					
Animal caretaker	64(71.1)	27(65.8)	5(62.5)	32(78.1)	0.42
Scientist	7(7.8)	3(7.3)	2(25.0)	2(4.9)	
Lab. Technician	12(13.3)	6(14.6)	1(12.5)	5(12.2)	
Other*	7(7.8)	5(12.2)	-	2(4.9)	
<b>Time of Survey (months)**</b>					
Re-enrolled, mean ±SD	49.5 ±10.4	49.3 ±11.1	58.0 ±8.2	46.7 ±9.6	0.06
Newly enrolled, mean ±SD	8.1 ±4.5	9.2 ±5.5	6 ±0.0	6.8 ±2.1	0.12
<b>Years of employment</b>					
<b>Less than 2 years</b>	58(53)	48(28)	3(2)	39(23)	0.06
<b>More than 2 years</b>	37(33)	28(9)	18(6)	54(18)	
<b>Mus m 1 Exposure, ng/m<sup>3</sup></b>					
Median (IQR)	18.56 (1.64 – 129.45)	10.54 (0.47 – 117.14)	10.34 (1.64 – 148.38)	29.56 (7.56 – 131.61)	0.39
<b>Allergic History</b>					
Hay fever	25(27.8)	8(19.5)	3(37.5)	14(34.2)	0.28
Asthma: Never	65(73.8)	33(80.5)	7(87.5)	25(64.1)	0.24
Former	11(12.5)	3(7.3)	-	8(20.5)	
Current	12(13.6)	5(12.2)	1(12.5)	6(15.4)	
<b>Atopy</b>					
Total IgE (kU/L), median, (IQR)	18.1 (6.1 – 65.5)	13.4 (5.7 – 35.9)	33.1 (2.6 – 83.5)	28.3 (7.9 – 79.0)	0.48
Atopic (≥1 positive SPT)	55(61.1)	23(56.1)	4(50.0)	28(68.3)	0.42

Survey was distributed during Phase 2 of the cohort. Workers who were re-enrolled from Phase 1 completed the survey during their first Phase 2 visit. Workers who were newly enrolled in Phase 2 completed the survey in either their 1<sup>st</sup> follow-up visit. Kruskal-Wallis test used to determine if there were significant differences between workers who used respiratory protection consistently, intermittently, or not at all.

\*Other jobs include: materials handlers, health and safety officers, etc.

## A2.3 Responses to Individual Questionnaire Items by Health Belief Construct

### i. Susceptibility:

Table A2: Responses to Eight Items used to Measure Susceptibility (n=86)

Participants were asked to complete the statement: “I was offered respiratory protection because of...”

	No DPR use <sup>€</sup> n(%)	DPR use <sup>□</sup> n(%)	p-value <sup>°</sup>
history of allergies			
No	31 (57)	23 (42)	0.004
Yes	8 (25)	24 (75)	
history of asthma			
No	34 (47)	39 (53)	0.59
Yes	5 (39)	8 (62)	
history of COPD			
No	38 (97)	47 (100)	0.27
Yes	1 (3)	-	
history of another medical condition			
No	39 (100)	46 (98)	0.36
Yes	-	1 (2)	
exposure to mouse allergen			
No	12 (31)	7 (15)	0.07
Yes	27 (69)	40 (85)	
exposure to dust			
No	34 (87)	37(79)	0.30
Yes	5 (13)	10 (21)	
exposure to chemicals			
No	35 (90)	45 (96)	0.27
Yes	4 (10)	2 (4)	
exposure to fumes			
No	37 (95)	44 (94)	0.80
Yes	2 (5)	3 (6)	

<sup>€</sup> n=39

<sup>□</sup> n=47

<sup>°</sup> Chi-squared test

## v. Self-Efficacy

Table A3: Associations between the Eight Items used to Measure Self-Efficacy and DPR use (n=86).

Participants were asked to respond to the following statements  
*"I can use a DPR even if....."*

Items:	Disagree n(%)	No opinion n(%)	Agree n(%)	p-value °
I don't know how they work				
No DPR use <sup>€</sup>	9 (82)	8 (47)	22 (38)	0.03
DPR use <sup>□</sup>	2 (18)	9 (53)	36 (62)	
others do not use them				
No DPR use	4 (80)	3 (75)	32 (41)	0.12
DPR use	1 (20)	1 (25)	45 (58)	
others don't think they are necessary				
No DPR use	3 (75)	7 (88)	29 (39)	0.02
DPR use	1 (25)	1 (12)	45 (61)	
I am stressed				
No DPR use	4 (80)	5 (71)	30 (41)	0.08
DPR use	1 (20)	2 (29)	44 (59)	
I am tight on time				
No DPR use	3 (60)	5 (83)	31 (41)	0.11
DPR use	2 (40)	1 (17)	44 (59)	
I have to wear it even for a few hours				
No DPR use	5 (13)	6 (55)	28 (40)	0.03
DPR use	-	5 (45)	42 (60)	
I have to wear it all day				
No DPR use	4 (67)	5 (56)	30 (42)	0.42
DPR use	2 (33)	4 (44)	41 (58)	
it is hot				
No DPR use	5 (50)	6 (86)	28 (41)	0.07
DPR use	5 (50)	1 (14)	41 (59)	

<sup>€</sup> n=39

<sup>□</sup> n=47

<sup>°</sup> Chi-squared test

### iii. Cues to Action

Table A4: Association between the Four Items used to Measure Cues to Action and DPR use (n=86)

Workers were asked to complete the following statements:

Items:	Disagree n(%)	No opinion n(%)	Agree n(%)	p-value <sup>o</sup>	
My supervisor wants me to always use a DPR					
No DPR use <sup>ε</sup>	7 (88)	5 (33)	27 (43)	0.03	
DPR use <sup>□</sup>	1 (13)	10 (67)	36 (57)		
My co-workers want me to always use a DPR					
No DPR use	6 (86)	13(37)	20 (47)	0.06	
DPR use	1 (14)	22 (63)	23 (53)		
I know if my co-workers use DPRs		No	Yes		
No DPR use		3 (43)	36 (46)	0.89	
DPR use		4 (57)	43 (54)		
My co-workers use DPRs <sup>§</sup>		Never	Sometimes	Always	
No DPR use		9 (50)	3 (43)	24 (45)	0.93
DPR use		9 (50)	4 (57)	29 (55)	

<sup>ε</sup> n=39

<sup>□</sup> n=47

<sup>o</sup> chi-squared test

<sup>§</sup>n=79

#### iv. Barriers to Use

Table A5: Associations between the Six Items used to Measure Barriers to use and DPR use (n=86).

Participants were asked to respond to the following statements:  
*“if I always use a DPR ...”*

Items	SA n(%)	A n(%)	N n(%)	D n(%)	SD n(%)	p-value <sup>o</sup>
I will be less productive						
No DPR use <sup>e</sup>	-	3(38)	8(53)	13(32)	15(68)	0.07
DPR use <sup>a</sup>	1(100)	5(62)	7(47)	27(68)	7(32)	
my work will be harder						
No DPR use	-	4(36)	9(56)	11(31)	15(65)	0.08
DPR use	1(100)	7(63)	7(44)	24(69)	8(35)	
my job will be less satisfying						
No DPR use	2(67)	2(40)	11(50)	12(35)	12(55)	0.57
DPR use	1(33)	3(60)	11(50)	22(65)	10(45)	
my co-workers will respect me less						
No DPR use	1(50)	2(100)	5(50)	12(32)	19(56)	0.14
DPR use	1(50)	-	5(50)	26(68)	15(44)	
my supervisor will think I'm being difficult						
No DPR use	1(50)	-	4(57)	10(29)	24(59)	0.09
DPR use	1(50)	1(100)	3(43)	25(71)	17(41)	
I will annoy my co-workers						
No DPR use	1(50)	-	5(56)	8(27)	25(57)	0.10
DPR use	1(50)	1(100)	4(44)	22(73)	19(43)	

<sup>e</sup> n=39      <sup>a</sup> n=47      <sup>o</sup> Chi-squared tests

SA= Strongly Agree

A=Agree

N=No Opinion

D=Disagree

SD= Strongly Disagree

## v. Benefits of Use

Table A6: Associations between the Eight Items used to Measure Benefits of DPR use and DPR use (n=86)

Participants were asked to responds to the following statements: “If I always use a DPR I will...”

Items:		Disagree n(%)	No opinion n(%)	Agree n(%)	p-value °
miss fewer days of work	No DPR use <sup>€</sup>	8(47)	19(41)	12(52)	0.68
	DPR use <sup>□</sup>	9(53)	27(59)	11(48)	
be more respected by my co-workers	No DPR use	14(56)	18(41)	7(41)	0.45
	DPR use	11(44)	26(59)	10(59)	
be in compliance with laboratory regulations	No DPR use	5(83)	6(46)	28(42)	0.15
	DPR use	1(17)	7(54)	39(58)	
I will be more appreciated by my supervisor	No DPR use	11(50)	15(43)	13(45)	0.89
	DPR use	11(50)	20(57)	16(55)	
my job will be more satisfying	No DPR use	12(50)	10(33)	17(53)	0.25
	DPR use	12(50)	20(67)	15(47)	
my job will be more productive	No DPR use	13(48)	11(39)	15(50)	0.61
	DPR use	14(52)	18(62)	15(50)	
		Not at all	Somewhat	A Lot	
I will benefit from using a DPR...	No DPR use	11(73)	7(30)	21(45)	0.03
	DPR use	4(27)	16(69)	26(55)	

<sup>€</sup>n=39

<sup>□</sup>n=47

<sup>°</sup> Chi-squared test

## A2.4 Predictors of Individual Health Belief Constructs

### i. Susceptibility:

Table A7: Associations between Covariates of Interest and Susceptibility<sup>ε</sup> (n=86)

Covariate	Coefficient	95%CI
Population <sup>ο</sup>	0.23	(-0.19 - 0.66)
Year <sup>δ</sup>	-0.09	(-0.25 - 0.08)
Age	-0.02	(-0.04 - 0.01)
sex	0.04	(-0.38 - 0.46)
Job:		
Researcher	-0.31	(-1.01 - 0.46)
Lab tech	0.15	(-0.46 - 0.77)
Education		
2	-0.22	(-0.84 - 0.41)
3	-0.22	(-0.78 - 0.35)
4	-0.72	(-1.52 - 0.07)
Quartiles of exposure		
2	-0.18	(-0.77 - 0.41)
3	0.37	(-0.22 - 0.96)
4	0.57	(-0.04 - 1.18)
Time spent Handling Mice		
1-2 days / week	-0.15	(-1.45 - 1.150)
3-4 days/week	0.76	(-0.41 - 1.94)
5 or more days/week	0.20	(-0.70 - 1.10)
Asthma		
former	<b>0.81</b>	<b>(0.23 - 1.39)</b>
current	<b>1.05</b>	<b>(0.49 - 1.61)*</b>
Atopic	<b>0.62</b>	<b>(0.18 - 1.02)*</b>
Smoker		
former	-0.39	(-0.95 - 0.16)
current	-0.04	(-0.57 - 0.49)

<sup>ε</sup> Univariate regression was used to determine if covariates of interest were associated with participants scores on the summated scale for perceived susceptibility      Bold=p<0.05      \* p<0.005

<sup>ο</sup> Re-enrolled from JAX1Cohort, or newly recruited to JAX2Cohort

<sup>δ</sup> Number of years of working at facility prior to completing questionnaire

## ii. Self-efficacy

Table A8: Associations between Covariates of Interest and Self-Efficacy<sup>€</sup> (n=86)

Covariate	Coefficient	95%CI
<b>Population</b>	<b>3.25</b>	<b>(0.97 – 5.54)</b>
<b>Years of employment</b>	<b>-1.11</b>	<b>(-1.97 - -0.24)</b>
Age	-0.40	(-0.18 -0.09)
Sex	-0.01	(-2.33 – 2.32)
Job:		
Researcher	-2.71	(-6.97 – 1.54)
Lab tech	2.05	(-1.32 – 5.42)
Educational level		
HS	1.35	(-2.02 – 4.73)
College	0.12	(-2.94 – 3.18)
Post-college	-3.50	(-7.79 – 0.79)
Quartiles of exposure		
2	-1.23	(-4.71 – 2.34)
3	0.67	(-2.81 – 4.13)
4	1.47	(-2.14 – 5.11)
Time spent Handling Mice		
1-2 days / week	-0.85	(-8.27 – 6.57)
3-4 days/week	-1.76	(-8.47 – 4.93)
5 or more days/week	1.21	(-3.9 – 6.35)
Asthma		
former	3.15	(-0.35 – 6.64)
current	1.23	(-2.14 – 4.59)
Atopic	0.54	(-1.86 – 2.94)
Smoker		
former	-0.27	(-3.39 – 2.84)
current	1.00	(-1.97 – 3.98)

<sup>€</sup> Univariate regression was used to determine if covariates of interest were associated with participants scores on the summated scale for perceived self-efficacy      Bold=p<0.05      \* p<0.005

<sup>°</sup> Re-enrolled from JAX1Cohort, or newly recruited to JAX2Cohort

<sup>€</sup> Number of years of working at facility prior to completing questionnaire

### iii. Cues to Action to use DPR

Table A9: Associations between Covariates of Interest and Cues to Action<sup>ε</sup> (n=86)

Covariate	Coefficient	95%CI
Population <sup>ο</sup>	<b>2.61</b>	<b>(1.27 – 3.96)</b>
Year <sup>ε</sup>	<b>-0.93</b>	<b>(-1.44 – -0.42)</b>
Age	-0.05	(-0.13 – 0.04)
Sex	-0.59	(-2.02 – 0.83)
Job:		
Researcher	<b>-4.71</b>	<b>(-7.22 - -2.21)*</b>
Lab tech	0.61	(-1.32 – 2.52)
Education		
HS	-0.32	(-2.36 – 1.75)
College	0.13	(-1.71 – 1.95)
Post-college	<b>-3.68</b>	<b>(-6.27 - -1.09)*</b>
Quartiles of exposure		
2	1.69	(-0.29 – 3.67)
3	<b>3.33</b>	<b>(1.32 – 5.35)*</b>
4	<b>2.72</b>	<b>(0.61 – 4.83)</b>
Time spent Handling Mice		
1-2 days / week	-3.66	(-8.15 – 0.82)
3-4 days/week	-2.60	(-6.53 – 1.33)
5 or more days/week	1.47	(-1.55 – 4.49)
Asthma		
former	<b>2.57</b>	<b>(0.48 – 4.68)</b>
current	0.87	(-1.22 – 2.97)
Atopic	<b>2.06</b>	<b>(0.65 – 3.45)*</b>
Smoker		
former	0.44	(-1.49 – 2.38)
current	-0.56	(-2.36 – 1.24)

<sup>ε</sup> Univariate regression was used to determine if covariates of interest were associated with participants scores on the summated scale for perceived cues to action      Bold=p<0.05      \* p<0.005

<sup>ο</sup> Re-enrolled from JAX1Cohort, or newly recruited to JAX2Cohort

<sup>ε</sup> Number of years of working at facility prior to completing questionnaire

iv. Barriers to Use

Table A10: Associations between Covariates of Interest and Barriers to Use<sup>ε</sup> (n=86)

Covariate	Coefficient	95%CI
Population	0.48	(-1.56 – 2.54)
Year <sup>δ</sup>	-0.18	(-0.95 – 0.59)
Age	-0.07	(-0.18 – 0.04)
Sex	<b>-2.82</b>	<b>(-4.73 - -0.91)*</b>
Job:		
Researcher	-0.36	(-4.01 – 3.35)
Lab tech	1.01	(-1.87 – 4.01)
Education		
HS	-0.33	(-3.37 – 2.71)
College	-0.09	(-2.86 – 2.66)
Post-college	-1.00	(-4.87 – 2.86)
Quartiles of exposure		
2	-0.47	(-3.32 – 2.35)
3	0.22	(-2.61 – 3.05)
4	0.45	(-2.51 – 3.41)
Time spent Handling Mice		
1-2 days / week	4.35	(-2.02 – 10.71)
3-4 days/week	1.26	(-4.48 – 7.01)
5 or more days/week	1.76	(-2.65 – 6.16)
Asthma		
former	-0.39	(-3.47 – 2.67)
current	-0.31	(-3.27 – 2.65)
Atopic	-0.41	(-2.48 – 1.65)
Smoker		
former	0.44	(-2.25 – 3.12)
current	0.89	(-1.67 – 3.46)

<sup>ε</sup> Univariate regression was used to determine if covariates of interest were associated with participants scores on the summated scale for perceived barrier to use      Bold=p<0.05      \* p<0.005

<sup>δ</sup> Re-enrolled from JAX1Cohort, or newly recruited to JAX2Cohort

<sup>ε</sup> Number of years of working at facility prior to completing questionnaire

## v. Benefits of Use

Table A11: Associations between Covariates of Interest and Benefits of use<sup>ε</sup>  
(n=86)

Covariate	Coefficient	95%CI
Population <sup>o</sup>	<b>4.28</b>	<b>(2.09 – 6.47)*</b>
Year <sup>ε</sup>	<b>-1.36</b>	<b>(-2.21 - -0.51)*</b>
Age	-0.11	(-0.24 – 0.03)
Sex	-1.45	(-3.76 – 0.84)
Job:		
Researcher	-3.13	(-7.29 – 1.06)
Lab tech	0.65	(-2.65 – 3.95)
Education		
HS	-1.77	(-5.29 – 1.75)
College	-1.45	(-4.65 – 1.73)
Post-college	-3.06	(-7.53 – 1.42)
Quartiles of exposure		
2	-0.46	(-3.95 – 3.04)
3	1.14	(-2.5 – 4.64)
4	1.09	(-2.55 – 4.75)
Time spent Handling Mice		
1-2 days / week	-4.15	(-11.26 – 2.96)
3-4 days/week	-0.40	(-6.82 – 6.02)
5 or more days/week	1.22	(-3.71 – 6.14)
Asthma		
former	2.56	(-0.93 – 6.06)
current	1.11	(-2.25 – 4.48)
Atopic	<b>2.83</b>	<b>(0.51 – 5.14)</b>
Smoker		
former	-0.42	(-3.51 – 2.68)
current	0.19	(-2.76 – 3.16)

<sup>ε</sup> Univariate regression was used to determine if covariates of interest were associated with participants scores on the summated scale for perceived benefits of use

Bold=p<0.05      \* p<0.005

<sup>o</sup> Re-enrolled from JAX1Cohort, or newly recruited to JAX2Cohort

<sup>ε</sup> Number of years of working at facility prior to completing questionnaire

## A2.5 Correlation Matrix for Health Belief Constructs

Table A12: Bi-variate correlations ( $r^2$ ) between DPR use and the health belief constructs used to evaluate if each construct could be included in the model<sup>‡</sup> (n=86).

	DPR Use	Susceptibility	Self-Efficacy	Cues to Action	Barriers to use
Susceptibility	0.30				
Self-efficacy	0.08	-0.12			
Cues to Action	0.17	-0.12	-0.03		
Barriers to use	-0.22	-0.05	0.32	0.09	
Benefits of use	0.08	0.16	0.11	0.44	0.41

<sup>‡</sup>Correlations between health belief constructs were evaluated using their summated scale scores.

## A2.6 Effect Modification

Table A13: Likelihood ratio testing to determine if cues to action acts as an effect modifier of the associations between each of the other four health belief constructs and DPR use (n=86).

Interaction term		Likelihood ratio test result <sup>§</sup>
Susceptibility	* Cues to Action	0.29
Self-Efficacy	* Cues to Action	0.11
Barriers to use	* Cues to Action	0.69
Benefits of use	* Cues to Action	0.89

Interaction terms were generated for each pair (i.e. Susceptibility and Cues to Action). Model 2 was re-fit using each additional term. Change in the magnitude and direction of the covariate coefficients as well as likelihood ratio testing were used to determine if there was evidence of effect modification.

<sup>§</sup>a significant test result would have been  $p > 0.05$

## A2.7 Sensitivity Analysis

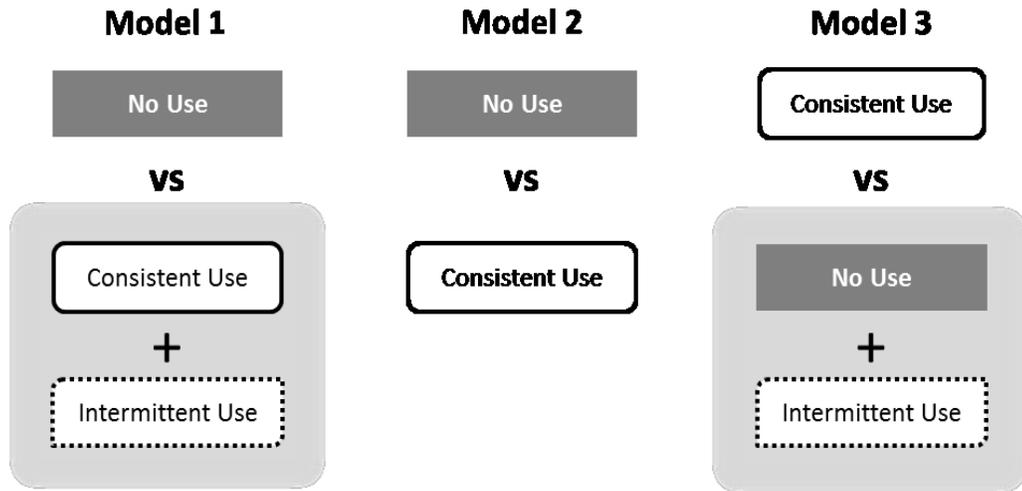


Figure A2: Diagram of the three different ways in which the DPR use variable was constructed, and then used in sensitivity analysis (Table A14).

Table A14: Comparison of Multivariate Logistic Regression Models using three different DPR-use Variables.

	<b>Model 1</b>				<b>Model 2</b>		<b>Model 3</b>	
	Unadjusted		Adjusted		Adjusted		Adjusted	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Susceptibility	<b>3.7</b>	<b>(1.39 – 10.04)</b>	<b>11.3</b>	<b>(2.26 – 56.32)*</b>	<b>16.8</b>	<b>(2.83 – 100.02)*</b>	<b>11.8</b>	<b>(2.68 – 52.22)*</b>
Self-efficacy	2.7	(0.95 – 7.78)	<b>5.8</b>	<b>(1.17 – 28.70)</b>	4.7	(0.86 – 24.74)	1.7	(0.45 – 6.03)
Cues to Action	1.	5.44)	5.3	(0.90 – 31.27)	<b>8.3</b>	<b>(1.24 – 54.76)</b>	<b>10.7</b>	<b>(1.94 – 59.5)</b>
Barriers to use	<b>0.</b>	<b>0.67)</b>	<b>0.1</b>	<b>(0.01 – 0.78)</b>	<b>0.1</b>	<b>(0.01 – 0.89)</b>	0.3	(0.06 – 1.81)
Benefits of use	1.	5.08)	6.8	(0.81 – 56.73)	10.3	(0.84 – 125.48)	2.2	(0.36 – 12.94)

Model 1: Intermittent DPR use workers who did not use DPRs health beliefs of participants who did not use DPRs were included in the “No Users” group. Model 2: Intermittent DPR users were excluded from the analysis. The consistently used DPRs were compared to participants who did not use DPRs (n=78). Model 3: Intermittent DPR users were included in the “No Users” group. Consistent DPR users were compared to participants who reported not using DPR (n=86). Models were adjusted for year of survey completion, calendar year of survey completion, type of job, number of days a week handling mice, age and gender. Bold= p<0.05

Model 1: Intermittent DPR use workers who did not use DPRs health beliefs of participants who did not use DPRs were included in the “No Users” group. Model 2: Intermittent DPR users were excluded from the analysis. The consistently used DPRs were compared to participants who did not use DPRs (n=78). Model 3: Intermittent DPR users were included in the “No Users” group. Consistent DPR users were compared to participants who reported not using DPR (n=86). Models were adjusted for year of survey completion, calendar year of survey completion, type of job, number of days a week handling mice, age and gender. Bold= p<0.05

## A2.8 Health Belief Questionnaire

## Appendix 2.9



### Follow Up Respiratory Protection Questionnaire JAX Cohort 2

Form: CV DCF 006

Participant ID#: J A X 2

Date: / /  
M M D D Y Y Y Y

VISIT:

6 mth  12 mth  18 mth  24 mth  30 mth  36 mth  42 mth  48 mth  54 mth  60 mth

**For participants not previously offered a respirator (as documented on a previous RP questionnaire at previous visits):**

1. Have you been offered a respirator to use when working with or around mice by T.J.L. health and/or safety staff? (includes a NIOSH-approved disposable respirator or a HEPA filtered PAPR; does not include a surgical mask).

yes *If Yes, when* /  
 no M M Y Y Y Y

2. Have you been fit tested for a respirator since starting work at TJL?

yes *If Yes, when* / and which one are you using?  
M M Y Y Y Y

- Power air-purifying respirator (Hood)
- Kimberly Clark
- 9210 (3M)
- Other, specify:

no *If No: Have you chosen, on your own, to wear a respirator?*

yes, since when /  
M M Y Y Y Y  
 no

3. Which statements best describe your understanding of why you were offered a respirator (select all that apply):

3a. I was offered a respirator because I am exposed to (select all that apply):

- Fumes
- Dust
- Chemicals
- Mouse allergen
- Other, specify:

3b. I was offered a respirator because I have (select all that apply):

- Asthma
- COPD or emphysema or chronic bronchitis
- Allergies
- Other medical condition, specify:
- Other reasons, specify:

**For participants previously offered a respirator (as documented on a previous RP questionnaire or on this questionnaire):**

4. Which statement best describes what you think about the benefits of using a respirator?

- a.  Using a respirator will not be beneficial to me.
- b.  Using a respirator will be slightly beneficial to me.
- c.  Using a respirator will be somewhat beneficial to me.
- d.  Using a respirator will be very beneficial to me.
- e.  Using a respirator will be extremely beneficial to me.

[IF SELECT b-e FOR (4), THEN GO ONTO (5) BELOW]

5. Which statements best describe what you believe is the benefit of using a respirator (select all that apply)?

- The respirator will keep my asthma from flaring at work
- The respirator will keep my allergies from flaring at work
- The respirator will keep my asthma from getting worse over time.
- The respirator will keep my allergies from getting worse over time.
- The respirator will prevent me from developing asthma.
- The respirator will prevent me from developing mouse allergy.
- Other:
- None of the above

6. How often do you use a respirator when working with or near mice?

- Always   
  Usually   
  Sometimes   
  Rarely   
  Never

**Social and Behavioral Determinants of Respirator Use**

**I. Self-Efficacy in Respiratory Protection Use**

*These next questions are about how confident you are that you use a respirator. There are no right or wrong answers. This is not a test. Choose the answer that is most true for you. Your answers will be kept strictly as a part of study records, not your employee records or health office records.*

	Strongly Disagree	Disagree	No Opinion	Agree	Strongly Agree
1. I am sure I am able to use a respirator even through I do not know a lot about how a respirator works.	<input type="radio"/>				
2. I am sure I am able to use a respirator even when others do not use respirators.	<input type="radio"/>				
3. I am sure that I am able to always use a respirator even when my co-workers disagree that a respirator is necessary.	<input type="radio"/>				
4. I am sure I am able to always use a respirator even when it is very hot.	<input type="radio"/>				
5. I am sure I am able to always use a respirator even when I am stressed at work.	<input type="radio"/>				
6. I am sure I am able to always use a respirator even if I am pressed for time.	<input type="radio"/>				
7. I am sure I am able to use a respirator even when there is not enough time to put the respirator on.	<input type="radio"/>				
8. I am sure I am able to use a respirator because my co-workers also use respirators.	<input type="radio"/>				
9. I am sure I am able to use a respirator even though I know that the respirator must be used all day long.	<input type="radio"/>				
10. I am sure I am able to always use a respirator even if it only needs to be used for a few hours each day.	<input type="radio"/>				

## II. Social Support

These next questions are about how you think that the people around you view respirators. There are no right or wrong answers. This is not a test. Choose the answer that is most true for you. Your answers will be kept strictly as part of study records, not your employee records or health office records.

1. How often do your co-workers use respirators at work?
  - Always (every day)
  - Most of the time (3 or 4 days a week)
  - Sometimes (1 or 2 days a week)
  - Rarely (less than once per week)
  - Never
  - Don't know
2. My spouse/parent/significant other wants me to always use a respirator.
  - Definitely YES
  - Yes
  - No opinion
  - No
  - Definitely NO
3. My supervisor wants me to always use a respirator.
  - Definitely YES
  - Yes
  - No opinion
  - No
  - Definitely NO
4. My co-workers want me to always use a respirator.
  - Definitely YES
  - Yes
  - No opinion
  - No
  - Definitely NO

## III. Health Beliefs of Using Respiratory Protection Equipment

Please tell me how much you agree or disagree with each of these sentences. There are no right or wrong answers. Your answers will be kept as part of study records, not your employee records or health office records. We are just interested in your opinion.

Positive Consequences	Strongly Disagree	Disagree	No Opinion	Agree	Strongly Agree
1. If I always use a respirator, my work site becomes safer and I will not develop allergies to mice.	<input type="radio"/>				
2. If I always use a respirator, I will miss fewer days of work.	<input type="radio"/>				
3. If I always use a respirator, I will get more respect from my co-workers.	<input type="radio"/>				
4. If I always use a respirator, I will be working in accordance with laboratory regulations.	<input type="radio"/>				
5. If I always use a respirator, I will be more appreciated by my supervisor.	<input type="radio"/>				
6. If I always use a respirator, I will have more job satisfaction.	<input type="radio"/>				
7. If I always use a respirator, I will be more productive.	<input type="radio"/>				

	Strongly Disagree	Disagree	No Opinion	Agree	Strongly Agree
<b>Negative Consequences</b>					
8. If I always use a respirator, I will have lower productivity.	<input type="radio"/>				
9. If I always use a respirator, my work becomes more difficult.	<input type="radio"/>				
10. If I always use a respirator, I am less satisfied with my job.	<input type="radio"/>				
11. If I always use a respirator, my co-workers will make fun of me.	<input type="radio"/>				
12. If I always use a respirator, my supervisor will think that I am being difficult.	<input type="radio"/>				
13. If I always use a respirator, I will be annoying to my co-workers.	<input type="radio"/>				

## Appendix 3: Supplemental Materials for Manuscript 2

### Additional data collection

Under specific aim 2 workers' blood was tested for the presence of mouse-specific IgG<sub>1-3</sub>, and mouse-specific IgG<sub>4</sub> as markers of exposure to mouse allergen. Cox proportionate hazard models were used to evaluate the association between DPR use and risk for exposure. According to these models there was no significant difference in risk for developing either marker of exposure. When consistent users were compared to all other users there appeared to be a reduction in risk, however, it was not significant.

#### *Detection of Mouse-specific IgG1-3, IgG4:*

In order to measure mouse-specific IgGs in serum venipuncture was performed to collect blood at baseline and in six month intervals thereafter. Solid phase antigen binding assays were used to detect mouse-specific IgG1-4 according to the protocol described in Peng et al, 2011. RAST was used to determine if a participant had developed mouse-specific IgG4, in keeping with the methods described in Matsui et al., 2005 and Peng et al., 2011. A positive solid phase antigen binding result for IgG1-4 was defined as 20AU/ml, whereas a positive RAST result for IgG4 was defined as 15AU/ml<sup>14,55,119</sup>. If a participant had a positive solid-phase antigen binding result, but a negative RAST result, they were considered to have developed mouse-specific IgG1-3, but not IgG4<sup>14,55,119</sup>. Mouse specific IgG1-3 and IgG4 were measured as biomarkers of exposure in order determine the associations between different frequencies of DPR use and risk for exposure

10,49,52,53,62,80,110,112,119,120,184

### Additional statistical analysis

Summary statistics and incidence rates for outcomes of interest were calculated for each phase of the cohort. In addition, Cox proportionate hazard models were used to estimate the relationships between DPR use and risk for the outcomes of interest for each phase. Student's t-test for independent samples was used in order to determine if there were differences between the populations in each phase. The same statistics and models were used to explore and analyze the data of the final population. This information is presented in the following order:

### A3.1 Analysis of Data Collected in Phase 1 of the JAXCohort

#### i. Phase 1 Population Characteristics

Table A15: Phase 1: Characteristics of the Population: (n=124)

	Respiratory Protection Use				p-value
	Overall n=124 n(%)	Non-user (n=45) n(%)	Intermittent (n=15) n(%)	Consistent (n=42) n(%)	
<b>Follow-up time</b> (mo), median (IQR) <sup>§</sup>	24(12-48)	24(12-48)	36(24-60)	18(12-48)	0.37
<b>Age</b> (y), mean ±SD	31.3±9.7	30.4±10.8	28.9±8.3	30.8±9.3	0.51
<b>Sex</b>					
Female	70 (68.8)	26(57.7)	13(86.6)	31(73.8)	0.07
Male	32(31.1)	19(42.2)	2(23.3)	11(26.2)	
<b>Race</b>					
White	95(90.1)	40(88.8)	15(100)	40(95.2)	0.27
Asian	4(5.7)	3(6.6)	-	1(2.3)	
Other*	3(3.2)	2(4.4)	-	1(2.3)	
<b>Smoking status</b>					
Never	54(51.2)	21(46.7)	10(66.6)	23(54.7)	0.23
Former	19(19.0)	9(20.0)	4(26.6)	6(14.3)	
Current	29(29.8)	15(33.3)	1(6.6)	13(30.1)	
<b>Job Category</b>					
Animal caretaker	67(63.9)	25(55.5)	7(46.6)	35(83.3)	<0.01
Scientist	18(19.7)	10(22.2)	4(26.6)	4(9.5)	
Lab. Technician	17(22.2)	10(22.2)	4(26.6)	3(7.1)	
<b>Mus m 1 Exposure, ng/m<sup>3</sup></b>					
Median (IQR)	7.8 (1.2-16.3)	5.9 (1.2-16.1)	3.0 (0.9-10.7)	10.0 (4.8-19.6)	0.04
<b>Allergic History</b>					
Hay fever	13(31.2)	2(4.4)	3(20.0)	5(11.9)	0.18
Asthma: Never	84(83.6)	43(95.6)	10(66.7)	31(73.8)	<0.01
Former	11(9.8)	1(2.2)	3(20.0)	7(16.7)	
Current	7(6.5)	1(2.2)	2(13.4)	4(9.5)	
<b>Atopy</b>					
Total IgE (kU/L), median, (IQR)	9.7 (5.2-15.7)	16.2 (4.7-35.8)	15.2 (5.0-43.6)	12.8 (5.4-25.2)	0.21
Atopic (≥1 positive SPT)	56(53.3)	15(33.3)	11(73.3)	30(71.4)	<0.01
<b>Skin Test Sensitivity</b>					
Dust mite	40(35.3)	10(22.2)	8(53.3)	22(52.4)	<0.01
Pollen	35(34.4)	8(17.8)	9(60.0)	18(42.8)	<0.01
Mold	8(8.2)	1(2.2)	3(20.0)	4(9.5)	0.08
Cat	11(13.1)	3(6.7)	3(20.0)	5(11.9)	0.34
Dog	2(1.8)	-	1(7.1)	1(2.3)	0.24

Workers compared across categories of self-reported respiratory protection use at 6 months.

<sup>§</sup>IQR= Interquartile range (25% -75%)

\*Other race: Hispanic, black, Native American, East Indian

## ii. Risk of Outcomes of Interest for Phase 1 of the JAXCohort

Table A16: Phase 1: Cox Proportional Hazards Models of the Associations between DPR use and Outcomes of Interest (n=124)

Outcome	DPR Use	Crude HR (95% CI)	Adjusted HR (95% CI)
Mus m 1-specific IgG <sub>1-3</sub>	Never	-ref-	-ref-
	Intermittent	2.8(0.79-9.96)	3.2(0.67-15.57)
	Consistent	0.6(0.18-2.06)	0.4(0.08-1.71)
Mus m 1-specific IgG <sub>4</sub>	Never	-ref-	-ref-
	Intermittent	1.0(0.12-9.03)	1.1(0.09-11.92)
	Consistent	1.3(0.41-4.12)	1.2(0.27-5.03)
Mouse-specific SPT+	Never	-ref-	-ref-
	Intermittent	<b>4.8(1.51-15.32)</b>	2.2 (0.59-7.76)
	Consistent	1.7(0.66-4.61)	1.1 (0.33-3.85)
Mus m 1-specific IgE	Never	-ref-	-ref-
	Intermittent	<b>10.4(1.63-66.77)</b>	5.1(0.61-42.95)
	Consistent	1.5(0.25-9.26)	0.5(0.05-4.43)
Any Mouse- Related Respiratory Symptom <sup>§</sup>	Never	-ref-	-ref-
	Intermittent	1.0(0.28-3.57)	0.9(0.23-3.84)
	Consistent	1.4(0.69-2.97)	1.4(0.51-3.59)
Mouse-Related Rhinoconjunctival Symptoms <sup>§</sup>	Never	-ref-	-ref-
	Intermittent	1.1(0.31-4.01)	1.1(0.25-4.37)
	Consistent	1.4(0.64-2.94)	1.3(0.47-3.72)
Mouse-Related Lower Respiratory Symptoms <sup>§</sup>	Never	-ref-	-ref-
	Intermittent	0.7(0.15-2.96)	0.6(0.11-2.95)
	Consistent	1.2(0.56-2.54)	0.9(0.32-2.56)
Laboratory Animal Allergy <sup>§€</sup>	Never	-ref-	-ref-
	Intermittent	5.3(0.67-41.30)	1.8(0.17-17.72)
	Consistent	1.9(0.32-11.69)	1.4(0.17-11.95)

Models were adjusted for: gender, age, atopy, mean log Mus m 1 exposure and job type.

Bold indicates a significant ( $p \leq .05$ ) <sup>§</sup>Modeled using a lagged DPR use variable

<sup>€</sup>Also controlled for smoking and asthma

### iii. Phase 1: Incidence Rates of Outcomes of Interest

Table A17: Phase 1: Incidence Rates for Outcomes of Interest (n=124)

	Overall (n=124)	Respiratory Protection Use			p-value
		Never (n=48)	Intermittent (n=35)	Consistent (n=41)	
Mus m 1-specific IgG <sub>1-3</sub>	96.9	122	320	67	0.08
Mus m 1-specific IgG <sub>4</sub>	69.8	80.3	76.9	96.7	0.23
Mouse-specific SPT+	129.5	95.2	5333.3	168.1	<0.00
Mus m 1-specific IgE	38.6	24.8	226.4	46.5	<0.00
Any Symptom	172.6	147.4	153.8	207.3	0.34
Respiratory Symptoms	165	133.3	153.8	206.1	0.27
Rhinoconjunctivitis	147.8	122.5	150.0	177.5	0.41
Lower Respiratory	143.9	132.6	97.6	169.7	0.20
Laboratory Animal Allergy	32.6	19.2	93.0	33.9	0.07
Dermal symptoms	32.3	19.6	44.4	43.7	0.19

Respiratory protection use categories are average use, not time dependent. Rates were calculated per 1000 worker years.

## A3.2 Analysis of Data Collected in Phase 2 of the JAXCohort

### i. Characteristics of the Phase 2 JAXCohort Population

Table A18: Phase 2: Characteristics of the Population, (n=98)

	Overall	Respiratory Protection Use			p-value
		Non-user	Intermittent	Consistent	
	n=96 n(%)	(n=71) n(%)	(n=1) n(%)	(n=24) n(%)	
<b>Follow-up time</b> (mo), median (IQR) §	18(6-24)	18(6-24)	12	18(12-24)	0.55
<b>Age</b> (y), mean ±SD	29.5±7.6	29.8±7.8	45.5	27.6±6.1	0.18
<b>Sex</b>					
Female	42(43.8)	34(47.8)	-	8(33.3)	0.31
Male	54(56.1)	37(52.1)	1(100.0)	16(66.7)	
<b>Race</b>					
White	84(87.8)	60(84.3)	1(100.0)	23(95.5)	0.33
Other*	12(12.2)	11(15.7)	-	1(4.5)	
<b>Smoking status</b>					
Never smoker	59(61.2)	47(66.2)	1(100.0)	11(45.8)	0.14
Former smoker	22(22.5)	15(21.3)	-	7(29.2)	
Current smoker	15(16.3)	9(12.7)	-	6(25.0)	
<b>Job Category</b>					
Animal caretaker	68(71.4)	44(61.9)	1(100.0)	23(95.8)	<0.01
Scientist	15(15.3)	14(19.7)	-	1(4.2)	
Lab. Technician	13(13.3)	13(18.3)	-	-	
<b>Muscle Exposure</b>					
Median (ng/m <sup>3</sup> ) (IQR)	28.86 (1.1-180.0)	10.50 (0.2- 158.9)	115.28 (21.4 – 280.6)	41.72 (8.5-245.3)	0.09
<b>Allergic History</b>					0.02
Hay fever	31(31.6)	17(23.9)	-	13(54.2)	<0.01
Asthma: Never	78(82.5)	64(95.1)	1(100.0)	13(54.2)	
Former	8(8.3)	2(2.8)	-	6(25.0)	
Current	9(9.3)	4(5.7)	-	5(20.8)	
<b>Atopy</b>					
Total IgE (kU/L), median, (IQR)	27.8 (11.6 - 86.1)	24.7 (11.7 - 96.9)	5.5 -	39.5 (11.9 - 86.1)	0.31
Atopic (≥1 positive SPT)	70(71.4)	53(74.7)	-	17(70.8)	0.24
<b>Skin Test Sensitivity</b>					
Dust mite	52(53.1)	36(50.7)	-	16(66.7)	0.22
Pollen	35(35.7)	26(33.8)	-	9(29.4)	0.81
Mold	16(16.3)	12(36.6)	-	4(37.5)	0.75
Cat	12(14.3)	9(12.7)	-	3(12.5)	0.93
Dog	2(2.2)	1(1.4)	-	1(4.5)	0.68

Workers compared across categories of self-reported respiratory protection use at 6 months.

§IQR= Interquartile range (25% -75%)

\*Other race: Hispanic, black, Native American, East Indian

ii. Risk for Outcomes of Interest for Phase 2 of the JAXCohort

Table A19: Cox Proportional Hazards models of the Associations between DPR use and Risk for Developing Outcomes of Interest (n=98).

Outcome	DPR Use	Crude HR (95% CI)	Adjusted HR (95% CI)
Mus m 1-specific IgG <sub>1-3</sub>	Never Consistent <sup>‡</sup>	-ref- 1.2(0.66-2.29)	-ref- 1.2(0.59-2.36)
Mus m 1-specific IgG <sub>4</sub>	Never Intermittent Consistent	-ref- 5.0(0.59-41.89) 0.4(0.04-3.03)	-ref- 5.6(0.56-55.41) <sup>□</sup> 0.3(0.03-2.59) <sup>□</sup>
Mouse-specific SPT+	Never Intermittent Consistent	-ref- <b>8.9(1.37-57.39)</b> 3.4(0.93-13.02)	-ref- <b>19.7(2.03-190.31)</b> 4.1(0.87-19.35)
Mus m 1-specific IgE	Never Intermittent Consistent	-ref- 5.8(0.59-56.30) 1.8(0.29-10.73)	-ref- 5.6(0.5-64.44) 1.9(0.28-12.77)
Any Mouse- Related Respiratory Symptom <sup>§</sup>	Never Intermittent Consistent	-ref- 2.7(0.36-20.05) 1.4(0.68-2.81)	-ref- 9.3(0.78-110.88) 0.64(0.25-1.57)
Mouse-Related Rhinoconjunctival Symptoms <sup>§</sup>	Never Intermittent Consistent	-ref- 3.1(0.42-23.46) 1.4(0.68-53.05)	-ref- 7.5(0.65-86.72) 0.8(0.33-2.03)
Mouse-Related Lower Respiratory Symptoms <sup>‡§</sup>	Never Consistent	-ref- 1.1(0.59-1.91)	-ref- 0.6(0.24-1.25)
Laboratory Animal Allergy <sup>□ §</sup> <sup>‡</sup>	Never Intermittent Consistent	-ref- <b>11.2(1.3-95.98)</b> 1.7(0.40-7.13)	-ref- 40.2(0.87- 1843.27) 1.0(0.19-5.21)

Models were adjusted for: gender, age, atopy, mean log Mus m 1 exposure and job type. Bold indicates a significant ( $p \leq .05$ ) <sup>‡</sup>Too few failures, consistent and intermittent users were grouped together

<sup>□</sup>Adjusted for mean log Mus m 1 instead of tertiles of exposure

<sup>§</sup>Modeled using a lagged DPR use variable

<sup>‡</sup>Also controlled for smoking and asthma

<sup>‡</sup> Could not control for job

### iii. Incidence Rates of Outcomes of Interest for Phase 2 of the JAXCohort

Table A20: Phase 2: Incidence Rates for Outcomes of Interest (n=98)

	Overall (n=98)	Respiratory Protection Use			p-value
		Never (n=62)	Intermittent (n=19)	Consistent (n=17)	
Mouse-specific IgG <sub>1-3</sub>	93.6	89.2	0.0	135.6	0.01
Mouse-specific IgG <sub>4</sub>	61.5	71.0	166.7	29.8	0.67
Mouse SPT+	130.5	45.9	363.6	156.25	<0.00
Mouse-specific IgE	44.8	34.3	181.8	59.7	0.06
Any Symptoms	361.2	316.4	666.7	510.6	0.02
Respiratory Symptoms	331.8	293.8	666.7	458.3	0.04
Rhinoconjunctivitis:	293.1	255.6	666.7	416.7	0.05
Lower Respiratory:	104.8	100.5	0.0	125.0	0.17
Laboratory Animal Allergy	66.7	49.7	400.0	95.23	0.09
Dermal Symptoms	58.6	39.0	0.0	123.6	<0.00

Respiratory protection use categories are average use, not time dependent. Rates were calculated per 1000 worker years.

### A3.3. Comparison of Population Characteristics:

Table A21: Comparison of the Phase 1 and Phase 2 Populations (n=222)

	Phase 1 n(%)	Phase 2 n(%)	Combined n(%)	Difference (95%CI)	p-value <sup>¥</sup>
<b>Respiratory Protection Use:</b>					
Non-users	45(44.1)	71(73.9)	116(58.6)	29.8% (16.6 – 43.1)	<0.01
Intermittent	15(14.7)	1(1.0)	16(8.1)	13.6% (6.2-21.1)	<0.01
Consistent	42(41.1)	24(25.0)	66(33.3)	16.2% (3.1- 29.3)	0.02
<b>Average Follow-up time in months</b> (95%CI)	31.8 (27.5 – 36.1)	17.3 (15.4 – 19.1)	25.4 (22.7 – 28.1)	14.5 (9.5 – 19.6)	<0.01
<b>Non-animal care takers</b>	43(34.7)	28(28.6)	71(31.9)	6.1% (6.4 - 18.6)	0.34
<b>Female</b>	84(69.4)	43(44.7)	127(58.1)	25.4% (12.7 - 38.2)	<0.01
<b>Average age in years</b> (95%CI)	30.2 (28.6 – 31.8)	28.9 (27.5 – 30.5)	29.7 (28.5 – 30.8)	1.254 (1.0 – 3.5)	0.28
<b>Caucasian</b>	111(91.1)	86(87.8)	197(89.6)	3.4% (0.1 – 11.5)	0.42
<b>Current smoker</b>	36(29.5)	16(16.3)	52(23.9)	13.5% (1.9 – 24.5)	0.02
<b>Currently has asthma symptoms</b>	8(6.6)	9(9.3)	17(7.8)	2.7% (-9.9 – 4.5)	0.96
<b>Atopy</b> (≥1 positive SPT)	65(49.2)	70(71.4)	135(59.0)	22.2% (9.4 – 35.5)	<0.01
<b>Mean Total IgE,</b> (kU/L) (95%CI)	46 (12– 80)	94 (57 – 131)	63 (39 – 89)	48 (4 – 100)	0.07
<b>Mean Mus m 1 exposure</b> (ng/m <sup>3</sup> ) <sup>□</sup> (95%CI)	20 (10 – 30)	139 (80 – 198)	70 (43- 96)	119 (69 – 170)	<0.01
<b>Distribution among the tertiles of mean Mus m 1 exposure</b>					
Tertile 1:	209(32.7)	111(32.9)	320(32.7)	0.23% (-6.4 – 5.9)	0.94
Tertile 2:	273(42.7)	50(14.8)	323(33.1)	27.8% (21.9-33.8)	<0.01
Tertile 3:	157(24.7)	176(52.3)	333(34.1)	27.7% (27.6-33.7)	<0.01

Phase 1 and phase 2 populations were compared on statistics calculated for the first 6-month follow up visit.

<sup>¥</sup> Two-tailed Student's T-test for significance of differences in means between two independent samples with unequal variances

<sup>□</sup> When the mean log<sub>10</sub> Mus m 1 of exposure was compared there were no significant differences

<sup>£</sup> Compared across all visits, total number of observations: 976.

### A3.4 Analysis of final study population

#### i. Cox proportional hazard modeling of outcomes of interest for the final study population

Table A22: Final Study Population: Cox Proportional Hazards Models of the Associations between DPR use and risk for Developing Outcomes of Interest(n=222).

<b>Outcome</b>	<b>DPR Use</b>	<b>Crude HR (95% CI)</b>	<b>Adjusted HR (95% CI)</b>
Mus m 1-specific IgG <sub>1-3</sub>	Never	-ref-	-ref-
	Intermittent	2.1(0.68-6.21)	1.85(0.58-5.90)
	Consistent	0.8(0.34-1.89)	0.5(0.21-1.41)
Mus m 1-specific IgG <sub>4</sub>	Never	-ref-	-ref-
	Intermittent	1.4(0.29-6.05)	1.5(0.31-7.08)
	Consistent	0.8(0.32-2.04)	0.6(0.21-1.64)
Mouse-specific SPT+	Never	-ref-	-ref-
	Intermittent	<b>5.9(2.38-14.98)</b>	<b>4.5(1.68-11.29)</b>
	Consistent	<b>2.4(1.08-5.15)</b>	1.7(0.71-4.21)
Mus m 1-specific IgE <sup>y</sup>	Never	-ref-	-ref-
	Intermittent	<b>8.8(2.32-33.47)</b>	<b>8.6(2.18-34.14)</b>
	Consistent	1.5(0.47-5.22)	1.1(0.27-4.21)
Any Mouse- Related Respiratory Symptom <sup>§</sup>	Never	-ref-	-ref-
	Intermittent	0.8(0.29-2.30)	0.9(0.29-2.59)
	Consistent	1.1(0.69-1.81)	0.9(0.46-1.59)
Mouse-Related Rhinoconjunctival Symptoms <sup>§</sup>	Never	-ref-	-ref-
	Intermittent	0.9(0.33-2.63)	1.1(0.35-3.26)
	Consistent	1.1(0.69-1.88)	0.9(0.51-1.87)
Mouse-Related Lower Respiratory Symptoms <sup>§</sup>	Never	-ref-	-ref-
	Intermittent	0.7(0.18-3.09)	0.6(0.12-2.67)
	Consistent	1.3(0.73-2.42)	0.7(0.32-1.70)
Laboratory Animal Allergy <sup>§,ε</sup>	Never	-ref-	-ref-
	Intermittent	3.1(0.79-12.01)	3.6(0.76-17.26)
	Consistent	1.42(0.47-4.24)	1.1(0.34-4.21)

Models were adjusted for: gender, age, atopy, mean log Mus m 1 exposure and job type.  
 Bold indicates a significant (p≤.05) <sup>y</sup> Could not control for job <sup>§</sup>Modeled using a lagged DPR use variable <sup>ε</sup>Also controlled for smoking and asthma

**ii. Difference in Hazard Ratios for Outcomes of Interest between the Total Study Population as Compared to the Final Study Population Excluding Participants Reporting Asthma**

Table A23: Final Study Population: Comparison of Unadjusted and Adjusted Hazard Ratios for Risk for Exposure, Sensitization and LAA, between the Study Populations and a Population Excluding Asthmatics (n=222).

	<b>Crude HR</b> Current model n=222 <b>HR(95%CI)</b>	<b>Crude HR</b> Excluding Current Asthmatics n=202 <b>HR(95%CI)</b>	<b>Adjusted HR</b> Current model: <b>HR(95%CI)</b>	<b>Adjusted</b> Excluding Current Asthmatics <b>HR(95%CI)</b>
<b>Mouse-Specific SPT+</b>				
<i>Ref: Non user</i>	- ref -	- ref -	- ref -	- ref -
Intermittent	<b>5.8 (2.33 - 14.7)</b>	<b>5.8 (2.07 - 15.9)</b>	<b>4.8 (1.84 - 12.74)</b>	<b>5.4(1.89 - 15.36)</b>
Consistent	<b>2.3 (1.04 - 4.96)</b>	2.1 (0.87 - 5.07)	1.8 (0.72 - 4.27)	1.7 (0.61 - 4.61)
<i>Ref: Non &amp; Consist</i>	- ref -	- ref -	- ref -	- ref -
Intermittent	<b>4.0 (1.78 - 8.99)</b>	<b>4.26 (1.69 - 10.72)</b>	<b>3.9 (1.61 - 9.25)</b>	<b>4.5 (1.71 - 11.99)</b>
<b>Mouse-Specific IgE</b>				
<i>Ref: Non user</i>	- ref -	- ref -	- ref -	- ref -
Intermittent	<b>6.3 (1.66 - 23.79)</b>	<b>5.9 (1.41 - 25.19)</b>	<b>6.8 (1/71 - 27.57)</b>	<b>8.4 (1.79 - 39.27)</b>
Consistent	1.5 (0.44 - 5.33)	0.8 (0.15 - 4.20)	1.1 (0.26 - 4.21)	0.59 (0.11 - 3.30)
<i>Ref: Non &amp; Consist</i>	- ref -	- ref -	- ref -	- ref -
Intermittent	<b>5.2 (1.59 - 17.02)</b>	<b>6.3 (1.67 - 24.86)</b>	<b>6.7 (1.87 - 24.05)</b>	<b>9.6 (2.15 - 43.24)</b>
<b>Mouse-Specific IgG</b>				
<i>Ref:</i>	- ref -	- ref -	- ref -	- ref -
<i>Consistent</i>				
Intermittent	2.5 (0.76 - 8.60)	2.9 (0.69 - 12.47)	2.9 (0.79 - 11.03)	3.9 (0.79 - 19.33)
Non-user	1.2 (0.53 - 2.91)	1.6 (0.57 - 4.26)	1.4 (0.55 - 3.76)	2.1 (0.65 - 6.56)
<i>Ref:</i>	- ref -	- ref -	- ref -	- ref -
<i>Consistent</i>				
Non & Intermit	1.38 (0.61 - 3.15)	1.7 (0.62 - 4.51)	1.6 (0.65 - 4.12)	2.2 (0.72 - 6.98)
<b>LAA<sup>§</sup></b>				
<i>Ref: Non user</i>	- ref -	- ref -	- ref -	- ref -
Intermittent	3.1 (0.79 - 12.02)	<b>4.0 (1.0 - 16.25)</b>	3.3 (0.78 - 13.87)	4.6(0.95 - 22.53)
Consistent	1.4 (0.48 - 4.24)	1.2 (0.34 - 4.35)	1.0 (0.31 - 3.31)	0.43 (0.07 - 2.56)
<i>Ref: Non &amp; Consist</i>	- ref -	- ref -	- ref -	- ref -
Intermittent	2.7 (0.76 - 9.41)	<b>3.7 (1.02 - 13.68)</b>	3.1 (0.82 - 12.3)	<b>6.0 (1.33 - 27.27)</b>

Models were adjusted for age, gender, atopy, job, smoking and mean Mus m l exposure. Risk for outcomes of interest was compared across all three categories of respiratory protection (Non-DPR user, Intermittent users, Consistent users) as well as between 2 categories of use (Intermittent users were compared to a reference category which included Non-users and Consistent users). Bold indicates significance of  $p \leq 0.05$ . <sup>§</sup>Modeled using a lagged DPR use variable, and also controlled for smoking and asthma

### iii. Difference in Hazard Ratios for Outcomes between the Total Study Population as Compared to the Final Study Population Excluding Participants Reporting Asthma

Table A24: Final Study Population: Comparison of the Unadjusted and Adjusted Hazard Ratios for Risk of Developing Respiratory Symptoms, between the Total Study Population and a Population Excluding Asthmatics. (n=222)

	Crude HR Current model n=222 HR(95%CI)	Crude HR Excluding Current Asthmatics n=202 HR(95%CI)	Adjusted HR Current model HR(95%CI)	Adjusted Excluding Current Asthmatics HR(95%CI)
<b>Itchy / watery eyes</b>				
<i>Ref: Non user</i>	- ref -	- ref -	- ref -	- ref -
Intermittent	1.8 (0.63 – 5.54)	2.5 (0.84 – 7.53)	1.9 (0.62 – 5.83)	<b>3.7 (1.14 – 11.78)</b>
Consistent	1.3 (0.65 – 2.63)	1.3 (0.61 – 2.89)	0.9 (0.41 – 1.97)	0.9 (0.36 – 2.32)
<i>Ref: Non &amp; Consist</i>	- ref -	- ref -	- ref -	- ref -
Intermittent	1.7 (0.59 – 4.75)	2.3 (0.79 – 6.59)	1.9 (0.67 – 5.86)	<b>3.8 (1.21 – 11.71)</b>
<b>Sneezing</b>				
<i>Ref: Non user</i>	- ref -	- ref -	- ref -	- ref -
Intermittent	0.8 (0.24 – 2.59)	1.1 (0.34 – 3.70)	0.9 (0.28 – 3.24)	1.6 (0.46 – 5.36)
Consistent	1.2 (0.71 – 2.00)	1.2 (0.64 – 2.14)	0.9 (0.47 – 1.64)	0.7 (0.31 – 1.40)
<i>Ref: Non &amp; Consist</i>	- ref -	- ref -	- ref -	- ref -
Intermittent	0.7 (0.23 – 2.36)	1.1 (0.33 – 3.45)	1.0 (0.31 – 3.33)	1.8 (0.52 – 5.94)
<b>Cough</b>				
<i>Ref: Non user</i>	- ref -	- ref -	- ref -	- ref -
Intermittent	0.9 (0.23 – 4.27)	1.7 (0.39 – 7.50)	1.0 (0.22 – 4.54)	2.2 (0.46 – 10.22)
Consistent	1.7 (0.87 – 3.23)	1.9 (0.87 – 4.11)	1.1 (0.51 – 2.49)	0.9 (0.34 – 2.74)
<i>Ref: Non &amp; Consist</i>	- ref -	- ref -	- ref -	- ref -
Intermittent	0.8 (0.19 – 3.28)	1.3 (0.31 – 5.61)	0.9 (0.22 – 4.22)	2.2 (0.47 – 10.12)
<b>Shortness of breath</b>				
<i>Ref: Non user</i>	- ref -	- ref -	- ref -	- ref -
Intermittent	1.6 (0.32 – 7.33)	2.9 (0.56 – 15.69)	0.5 (0.05 – 4.12)	1.9 (0.18 – 19.79)
Consistent	1.4 (0.54 – 3.65)	2.2 (0.69 – 6.69)	0.8 (0.29 – 2.44)	1.5 (0.37 – 5.92)
<i>Ref: Non &amp; Consist</i>	- ref -	- ref -	- ref -	- ref -
Intermittent	1.3 (0.29 – 5.87)	2.1 (0.44 – 10.23)	0.5 (0.06 – 4.19)	1.6 (0.17 – 14.86)
<b>Wheeze</b>				
<i>Ref: Non user</i>	- ref -	- ref -	- ref -	- ref -
Intermittent	2.6 (0.51 – 13.39)	4.3 (0.72 – 25.47)	3.2 (0.49 – 21.28)	<b>14.8 (1.22 – 178.5)</b>
Consistent	2.1 (0.71 – 5.92)	2.5 (0.65 – 9.09)	0.8 (0.22 – 3.21)	1.4 (0.24 – 8.13)
<i>Ref: Non &amp; Consist</i>	- ref -	- ref -	- ref -	- ref -
Intermittent	1.8 (0.39 – 8.31)	2.3 (0.47 – 11.82)	3.5 (0.60 – 20.64)	<b>11.7 (1.38 – 98.67)</b>

Models were adjusted for age, gender, atopy, job, smoking, asthma and mean Mus m 1 exposure. Risk for outcomes of interest was compared across all three categories of respiratory protection (Non-DPR user, Intermittent users, Consistent users) as well as between 2 categories of use (Intermittent users were compared to a reference category which included Non-users and Consistent users). Bold indicates significance of  $p \leq 0.05$ . A lagged DPR use variable was used.

### A 3.5 Phase 1 Baseline Questionnaire

Participant ID#:	J	X	C				
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#### **JAXCohort Cover Page Instructions for Interviewer**

#### **Baseline Questionnaire**

**Instructions:** A ball point pen may be used to complete this questionnaire. Please DO NOT use a marker or felt tip pen. Please darken in bubbles to indicate your answer and clearly print requested information in the appropriate boxes. Print in boxes using block lettering. Instructions for the interviewer are italicized and are not to be read out loud. If you make a mistake for multiple choice, cross out the incorrect values and write the correct values above or inside boxes and bubbles.

Interviewers Initials: 

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Participant ID#:

**JAXCohort Baseline Questionnaire**

Date:   /   /      
M M D D Y Y Y Y

**Part 1. MEDICAL AND FAMILY HISTORY**

1. Date of Birth:   /   /      
M M D D Y Y Y Y

2. Place of Birth:     
city state country

3. Are you male or female?  Male  
 Female

4. What is your marital status?  Single  
 Married/Partnered  
 Widowed  
 Separated  
 Other

Participant ID#:

5. How would you describe your race/ethnic background? (select all that apply)

- White
- Black, African-American, or Negro
- Asian Indian
- Chinese
- American Indian or Alaska Native
- Filipino
- Japanese
- Korean
- Vietnamese
- Other Asian ..... What is this race?
- Native Hawaiian
- Guamanian/Chamorro
- Samoan
- Other Pacific Islander ..... What is this race?
- Some other race ..... What is this race?
- I don't know

5a. Are you Mexican, Puerto Rican, Cuban, or of another Hispanic or Latino group? (Please select one)

- No, not Spanish/Hispanic/Latino
- Yes, Mexican/Mexican-American/Chicano
- Yes, Puerto Rican
- Yes, Cuban
- Yes, other Spanish/Hispanic/Latino If other, what is the group?

Participant ID#:

6. How much of school have you completed?

- 8th grade or less
- 9th-11th grade
- high school graduate
- some college or technical school
- college graduate
- post-graduate

These questions pertain mainly to your chest. Please answer *yes* or *no* if possible. If you are in doubt about whether your answer is *yes* or *no*, select *no*.

**COUGH**

7. Do you usually have a cough? (*If no, skip to Question 7b.*)  yes  no

7a. Do you usually cough as much as 4 to 6 times a day, 4 or more days out of the week?  yes  no

7b. Do you usually cough at all on getting up, or first thing in the morning?  yes  no

7c. Do you usually cough at all during the rest of the day or at night?  yes  no

*IF YES TO ANY OF THE ABOVE (7a, b, or c), ANSWER THE FOLLOWING:  
IF NO TO ALL, SELECT DOES NOT APPLY AND SKIP TO THE NEXT PAGE.*

7d. Do you usually cough like this on most days for 3 consecutive months or more during the year?  yes  no  does not apply

7e. For how many years have you had this cough?   years  does not apply

Participant ID#:

**PHLEGM (MUCUS)**

8. Do you usually bring up phlegm (mucus) from your chest? ((Count phlegm (mucus) on first going outdoors and swallowed phlegm (mucus). Do not count phlegm (mucus) from the nose.))  yes  no  
*(If no, skip to Question 8b.)*

8a. Do you usually bring up phlegm (mucus) like this as much as twice a day, 4 or more days out of the week?  yes  no

8b. Do you usually bring up phlegm (mucus) at all on getting up, or first thing in the morning?  yes  no

8c. Do you usually bring up phlegm (mucus) at all during the rest of the day or at night?  yes  no

*IF YES TO ANY OF THE ABOVE (8,a, b,or c), ANSWER THE FOLLOWING:  
IF NO TO ALL, SELECT DOES NOT APPLY AND SKIP TO 9.*

8d. Do you bring up phlegm like this on most days for 3 consecutive months or more during the year?  yes  no  does not apply

8e. For how many years have you had trouble with phlegm (mucus)?   years  does not apply

**EPISODES OF COUGH AND PHLEGM (MUCUS)**

9. Have you had periods of (increased\*) cough and phlegm (mucus) lasting for 3 or more weeks each year?  yes  no

*\* (For persons who usually have cough and/or phlegm (mucus))*

*IF YES TO 9, ANSWER THE FOLLOWING:  
IF NO TO 9, SELECT DOES NOT APPLY AND SKIP TO 10.*

9a. For how long have you had at least 1 such episode per year?   years  does not apply

Participant ID#:

**WHEEZING**

Does your chest ever sound wheezy or whistling:

- 10. When you have a cold?  yes  no
- 10a. Occasionally apart from colds?  yes  no
- 10b. Most days or nights?  yes  no

*IF YES TO 10, 10a, OR 10b, ANSWER THE FOLLOWING:  
IF NO TO ALL, SELECT DOES NOT APPLY AND SKIP TO 11.*

10c. For how many years has this been present?   years  does not apply

- 11. Have you ever had an attack of wheezing that has made you feel short of breath?  yes  no

*IF YES TO 11, ANSWER THE FOLLOWING:  
IF NO TO 11, SELECT DOES NOT APPLY FOR 11A,B,C, AND SKIP TO 12.*

11a. How old were you when you had your first such attack?   years  does not apply

11b. Have you had two or more such episodes?  yes  no  does not apply

11c. Have you ever required medicine or treatment for the(se) attack(s)?  yes  no  does not apply

**BREATHLESSNESS**

12. Are you disabled from walking as a result of any condition?

yes  no *If YES, please describe:*

13. Are you troubled by shortness of breath when hurrying on the level or walking up a slight hill?  yes  no

Participant ID#:

*IF YES TO 13, ANSWER THE FOLLOWING:*

*IF NO TO 13, SELECT DOES NOT APPLY FOR 13A, B, C, D AND SKIP TO 14.*

- 13a. Do you have to walk slower than people of your own age on the level because of breathlessness?  yes  no  Does not apply
- 13b. Do you ever have to stop for breath when walking at your own pace on the level?  yes  no  Does not apply
- 13c. Do you ever have to stop for breath after walking about 100 yards (or after a few minutes) on the level?  yes  no  Does not apply
- 13d. Are you too breathless to leave the house or breathless on dressing and undressing?  yes  no  Does not apply

**CHEST COLDS AND CHEST ILLNESSES**

14. If you get a cold, does it usually go down to your chest? (Usually means more than 1/2 the time)  yes  no  Don't get colds
15. During the past 3 years, have you had any chest illnesses that have kept you off work, indoors at home, or in bed?  yes  no *(skip to question 16)*

*IF YES TO 15, ANSWER THE FOLLOWING:*

*IF NO TO 15 SELECT DOES NOT APPLY FOR 15A, B AND SKIP TO 16.*

- 15a. Did you produce phlegm (mucus) with any of these chest illnesses?  yes  no  Does not apply
- 15b. In the last 3 years, how many such illnesses, with (increased) phlegm, did you have which lasted a week or more?   Number of illnesses
- no such illnesses
- Does not apply

Participant ID#:

**PAST ILLNESSES**

16. Did you have any lung trouble before the age of 16?       yes       no

Have you ever had any of the following?

17. Attacks of bronchitis?       yes       no

*IF YES TO 17, ANSWER THE FOLLOWING:  
IF NO TO 17, SELECT DOES NOT APPLY FOR 17A, B AND SKIP TO 18*

17a. Was it confirmed by a doctor? <input type="radio"/> yes <input type="radio"/> no <input type="radio"/> Does not apply
17b. At what age was your first attack? <input type="text"/> <input type="text"/> age in years <input type="radio"/> Does not apply

18. Pneumonia (including bronchopneumonia)?       yes       no

*IF YES TO 18, ANSWER THE FOLLOWING:  
IF NO TO 18 SELECT DOES NOT APPLY FOR 18A, B, AND SKIP TO 19*

18a. Was it confirmed by a doctor? <input type="radio"/> yes <input type="radio"/> no <input type="radio"/> Does not apply
18b. At what age did you first have it? <input type="text"/> <input type="text"/> age in years <input type="radio"/> Does not apply

19. Hay fever?       yes       no

*IF YES TO 19, ANSWER THE FOLLOWING:  
IF NO TO 19 SELECT DOES NOT APPLY FOR 19A, B, AND SKIP TO 20.*

19a. Was it confirmed by a doctor? <input type="radio"/> yes <input type="radio"/> no <input type="radio"/> Does not apply
19b. At what age did it start? <input type="text"/> <input type="text"/> age in years <input type="radio"/> Does not apply

Participant ID#:

20. Have you ever had chronic bronchitis?  yes  no

*IF YES TO 20, ANSWER THE FOLLOWING:  
IF NO TO 20 SELECT DOES NOT APPLY FOR 20A,B,C AND SKIP TO 21.*

20a. Do you still have it?	<input type="radio"/> yes	<input type="radio"/> no	<input type="radio"/> Does not apply
20b. Was it confirmed by a doctor?	<input type="radio"/> yes	<input type="radio"/> no	<input type="radio"/> Does not apply
20c. At what age did it start?	<input type="text"/>	<input type="text"/>	age in years <input type="radio"/> Does not apply

21. Have you ever had emphysema?  yes  no

*IF YES TO 21, ANSWER THE FOLLOWING:  
IF NO TO 21 SELECT DOES NOT APPLY FOR 21A,B,C AND SKIP TO 22.*

21a. Do you still have it?	<input type="radio"/> yes	<input type="radio"/> no	<input type="radio"/> Does not apply
21b. Was it confirmed by a doctor?	<input type="radio"/> yes	<input type="radio"/> no	<input type="radio"/> Does not apply
21c. At what age did it start?	<input type="text"/>	<input type="text"/>	age in years <input type="radio"/> Does not apply

22. Have you ever had asthma?  yes  no

*IF YES TO 22, ANSWER THE FOLLOWING:  
IF NO TO 22 SELECT DOES NOT APPLY FOR 22A, B, C, D AND SKIP TO 23.*

22a. Do you still have it?	<input type="radio"/> yes	<input type="radio"/> no	<input type="radio"/> Does not apply
22b. Was it confirmed by a doctor?	<input type="radio"/> yes	<input type="radio"/> no	<input type="radio"/> Does not apply
22c. At what age did it start?	<input type="text"/>	<input type="text"/>	age in years <input type="radio"/> Does not apply
22d. If you no longer have it, at what age did it stop?	<input type="text"/>	<input type="text"/>	age stopped <input type="radio"/> Does not apply

Participant ID#:

23. Have you ever had:

23a. Any other chest illnesses?  yes  no

If yes, please specify:

23b. Any chest operations?  yes  no

If yes, please specify:

23c. Any chest injuries?  yes  no

If yes, please specify:

**OCCUPATIONAL HISTORY**

24. Prior to your current job, have you ever worked full time (30 hours a week or more) for 6 months or more?  yes  no

25. What has been your usual occupation or job - the one you have worked at the longest?

25a. Job-occupation:

25b. Number of years employed in this occupation:

25c. Position-job title:

25d. Business, field, or industry:

Participant ID#:

26. Did you ever work with mice before starting your job at Jackson Labs?  yes  no

*IF YES TO 26, ANSWER THE FOLLOWING:  
IF NO TO 26, SKIP TO 27.*

26a. What year did you start working with mice?	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>
26b. What year did you stop working with mice?	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>
26c. What was your <b>primary</b> (main) task? ( <i>select one</i> )	
<input type="radio"/> Husbandry (breeding,weaning)	
<input type="radio"/> Animal care (weaning/changing cages)	
<input type="radio"/> Laboratory experiments (ex:obtaining blood or tissue samples, performing surgery)	
<input type="radio"/> Autopsies	
<input type="radio"/> Dumping dirty boxes	
<input type="radio"/> Preparing mice for shipment	

27. Have you ever worked with laboratory animals other than mice?  yes  no

*IF YES TO 27: What types of animals? (Select **all that apply**)  
IF NO TO 27, SKIP TO 29.*

- 27a.  Rats
- 27b.  Guinea Pigs
- 27c.  Rabbits
- 27d.  Hamsters
- 27e.  Primates (monkeys,chimpanzees,gorillas,baboons)
- 27f.  Other-please specify

Participant ID#:

28. For each animal selected what year did you start and stop working with the animal? What was your primary task related to the animal?

			Primary Task Related
A Rats:	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year start	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year stop	<input type="text"/>
B Guinea Pigs:	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year start	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year stop	<input type="text"/>
C Rabbits:	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year start	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year stop	<input type="text"/>
D Hamsters:	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year start	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year stop	<input type="text"/>
E Primates:	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year start	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year stop	<input type="text"/>
F Other:	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year start	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year stop	<input type="text"/>

**TOBACCO SMOKING**

29. Have you ever smoked cigarettes? (No means less than 20 packs of cigarettes or 12 oz of tobacco in a lifetime or less than 1 cigarette a day for 1 year)  yes  no (skip to question 35)

IF YES TO 29, ANSWER THE FOLLOWING:  
IF NO TO 29 SELECT DOES NOT APPLY FOR 30,31,33,34 AND SKIP TO 35.

30. Do you now smoke cigarettes (as of 1 month ago)?	<input type="radio"/> yes <input type="radio"/> no <input type="radio"/> Does not apply
31. How old were you when you first started regular cigarette smoking?	<input type="text"/> <input type="text"/> Age in years <input type="radio"/> Does not apply
32. If you have stopped smoking cigarettes completely, how old were you when you stopped?	<input type="text"/> <input type="text"/> Age stopped <input type="radio"/> Still smoking
33. How many cigarettes do you smoke per day now?	<input type="text"/> <input type="text"/> Cigarettes per day <input type="radio"/> Does not apply
34. On the average of the entire time you smoked, how many cigarettes did you smoke per day?	<input type="text"/> <input type="text"/> Cigarettes per day <input type="radio"/> Does not apply

Participant ID#:

**FAMILY HISTORY**

35. Was your father/mother ever told by a doctor that they had a chronic lung condition such as:

FATHER

MOTHER

- A. Chronic bronchitis?     yes    no    don't know
- B. Emphysema?         yes    no    don't know
- C. Asthma?              yes    no    don't know
- D. Lung cancer?        yes    no    don't know
- E. Other chest conditions?    yes    no    don't know

- yes    no    don't know
- yes    no    don't know
- yes    no    don't know
- yes    no    don't know
- yes    no    don't know

36. Is your father currently alive?

Is your mother currently alive?

36a. Please specify:     yes    no    don't know

yes    no    don't know

age if living

age if living

age at death

age at death

don't know

don't know

36b. If your father is deceased, please specify cause of death?

If your mother is deceased, please specify cause of death?

**PART II SYMPTOMS**

Participant ID: J X C [ ] [ ] [ ] [ ] [ ] [ ]

**RHINITIS**

37. Have you **EVER** had a problem with sneezing or a runny or stuffy nose when you **DID NOT** have a cold or the flu?  yes  no (skip to question 40.)

IF YES TO 37, ANSWER THE FOLLOWING:

Have you **EVER** had a problem with sneezing or a runny or stuffy nose as a result of exposure to any of the following circumstances?

37a. being near lab mice.....  yes  no  no exposure  uncertain

37b. cats.....  yes  no  no exposure  uncertain

37c. dogs.....  yes  no  no exposure  uncertain

37d. pollens (grasses, trees, weeds, etc.)...  yes  no  no exposure  uncertain

37e. during certain seasons.....  yes  no  no exposure  uncertain

IF YES TO 37e, which seasons? (select all that apply):

Winter  Spring  Summer  Fall

38. Have you had a problem with sneezing or a runny or stuffy nose as a result of exposure to any of the following circumstances **IN THE PAST 12 MONTHS**?

38a. being near lab mice.....  yes  no  no exposure  uncertain

38b. cats.....  yes  no  no exposure  uncertain

38c. dogs.....  yes  no  no exposure  uncertain

38d. pollens (grasses, trees, weeds, etc.)..  yes  no  no exposure  uncertain

38e. during certain seasons.....  yes  no  no exposure  uncertain

IF YES TO 38e, which seasons? (select all that apply):

Winter  Spring  Summer  Fall

39. Has a doctor or health care provider ever told you that you have allergies or hay fever?  yes  no

**ECZEMA**

Participant ID:

40. Have you **EVER** had an itchy, scaly or weepy skin rash that comes and goes for at least 6 months?

- yes       no (*skip to question 45.*)

*IF YES TO 40, ANSWER THE FOLLOWING:*

41. Has this itchy rash at any time affected any of the following places: The folds of the elbows, behind the knees, in front of the ankles, under the buttocks, or around the neck, ears, or eyes?

- yes       no

42. Have you **EVER** had this rash as a result of exposure to any of the following circumstances?

42a. being near lab mice.....  yes    no    no exposure    uncertain

42b. cats.....  yes    no    no exposure    uncertain

42c. dogs.....  yes    no    no exposure    uncertain

42d. pollens (grasses, trees, weeds, etc.)....  yes    no    no exposure    uncertain

43. Have you had this rash as a result of exposure to any of the following circumstances **IN THE PAST 12 MONTHS?**

43a. being near lab mice.....  yes    no    no exposure    uncertain

43b. cats.....  yes    no    no exposure    uncertain

43c. dogs.....  yes    no    no exposure    uncertain

43d. pollens (grasses, trees, weeds, etc.)....  yes    no    no exposure    uncertain

44. Has a doctor or health care provider ever told you that you have eczema or atopic dermatitis?

- yes       no

Participant ID:

**HIVES**

45. Have you **EVER** had welts or hives?       yes     no    (*skip to question 49*)

*IF YES TO 45, ANSWER THE FOLLOWING:*

46. Have you **EVER** had welts or hives as a result of exposure to any of the following circumstances?

46a. being near lab mice.....     yes     no     no exposure     uncertain

46b. cats.....     yes     no     no exposure     uncertain

46c. dogs.....     yes     no     no exposure     uncertain

46d. pollens (grasses, trees, weeds, etc.)...     yes     no     no exposure     uncertain

47. Have you had welts or hives as a result of exposure to any of the following circumstances **IN THE PAST 12 MONTHS**?

47a. being near lab mice.....     yes     no     no exposure     uncertain

47b. cats.....     yes     no     no exposure     uncertain

47c. dogs.....     yes     no     no exposure     uncertain

47d. pollens (grasses, trees, weeds, etc.)..     yes     no     no exposure     uncertain

48. Has a doctor or health care provider ever told you that you had hives or urticaria?     yes     no

Participant ID:

**COUGH**

49. Have you sometimes had a cough when you **DID NOT** have a cold or the flu?  
 yes     no (skip to question 52)

*IF YES TO 49, ANSWER THE FOLLOWING:*

50. Have you **EVER** had a cough as a result of exposure to any of the following circumstances?

50a. being near lab mice.....  yes    no    no exposure    uncertain

50b. cats.....  yes    no    no exposure    uncertain

50c. dogs.....  yes    no    no exposure    uncertain

50d. pollens (grassses, trees, weeds, etc.)...  yes    no    no exposure    uncertain

50e. during certain seasons.....  yes    no    no exposure    uncertain

*IF YES TO 50e, which seasons? (select all that apply):*

Winter    Spring    Summer    Fall

51. Have you had a cough as a result of exposure to any of the following circumstances **IN THE PAST 12 MONTHS?**

51a. being near lab mice.....  yes    no    no exposure    uncertain

51b. cats.....  yes    no    no exposure    uncertain

51c. dogs.....  yes    no    no exposure    uncertain

51d. pollens (grassses, trees, weeds, etc.)...  yes    no    no exposure    uncertain

51e. during certain seasons.....  yes    no    no exposure    uncertain

*IF YES TO 51e, which seasons? (select all that apply):*

Winter    Spring    Summer    Fall

Participant ID:

**WHEEZING**

52. Has your chest ever sounded wheezy or whistling when you **DID NOT** have a cold or the flu?

- yes     no (skip to question 55. )

*IF YES TO 52, ANSWER THE FOLLOWING:*

53. Has your chest **EVER** sounded wheezy or whistling as a result of exposure to any of the following circumstances?

53a. being near lab mice.....  yes    no    no exposure    uncertain

53b. cats.....  yes    no    no exposure    uncertain

53c. dogs.....  yes    no    no exposure    uncertain

53d. pollens (grasses, trees, weeds, etc.)...  yes    no    no exposure    uncertain

53e. during certain seasons.....  yes    no    no exposure    uncertain

*IF YES TO 53e, which seasons? (select all that apply):*

Winter    Spring    Summer    Fall

54. Has your chest ever sounded wheezy or whistling as a result of exposure to any of the following circumstances **IN THE PAST 12 MONTHS?**

54a. being near lab mice.....  yes    no    no exposure    uncertain

54b. cats.....  yes    no    no exposure    uncertain

54c. dogs.....  yes    no    no exposure    uncertain

54d. pollens (grasses, trees, weeds, etc.)..  yes    no    no exposure    uncertain

54e. during certain seasons.....  yes    no    no exposure    uncertain

*IF YES TO 54e, which seasons? (select all that apply):*

Winter    Spring    Summer    Fall

**SHORTNESS OF BREATH/TIGHTNESS IN CHEST**

Participant ID:

55. Have you **EVER** been bothered by shortness of breath or tightness in your chest when hurrying on flat ground or walking up a slight hill?

- yes     no (skip to question 58)

*IF YES TO 55, ANSWER THE FOLLOWING:*

56. Have you **EVER** been bothered by shortness of breath or tightness in your chest as a result of exposure to any of the following circumstances?

56a. being near lab mice.....  yes    no    no exposure    uncertain

56b. cats.....  yes    no    no exposure    uncertain

56c. dogs.....  yes    no    no exposure    uncertain

56d. pollens (grasses, trees, weeds, etc.)...  yes    no    no exposure    uncertain

56e. during certain seasons.....  yes    no    no exposure    uncertain

*IF YES TO 56e, which seasons? (select all that apply):*

Winter    Spring    Summer    Fall

57. Have you been bothered by shortness of breath or tightness in your chest as a result of exposure to any of the following circumstances **IN THE PAST 12 MONTHS**?

57a. being near lab mice.....  yes    no    no exposure    uncertain

57b. cats.....  yes    no    no exposure    uncertain

57c. dogs.....  yes    no    no exposure    uncertain

57d. pollens (grasses, trees, weeds, etc.)...  yes    no    no exposure    uncertain

57e. during certain seasons.....  yes    no    no exposure    uncertain

*IF YES TO 57e, which seasons? (select all that apply):*

Winter    Spring    Summer    Fall

**ITCHY, WATERY EYES:**

Participant ID:

58. Have you **EVER** been bothered by itchy, watery eyes with sneezing when you **DID NOT** have a cold or the flu?  yes  no (skip to question 61.)

*IF YES TO 58, ANSWER THE FOLLOWING:*

59. Have you **EVER** been bothered by itchy, watery eyes as a result of exposure to any of the following circumstances?

59a. being near lab mice.....  yes  no  no exposure  uncertain

59b. cats.....  yes  no  no exposure  uncertain

59c. dogs.....  yes  no  no exposure  uncertain

59d. pollens (grasses, trees, weeds, etc.)...  yes  no  no exposure  uncertain

59e. during certain seasons.....  yes  no  no exposure  uncertain

*IF YES TO 59e, which seasons? (select all that apply):*

Winter  Spring  Summer  Fall

60. Have you been bothered by itchy, watery eyes as a result of exposure to any of the following circumstances **IN THE PAST 12 MONTHS**?

60a. being near lab mice.....  yes  no  no exposure  uncertain

60b. cats.....  yes  no  no exposure  uncertain

60c. dogs.....  yes  no  no exposure  uncertain

60d. pollens (grasses, trees, weeds, etc.)...  yes  no  no exposure  uncertain

60e. during certain seasons.....  yes  no  no exposure  uncertain

*IF YES TO 60e, which seasons? (select all that apply):*

Winter  Spring  Summer  Fall

**ALLERGY SHOTS**

Participant ID:

61. Have you ever received shots for your allergies on a regular basis?

- yes
- no (skip to **PART III.** of the questionnaire)
- uncertain (skip to **PART III.** of the questionnaire)

*IF YES TO 61, ANSWER THE FOLLOWING:*

62. Are you still receiving shots?  
 yes  
 no (if no, what was the last year you received shots?)     year

63. For how many years did you receive/have you been receiving allergy shots?   years

64. What types of allergens (such as trees, grass, weeds, cat, dog, mouse, dustmite) were/are in your shots?

**PART III: ASTHMA**

65. Has any doctor or medical provider ever told you that you have chronic bronchitis, emphysema, or chronic obstructive pulmonary disease (COPD)?  yes  no
66. Has any doctor or medical provider ever told you that you have asthma?  yes  no  unsure

**IF NO TO QUESTION 66, SKIP TO PART IV. OF THE QUESTIONNAIRE, EXPOSURES**

Participant ID:

In the **past 4 weeks**, did you...(read this phrase prior to each question 67& 67a)

67. Miss any work, school, or normal daily activity because of your asthma?  yes  no  unsure

67a. Wake up at night because of asthma?  yes  no  unsure

Do you believe...

68. Your asthma was well controlled in the **past 4 weeks**?  yes  no  unsure

68a. You are able to take your asthma medicine(s) as directed?  yes  no  unsure

68b. Your medicine(s) are useful in controlling your asthma?  yes  no  unsure

69. Do you use an inhaler for quick relief from asthma symptoms?  yes  no  unsure

IF YES TO 69, ANSWER THE FOLLOWING:

69a. In the **past 4 weeks**, what was the highest number of puffs in one day you took of this inhaler?

0 puffs  
 1 to 4 puffs  
 5 to 8 puffs  
 9 to 12 puffs  
 over 12 puffs

70. Has a doctor or medical provider ever prescribed an asthma inhaler or pill that is **NOT** used for quick relief, but is used to control your asthma?  yes  no  unsure

70a. What best describes how you take this medicine now?

I take it every day  
 Some days I take it, but other days I don't  
 I used to take it, but now I don't  
 I only take it when I have symptoms  
 I never took it

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**ASTHMA ATTACKS**

Participant ID:

71. Have you **ever** needed to go to an emergency room, doctor's office or clinic because of an asthma attack?  
 yes     no (skip to question74. )

*IF YES TO 71, ANSWER THE FOLLOWING:*

72. How many times in the last 12 months?	<input type="text"/>	<input type="text"/>
73. How many times in your life?	<input type="text"/>	<input type="text"/>

74. Have you **ever** been hospitalized overnight because of an asthma attack?  
 yes     no (skip to question 77. )

*IF YES TO 74, ANSWER THE FOLLOWING:*

75. How many times have you been hospitalized for asthma in the last 12 months?	<input type="text"/>	<input type="text"/>	
76. Have you ever been hospitalized in an intensive care unit (ICU) for asthma?	<input type="radio"/> yes	<input type="radio"/> no	<input type="radio"/> uncertain
76a. Because of an asthma attack, has a tube ever been placed inside your lungs and connected to a machine to help you breathe?	<input type="radio"/> yes	<input type="radio"/> no	<input type="radio"/> uncertain

**For the past four weeks: (Read this phrase prior to questions 77-81)**

77. Has asthma kept you from getting as much done at work or home?  
 Not at all     A little     Moderately     Quite a lot     Extremely

78. Rate your asthma control:     Not controlled at all  
 Poorly controlled  
 Somewhat controlled  
 Well controlled  
 Completely controlled

Participant ID:

**For the past four weeks: (Read this phrase prior to questions 77-81)**

79. How often have you had shortness of breath?

- Not at all    Once/twice a week    3-6 times a week    Once a day    More than once a day

80. Have asthma symptoms woken you up at night or earlier than usual?

- Not at all    Once/twice    Once a week    2-3 nights a week    4 or more nights a week

81. How often have you used your rescue inhaler or nebulizer medication?    Not at all

Once a week or less

A few times a week

1-2 times per day

3 or more times per day

**PART IV EXPOSURES**

**HOME:**

82. Have you **ever** seen mice in your home?    yes    no

*IF YES TO 82, ANSWER THE FOLLOWING:*

- 82a. When did you last see mice in your home?    in the past month  
 in the past 12 months  
 more than 12 months ago

83. Have you **ever** seen evidence of mice (such as droppings or chewed materials) in your home?    yes    no

*IF YES TO 83, ANSWER THE FOLLOWING:*

- 83a. When did you last see evidence of mice in your home?    in the past month  
 in the past 12 months  
 more than 12 months ago

84. Have you **ever** seen rats in your home?    yes    no

*IF YES TO 84, ANSWER THE FOLLOWING:*

- 84a. When did you last see rats in your home?    in the past month  
 in the past 12 months  
 more than 12 months ago



Participant ID#:

92. Have you been offered a respirator to use when working with or around mice? (includes a NIOSH-approved fitted disposable respirator or a HEPA filtered PAPR; **does not** include surgical mask)

- Yes..... 92a. When was it given to you? 

--	--

--	--	--	--

  
M M      Y Y Y Y
- No (If no skip to 96.)

93. Why was it offered to you?

- To keep from getting mouse allergy
- I already have mouse allergy and need to prevent the symptoms
- Other (please specify) .....

94. Select the **one** statement that best describes your reasons for currently using a respirator

- 94a.  It is required by TJL health office in order for me to work with animals and I use it.
- 94b.  It is not required by TJL health office, but I have made the personal choice to use it
- 94c.  It is required by TJL health office, but I have chosen not to use it.
- 94d.  It is not required by TJL health office, and I have chosen not to use it.

*(If YES to 94a or 94b)*

- 94e. How often do you use the respirator?
- Always
  - Usually
  - Sometimes
  - Rarely
  - Never

95. Did you ever wear a respirator before starting your job at Jackson Labs?

- Yes.....please explain why?
- No

Participant ID#:

96. Look at the map of the Jackson Lab buildings. (*Show Map*) What is the name of the building you spend **most** of your time in?

[Empty text box for building name]

96a. What is the number of the building you spend most of your time in? [ ] [ ] [ ] [ ] [ ] [ ]

97. Look at the map of the building you work in, what is the number of the room you spend most of your time in? [ ] [ ] [ ] [ ] [ ] [ ]

98. List the rooms you work in currently and select the amount of time spent there in an average week:

Room Number: 1

[ ] [ ] [ ] [ ] [ ] [ ]

- less than 1 day per week
- at least 1 day, but less than 3 days per week
- at least 3 days, but less than 5 days per week
- 5 or more days per week

Room Number: 2

[ ] [ ] [ ] [ ] [ ] [ ]

- less than 1 day per week
- at least 1 day, but less than 3 days per week
- at least 3 days, but less than 5 days per week
- 5 or more days per week

Room Number: 3

[ ] [ ] [ ] [ ] [ ] [ ]

- less than 1 day per week
- at least 1 day, but less than 3 days per week
- at least 3 days, but less than 5 days per week
- 5 or more days per week

Room Number: 4

[ ] [ ] [ ] [ ] [ ] [ ]

- less than 1 day per week
- at least 1 day, but less than 3 days per week
- at least 3 days, but less than 5 days per week
- 5 or more days per week

**Thank you for completing this survey.**

## A3.6 Phase 2 Baseline Questionnaire

JAXCohort Baseline Questionnaire

Date:  /  /   
M M D D Y Y Y Y

### Part 1. MEDICAL AND FAMILY HISTORY

1. Date of Birth:  /  /   
M M D D Y Y Y Y

2. Place of Birth:     
city state country

3. Are you male or female?  Male  
 Female

4. What is your marital status?  Single  
 Married/Partnered  
 Widowed  
 Separated  
 Other

5. How would you describe your race/ethnic background? (select all that apply)

- White
- Black, African-American, or Negro
- Asian Indian
- Chinese
- American Indian or Alaska Native
- Filipino
- Japanese
- Korean
- Vietnamese
- Other Asian ..... What is this race?
- Native Hawaiian
- Guamanian/Chamorro
- Samoan
- Other Pacific Islander ..... What is this race?
- Some other race ..... What is this race?
- I don't know

5a. Are you Mexican, Puerto Rican, Cuban, or of another Hispanic or Latino group? (Please select one)

- No, not Spanish/Hispanic/Latino
- Yes, Mexican/Mexican-American/Chicano
- Yes, Puerto Rican
- Yes, Cuban
- Yes, other Spanish/Hispanic/Latino if other, what is the group?

6. How much school have you completed?

- 8th grade or less
- 9th-11th grade
- high school graduate
- some college or technical school
- college graduate
- post-graduate

These questions pertain mainly to your chest. Please answer *yes* or *no* if possible. If you are in doubt about whether your answer is *yes* or *no*, select *no*.

**COUGH**

7. Do you usually have a cough? (If no, skip to Question 7b.)  yes  no
- 7a. Do you usually cough as much as 4 to 6 times a day, 4 or more days out of the week?  yes  no
- 7b. Do you usually cough at all on getting up, or first thing in the morning?  yes  no
- 7c. Do you usually cough at all during the rest of the day or at night?  yes  no

*IF YES TO ANY OF THE ABOVE (7a, b, or c), ANSWER THE FOLLOWING:  
IF NO TO ALL, SELECT DOES NOT APPLY AND SKIP TO THE NEXT PAGE.*

7d. Do you usually cough like this on most days for 3 consecutive months or more during the year?  yes  no  does not apply

7e. For how many years have you had this cough?   years  does not apply

**PHLEGM (MUCUS)**

8. Do you usually bring up phlegm (mucus) from your chest? (Count phlegm (mucus) on first going outdoors and swallowed phlegm (mucus). Do not count phlegm (mucus) from the nose.) (If no, skip to Question 8b.)  yes  no
- 8a. Do you usually bring up phlegm (mucus) like this as much as twice a day, 4 or more days out of the week?  yes  no
- 8b. Do you usually bring up phlegm (mucus) at all on getting up, or first thing in the morning?  yes  no
- 8c. Do you usually bring up phlegm (mucus) at all during the rest of the day or at night?  yes  no

*IF YES TO ANY OF THE ABOVE (8, a, b, or c), ANSWER THE FOLLOWING:  
IF NO TO ALL, SELECT DOES NOT APPLY AND SKIP TO 9.*

8d. Do you bring up phlegm like this on most days for 3 consecutive months or more during the year?  yes  no  does not apply

8e. For how many years have you had trouble with phlegm (mucus)?   years  does not apply

**EPISODES OF COUGH AND PHLEGM (MUCUS)**

9. Have you had periods of (Increased\*) cough and phlegm (mucus) lasting for 3 or more weeks each year?  yes  no

\* (For persons who usually have cough and/or phlegm (mucus))

IF YES TO 9, ANSWER THE FOLLOWING:  
IF NO TO 9, SELECT DOES NOT APPLY AND SKIP TO 10.

9a. For how long have you had at least 1 such episode per year?   years  does not apply

**WHEEZING**

Does your chest ever sound wheezy or whistling:

10. When you have a cold?  yes  no

10a. Occasionally apart from colds?  yes  no

10b. Most days or nights?  yes  no

IF YES TO 10, 10a, OR 10b, ANSWER THE FOLLOWING:  
IF NO TO ALL, SELECT DOES NOT APPLY AND SKIP TO 11.

10c. For how many years has this been present?   years  does not apply

11. Have you ever had an attack of wheezing that has made you feel short of breath?  yes  no

IF YES TO 11, ANSWER THE FOLLOWING:  
IF NO TO 11, SELECT DOES NOT APPLY FOR 11A,B,C, AND SKIP TO 12.

11a. How old were you when you had your first such attack?   years  does not apply

11b. Have you had two or more such episodes?  yes  no  does not apply

11c. Have you ever required medicine or treatment for the(se) attack(s)?  yes  no  does not apply

**BREATHLESSNESS**

12. Are you disabled from walking as a result of any condition?

yes  no *If YES, please describe:*

13. Are you troubled by shortness of breath when hurrying on level ground or walking up a slight hill?

yes  no

IF YES TO 13, ANSWER THE FOLLOWING:  
IF NO TO 13, SELECT DOES NOT APPLY FOR 13A, B, C, D AND SKIP TO 14.

- 13a. Do you have to walk slower than people of your own age on the level because of breathlessness?  yes  no  Does not apply
- 13b. Do you ever have to stop for breath when walking at your own pace on the level?  yes  no  Does not apply
- 13c. Do you ever have to stop for breath after walking about 100 yards (or after a few minutes) on the level?  yes  no  Does not apply
- 13d. Are you too breathless to leave the house or breathless on dressing and undressing?  yes  no  Does not apply

#### CHEST COLDS AND CHEST ILLNESSES

14. If you get a cold, does it usually go down to your chest? (Usually means more than 1/2 the time)  yes  no  Don't get colds
15. During the past 3 years, have you had any chest illnesses that have kept you off work, indoors at home, or in bed?  yes  no (skip to question 16)

IF YES TO 15, ANSWER THE FOLLOWING:  
IF NO TO 15 SELECT DOES NOT APPLY FOR 15A, B AND SKIP TO 16.

- 15a. Did you produce phlegm (mucus) with any of these chest illnesses?  yes  no  Does not apply
- 15b. In the last 3 years, how many such illnesses, with (increased) phlegm, did you have which lasted a week or more?   Number of illnesses  
 no such illnesses  
 Does not apply

#### PAST ILLNESSES

16. Did you have any lung trouble before the age of 16?  yes  no

Have you ever had any of the following?

17. Attacks of bronchitis?  yes  no

IF YES TO 17, ANSWER THE FOLLOWING:  
IF NO TO 17, SELECT DOES NOT APPLY FOR 17A, B AND SKIP TO 18

- 17a. Was it confirmed by a doctor?  yes  no  Does not apply
- 17b. At what age was your first attack?   age in years  Does not apply

18. Pneumonia (including bronchopneumonia)?  yes  no

IF YES TO 18, ANSWER THE FOLLOWING:  
IF NO TO 18 SELECT DOES NOT APPLY FOR 18A, B, AND SKIP TO 19

- 18a. Was it confirmed by a doctor?  yes  no  Does not apply
- 18b. At what age did you first have it?   age in years  Does not apply

19. Hay fever?  yes  no

*IF YES TO 19, ANSWER THE FOLLOWING:  
IF NO TO 19 SELECT DOES NOT APPLY FOR 19A, B, AND SKIP TO 20.*

19a. Was it confirmed by a doctor?	<input type="radio"/> yes	<input type="radio"/> no	<input type="radio"/> Does not apply
19b. At what age did it start?	<input type="text"/>	<input type="text"/>	age in years <input type="radio"/> Does not apply

*IF YES TO 22, ANSWER THE FOLLOWING:  
IF NO TO 22 SELECT DOES NOT APPLY FOR 22A, B, C, D AND SKIP TO 23.*

22a. Do you still have it?	<input type="radio"/> yes	<input type="radio"/> no	<input type="radio"/> Does not apply
22b. Was it confirmed by a doctor?	<input type="radio"/> yes	<input type="radio"/> no	<input type="radio"/> Does not apply
22c. At what age did it start?	<input type="text"/>	<input type="text"/>	age in years <input type="radio"/> Does not apply
22d. If you no longer have it, at what age did it stop?	<input type="text"/>	<input type="text"/>	age stopped <input type="radio"/> Does not apply

20. Have you ever had chronic bronchitis?  yes  no

*IF YES TO 20, ANSWER THE FOLLOWING:  
IF NO TO 20 SELECT DOES NOT APPLY FOR 20A,B,C AND SKIP TO 21.*

20a. Do you still have it?	<input type="radio"/> yes	<input type="radio"/> no	<input type="radio"/> Does not apply
20b. Was it confirmed by a doctor?	<input type="radio"/> yes	<input type="radio"/> no	<input type="radio"/> Does not apply
20c. At what age did it start?	<input type="text"/>	<input type="text"/>	age in years <input type="radio"/> Does not apply

21. Have you ever had emphysema?  yes  no

*IF YES TO 21, ANSWER THE FOLLOWING:  
IF NO TO 21 SELECT DOES NOT APPLY FOR 21A,B,C AND SKIP TO 22.*

21a. Do you still have it?	<input type="radio"/> yes	<input type="radio"/> no	<input type="radio"/> Does not apply
21b. Was it confirmed by a doctor?	<input type="radio"/> yes	<input type="radio"/> no	<input type="radio"/> Does not apply
21c. At what age did it start?	<input type="text"/>	<input type="text"/>	age in years <input type="radio"/> Does not apply

22. Have you ever had asthma?  yes  no

23. Have you ever had:

23a. Any other chest illnesses?  yes  no

If yes, please specify:

23b. Any chest operations?  yes  no

If yes, please specify:

23c. Any chest injuries?  yes  no

If yes, please specify:

**OCCUPATIONAL HISTORY**

24. Prior to your current job, have you ever worked full time (30 hours a week or more) for 6 months or more?  yes  no

25. What has been your usual occupation or job - the one you have worked at the longest?

25a. Job-occupation:

25b. Number of years employed in this occupation:

25c. Position-job title:

25d. Business, field, or industry:

26. Did you ever work with mice before starting your job at Jackson Labs?  yes  no

*IF YES TO 26, ANSWER THE FOLLOWING:  
IF NO TO 26, SKIP TO 27.*

26a. What year did you start working with mice?

26b. What year did you stop working with mice?

26c. What was your primary (main) task? (select one)

- Husbandry (breeding, weaning)
- Animal care (weaning/changing cages)
- Laboratory experiments (ex: obtaining blood or tissue samples, performing surgery)
- Autopsies
- Dumping dirty boxes
- Preparing mice for shipment

27. Have you ever worked with laboratory animals other than mice?  yes  no

IF YES TO 27: What types of animals? (Select all that apply)  
 IF NO TO 27, SKIP TO 29.

- 27a.  Rats
- 27b.  Guinea Pigs
- 27c.  Rabbits
- 27d.  Hamsters
- 27e.  Primates (monkeys, chimpanzees, gorillas, baboons)
- 27f.  Other-please specify

28. For each animal selected what year did you start and stop working with the animal? What was your primary task related to the animal?

			Primary Task Related
A Rats:	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year start	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year stop	<div style="border: 1px solid black; height: 25px;"></div>
B Guinea Pigs:	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year start	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year stop	<div style="border: 1px solid black; height: 25px;"></div>
C Rabbits:	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year start	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year stop	<div style="border: 1px solid black; height: 25px;"></div>
D Hamsters:	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year start	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year stop	<div style="border: 1px solid black; height: 25px;"></div>
E Primates:	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year start	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year stop	<div style="border: 1px solid black; height: 25px;"></div>
F Other:	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year start	<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> year stop	<div style="border: 1px solid black; height: 25px;"></div>

**TOBACCO SMOKING**

29. Have you ever smoked cigarettes? (No means less than 20 packs of cigarettes or 12 oz of tobacco in a lifetime or less than 1 cigarette a day for 1 year)  yes  no (skip to question 35)

IF YES TO 29, ANSWER THE FOLLOWING:  
 IF NO TO 29 SELECT DOES NOT APPLY FOR 30,31,33,34 AND SKIP TO 35.

30. Do you now smoke cigarettes (as of 1 month ago)?  yes  no  Does not apply

31. How old were you when you first started regular cigarette smoking?  Age in years  Does not apply

32. If you have stopped smoking cigarettes completely, how old were you when you stopped?  Age stopped  Still smoking

33. How many cigarettes do you smoke per day now?  Cigarettes per day  Does not apply

34. On the average of the entire time you smoked, how many cigarettes did you smoke per day?  Cigarettes per day  Does not apply

**FAMILY HISTORY**

35. Was your father/mother ever told by a doctor that they had a chronic lung condition such as:

<u>FATHER</u>		<u>MOTHER</u>
A. Chronic bronchitis?	<input type="radio"/> yes <input type="radio"/> no <input type="radio"/> don't know	<input type="radio"/> yes <input type="radio"/> no <input type="radio"/> don't know
B. Emphysema?	<input type="radio"/> yes <input type="radio"/> no <input type="radio"/> don't know	<input type="radio"/> yes <input type="radio"/> no <input type="radio"/> don't know
C. Asthma?	<input type="radio"/> yes <input type="radio"/> no <input type="radio"/> don't know	<input type="radio"/> yes <input type="radio"/> no <input type="radio"/> don't know
D. Lung cancer?	<input type="radio"/> yes <input type="radio"/> no <input type="radio"/> don't know	<input type="radio"/> yes <input type="radio"/> no <input type="radio"/> don't know
E. Other chest conditions?	<input type="radio"/> yes <input type="radio"/> no <input type="radio"/> don't know	<input type="radio"/> yes <input type="radio"/> no <input type="radio"/> don't know

36. Is your father currently alive?  
 yes  no  don't know

36a. Please specify:

<input type="text"/>	<input type="text"/>	<input type="text"/>	age if living
<input type="text"/>	<input type="text"/>	<input type="text"/>	age at death

don't know

36b. If your father is deceased, please specify cause of death?

Is your mother currently alive?  
 yes  no  don't know

36a. Please specify:

<input type="text"/>	<input type="text"/>	<input type="text"/>	age if living
<input type="text"/>	<input type="text"/>	<input type="text"/>	age at death

don't know

If your mother is deceased, please specify cause of death?

**RHINITIS**

37. Have you EVER had a problem with sneezing or a runny or stuffy nose when you **DID NOT** have a cold or the flu?  yes  no (skip to question 40.)

*IF YES TO 37, ANSWER THE FOLLOWING:*

Have you EVER had a problem with sneezing or a runny or stuffy nose as a result of exposure to any of the following circumstances?

- 37a. being near lab mice.....  yes  no  no exposure  uncertain
- 37b. cats.....  yes  no  no exposure  uncertain
- 37c. dogs.....  yes  no  no exposure  uncertain
- 37d. pollens (grass, trees, weeds, etc.)....  yes  no  no exposure  uncertain
- 37e. during certain seasons.....  yes  no  no exposure  uncertain

*IF YES TO 37e, which seasons? (select all that apply):*

- Winter  Spring  Summer  Fall

38. Have you had a problem with sneezing or a runny or stuffy nose as a result of exposure to any of the following circumstances **IN THE PAST 12 MONTHS**?

- 38a. being near lab mice.....  yes  no  no exposure  uncertain
- 38b. cats.....  yes  no  no exposure  uncertain
- 38c. dogs.....  yes  no  no exposure  uncertain
- 38d. pollens (grass, trees, weeds, etc.)..  yes  no  no exposure  uncertain
- 38e. during certain seasons.....  yes  no  no exposure  uncertain

*IF YES TO 38e, which seasons? (select all that apply):*

- Winter  Spring  Summer  Fall

39. Has a doctor or health care provider ever told you that you have allergies or hay fever?  yes  no

**ECZEMA**

40. Have you EVER had an itchy, scaly or weepy skin rash that comes and goes for at least 6 months?

- yes  no (skip to question 45.)

*IF YES TO 40, ANSWER THE FOLLOWING:*

41. Has this itchy rash at any time affected any of the following places: The folds of the elbows, behind the knees, in front of the ankles, under the buttocks, or around the neck, ears, or eyes?  yes  no

42. Have you EVER had this rash as a result of exposure to any of the following circumstances?

- 42a. being near lab mice.....  yes  no  no exposure  uncertain
- 42b. cats.....  yes  no  no exposure  uncertain
- 42c. dogs.....  yes  no  no exposure  uncertain
- 42d. pollens (grass, trees, weeds, etc.)....  yes  no  no exposure  uncertain

43. Have you had this rash as a result of exposure to any of the following circumstances **IN THE PAST 12 MONTHS?**
- 43a. being near lab mice.....  yes  no  no exposure  uncertain
- 43b. cats.....  yes  no  no exposure  uncertain
- 43c. dogs.....  yes  no  no exposure  uncertain
- 43d. pollens (grass, trees, weeds, etc.)....  yes  no  no exposure  uncertain
44. Has a doctor or health care provider ever told you that you have eczema or atopic dermatitis?  yes  no

**HIVES**

45. Have you EVER had welts or hives?  yes  no (skip to question 49)

*IF YES TO 45, ANSWER THE FOLLOWING:*

46. Have you **EVER** had welts or hives as a result of exposure to any of the following circumstances?
- 46a. being near lab mice.....  yes  no  no exposure  uncertain
- 46b. cats.....  yes  no  no exposure  uncertain
- 46c. dogs.....  yes  no  no exposure  uncertain
- 46d. pollens (grass, trees, weeds, etc.)...  yes  no  no exposure  uncertain
47. Have you had welts or hives as a result of exposure to any of the following circumstances **IN THE PAST 12 MONTHS?**
- 47a. being near lab mice.....  yes  no  no exposure  uncertain
- 47b. cats.....  yes  no  no exposure  uncertain
- 47c. dogs.....  yes  no  no exposure  uncertain
- 47d. pollens (grass, trees, weeds, etc.)..  yes  no  no exposure  uncertain
48. Has a doctor or health care provider ever told you that you had hives or urticaria?  yes  no

**COUGH**

49. Have you sometimes had a cough when you **DID NOT** have a cold or the flu?

- yes    no (skip to question 52)

**IF YES TO 49, ANSWER THE FOLLOWING:**

<p>50. Have you <b>EVER</b> had a cough as a result of exposure to any of the following circumstances?</p> <p>50a. being near lab mice.....   <input type="radio"/> yes   <input type="radio"/> no   <input type="radio"/> no exposure   <input type="radio"/> uncertain</p> <p>50b. cats.....   <input type="radio"/> yes   <input type="radio"/> no   <input type="radio"/> no exposure   <input type="radio"/> uncertain</p> <p>50c. dogs.....   <input type="radio"/> yes   <input type="radio"/> no   <input type="radio"/> no exposure   <input type="radio"/> uncertain</p> <p>50d. pollens (grass, trees, weeds, etc.)...   <input type="radio"/> yes   <input type="radio"/> no   <input type="radio"/> no exposure   <input type="radio"/> uncertain</p> <p>50e. during certain seasons.....   <input type="radio"/> yes   <input type="radio"/> no   <input type="radio"/> no exposure   <input type="radio"/> uncertain</p> <p><b>IF YES TO 50e, which seasons? (select all that apply):</b></p> <p><input type="radio"/> Winter   <input type="radio"/> Spring   <input type="radio"/> Summer   <input type="radio"/> Fall</p>
<p>51. Have you had a cough as a result of exposure to any of the following circumstances <b>IN THE PAST 12 MONTHS</b>?</p> <p>51a. being near lab mice.....   <input type="radio"/> yes   <input type="radio"/> no   <input type="radio"/> no exposure   <input type="radio"/> uncertain</p> <p>51b. cats.....   <input type="radio"/> yes   <input type="radio"/> no   <input type="radio"/> no exposure   <input type="radio"/> uncertain</p> <p>51c. dogs.....   <input type="radio"/> yes   <input type="radio"/> no   <input type="radio"/> no exposure   <input type="radio"/> uncertain</p> <p>51d. pollens (grass, trees, weeds, etc.)...   <input type="radio"/> yes   <input type="radio"/> no   <input type="radio"/> no exposure   <input type="radio"/> uncertain</p> <p>51e. during certain seasons.....   <input type="radio"/> yes   <input type="radio"/> no   <input type="radio"/> no exposure   <input type="radio"/> uncertain</p> <p><b>IF YES TO 51e, which seasons? (select all that apply):</b></p> <p><input type="radio"/> Winter   <input type="radio"/> Spring   <input type="radio"/> Summer   <input type="radio"/> Fall</p>

**WHEEZING**

52. Has your chest ever sounded wheezy or whistling when you **DID NOT** have a cold or the flu?

- yes    no (skip to question 55.)

**IF YES TO 52, ANSWER THE FOLLOWING:**

<p>53. Has your chest <b>EVER</b> sounded wheezy or whistling as a result of exposure to any of the following circumstances?</p> <p>53a. being near lab mice.....   <input type="radio"/> yes   <input type="radio"/> no   <input type="radio"/> no exposure   <input type="radio"/> uncertain</p> <p>53b. cats.....   <input type="radio"/> yes   <input type="radio"/> no   <input type="radio"/> no exposure   <input type="radio"/> uncertain</p> <p>53c. dogs.....   <input type="radio"/> yes   <input type="radio"/> no   <input type="radio"/> no exposure   <input type="radio"/> uncertain</p> <p>53d. pollens (grass, trees, weeds, etc.)...   <input type="radio"/> yes   <input type="radio"/> no   <input type="radio"/> no exposure   <input type="radio"/> uncertain</p> <p>53e. during certain seasons.....   <input type="radio"/> yes   <input type="radio"/> no   <input type="radio"/> no exposure   <input type="radio"/> uncertain</p> <p><b>IF YES TO 53e, which seasons? (select all that apply):</b></p> <p><input type="radio"/> Winter   <input type="radio"/> Spring   <input type="radio"/> Summer   <input type="radio"/> Fall</p>
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54. Has your chest ever sounded wheezy or whistling as a result of exposure to any of the following circumstances **IN THE PAST 12 MONTHS**?

54a. being near lab mice.....  yes  no  no exposure  uncertain

54b. cats.....  yes  no  no exposure  uncertain

54c. dogs.....  yes  no  no exposure  uncertain

54d. pollens (grass, trees, weeds, etc.)..  yes  no  no exposure  uncertain

54e. during certain seasons.....  yes  no  no exposure  uncertain

*IF YES TO 54e, which seasons? (select all that apply):*

Winter  Spring  Summer  Fall

**SHORTNESS OF BREATH/TIGHTNESS IN CHEST**

55. Have you EVER been bothered by shortness of breath or tightness in your chest when hurrying on flat ground or walking up a slight hill?

yes  no (skip to question 58)

*IF YES TO 55, ANSWER THE FOLLOWING:*

56. Have you EVER been bothered by shortness of breath or tightness in your chest as a result of exposure to any of the following circumstances?

56a. being near lab mice.....  yes  no  no exposure  uncertain

56b. cats.....  yes  no  no exposure  uncertain

56c. dogs.....  yes  no  no exposure  uncertain

56d. pollens (grass, trees, weeds, etc.)...  yes  no  no exposure  uncertain

56e. during certain seasons.....  yes  no  no exposure  uncertain

*IF YES TO 56e, which seasons? (select all that apply):*

Winter  Spring  Summer  Fall

57. Have you been bothered by shortness of breath or tightness in your chest as a result of exposure to any of the following circumstances **IN THE PAST 12 MONTHS**?

57a. being near lab mice.....  yes  no  no exposure  uncertain

57b. cats.....  yes  no  no exposure  uncertain

57c. dogs.....  yes  no  no exposure  uncertain

57d. pollens (grass, trees, weeds, etc.)...  yes  no  no exposure  uncertain

57e. during certain seasons.....  yes  no  no exposure  uncertain

*IF YES TO 57e, which seasons? (select all that apply):*

Winter  Spring  Summer  Fall

**ALLERGY SHOTS**

61. Have you ever received shots for your allergies on a regular basis?  yes  
 no (skip to PART III. of the questionnaire)  
 uncertain (skip to PART III. of the questionnaire)

IF YES TO 61, ANSWER THE FOLLOWING:

62. Are you still receiving shots?  
 yes  
 no (if no, what was the last year you received shots?)     year

63. For how many years did you receive/have you been receiving allergy shots?   years

64. What types of allergens (such as trees, grass, weeds, cat, dog, mouse, dust/mite) were/are in your shots?

**PART III: ASTHMA**

65. Has any doctor or medical provider ever told you that you have chronic bronchitis, emphysema, or chronic obstructive pulmonary disease (COPD)?  yes  no
66. Has any doctor or medical provider ever told you that you have asthma?  yes  no  unsure

IF NO TO QUESTION 66, SKIP TO PART IV. OF THE QUESTIONNAIRE, EXPOSURES

In the past 4 weeks, did you... (read this phrase prior to each question 67 & 67a)

67. Miss any work, school, or normal daily activity because of your asthma?  yes  no  unsure
- 67a. Wake up at night because of asthma?  yes  no  unsure

Do you believe...

68. Your asthma was well controlled in the past 4 weeks?  yes  no  unsure
- 68a. You are able to take your asthma medicine(s) as directed?  yes  no  unsure
- 68b. Your medicine(s) are useful in controlling your asthma?  yes  no  unsure
69. Do you use an inhaler for quick relief from asthma symptoms?  yes  no  unsure

IF YES TO 69, ANSWER THE FOLLOWING:

69a. In the past 4 weeks, what was the highest number of puffs in one day you took of this inhaler?

0 puffs  
 1 to 4 puffs  
 5 to 8 puffs  
 9 to 12 puffs  
 over 12 puffs

70. Has a doctor or medical provider ever prescribed an asthma inhaler or pill that is **NOT** used for quick relief, but is used to control your asthma?  yes  no  unsure

- 70a. What best describes how you take this medicine now?
- I take it every day
  - Some days I take it, but other days I don't
  - I used to take it, but now I don't
  - I only take it when I have symptoms
  - I never took it

**ASTHMA ATTACKS**

71. Have you ever needed to go to an emergency room, doctor's office or clinic because of an asthma attack?  yes  no (skip to question 74.)

*IF YES TO 71, ANSWER THE FOLLOWING:*

72. How many times in the last 12 months?
73. How many times in your life?

74. Have you ever been hospitalized overnight because of an asthma attack?  yes  no (skip to question 77.)

*IF YES TO 74, ANSWER THE FOLLOWING:*

75. How many times have you been hospitalized for asthma in the last 12 months?
76. Have you ever been hospitalized in an intensive care unit (ICU) for asthma?  yes  no  uncertain
- 76a. Because of an asthma attack, has a tube ever been placed inside your lungs and connected to a machine to help you breathe?  yes  no  uncertain

**For the past four weeks: (Read this phrase prior to questions 77-81)**

77. Has asthma kept you from getting as much done at work or home?
- Not at all  A little  Moderately  Quite a lot  Extremely
78. Rate your asthma control:
- Not controlled at all
  - Poorly controlled
  - Somewhat controlled
  - Well controlled
  - Completely controlled

**For the past four weeks:** (Read this phrase prior to questions 77-81)

79. How often have you had shortness of breath?

- Not at all    Once/twice a week    3-6 times a week    Once a day    More than once a day

80. How often have asthma symptoms woken you up at night or earlier than usual?

- Not at all    Once/twice    Once a week    2-3 nights a week    4 or more nights a week

81. How often have you used your rescue inhaler or nebulizer medication?    Not at all

Once a week or less

A few times a week

1-2 times per day

3 or more times per day

**PART IV EXPOSURES**

**HOME:**

82. Have you **ever** seen mice or evidence of mice in your home?    yes    no

*IF YES TO 82, ANSWER THE FOLLOWING:*

- 82a. When did you last see mice or evidence of mice in your home?    In the past month  
 In the past 12 months  
 more than 12 months ago

83. Have you **ever** seen rats in your home?    yes    no

*IF YES TO 83, ANSWER THE FOLLOWING:*

- 83a. When did you last see rats in your home?    In the past month  
 In the past 12 months  
 more than 12 months ago

84. Do you currently have any pets at home?    yes    no (skip to question 88)

*IF YES TO 84, ANSWER THE FOLLOWING:*

85. Select the kind of pets that you currently have in your home (select all that apply):

- cat    dog    hamster    rabbit    guinea pig    mouse or mice    other (specify)

86. For each pet currently in your home, how many years has this kind of pet been in your home?

- Cat     Rabbit     Guinea pig     other (specify)    
Dog     Hamster     Mouse

**WORK:**

87. What is your current job title at The Jackson Laboratory?

88. What was your first day of work at The Jackson Laboratory?  /  /   
M M D D Y Y Y Y

89. For how long have you been working in your current position at The Jackson Laboratory?  
 1 Month  2 Months  3 Months  Other (specify)

90. In your current job at The Jackson Laboratory, do you handle mice?  
 yes  
 no

91. Look at the map of the Jackson Lab buildings. (*Show Map*) What is the name of the building you spend most of your time in?

91a. What is the number of the building you spend most of your time in?

92. Look at the map of the building you work in, what is the number of the room you spend most of your time in?

93. List the rooms you work in currently and select the amount of time spent there in an average week:

Room Number: 1

- less than 1 day per week
- at least 1 day, but less than 3 days per week
- at least 3 days, but less than 5 days per week
- 5 or more days per week

Room Number: 2

- less than 1 day per week
- at least 1 day, but less than 3 days per week
- at least 3 days, but less than 5 days per week
- 5 or more days per week

Room Number: 3

- less than 1 day per week
- at least 1 day, but less than 3 days per week
- at least 3 days, but less than 5 days per week
- 5 or more days per week

Room Number: 4

- less than 1 day per week
- at least 1 day, but less than 3 days per week
- at least 3 days, but less than 5 days per week
- 5 or more days per week

**Thank you for completing this survey.**

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Born in Portland Oregon, June 28, 1977

**EDUCATION**

**DrPH** Johns Hopkins School of Public Health, Baltimore, MD 09/09 – 10/14  
Occupational and Environmental Public Health, NIOSH Fellow, Certificate in Risk Assessment

**MSN/MPH**, Johns Hopkins School of Nursing, Baltimore, MD 07/07 –12/08  
Occupational and Environmental Public Health Nursing, Alice Gifford’s Award for Capstone Excellence

**BSN**, Johns Hopkins University School of Nursing, Baltimore, MD 06/05 – 08/06  
Accelerated program, Peace Corps Fellow

**BA**, Wesleyan University, Middletown, CT 09/95 – 06/99  
Graduated with Honors in Biology, Hughes Grant Research Fellow

**EXPERIENCE**

**Deputy Director, Community Asthma Program** 01/09 – 02/10  
Healty Homes Division, Baltimore City Health Department, Baltimore, MD

Coordinated a home visiting program for 250 low-income families with asthmatic children, focused on improving indoor-air quality and reducing other threats to health and safety in the home.

Developed and implemented home visiting and inspection protocols based on national guidelines and evidence-based research regarding pediatric asthma and healthy housing.

Recruited, trained and supervised a team of public health investigators to inspect homes and create plans of action for families based on their unique medical and environmental needs.

Developed the program’s budget, oversaw purchasing, tracked expenditures, and released requests for proposals for services with vendors.

Assisted the bureau’s lead-poisoning prevention program in developing and implementing their healthy homes inspection protocols, and provided clinical insight on their more medically complex cases.

Participated in a team effort to quantify and track Baltimore city’s emerging bedbug infestation including: determining the legal ramifications of infestation in different types of housing, creating bedbug inspection and investigation protocols, training staff, and, drafting and enforcing bedbug citations within multifamily properties.

Wrote grants and disseminated findings and lessons learned at local and national forums.

**Graduate Public Health Nursing Intern** 01/08 – 12/08

Healthy Homes Division, Baltimore city Health Department, Baltimore, MD

Facilitated a strategic partnership between Baltimore's health department and housing authority, HUD, the National Center for Healthy Housing, pest control providers and the residents of the pilot facility in order to implement an integrated pest management pilot at a public housing property for 180 elderly and disabled residents.

Performed site inspection and needs assessment focusing on the environmental and social factors contributing to pest infestation. Developed, implemented, and evaluated a series of interventions including structural improvements, trainings, and working one-on-one with residents in their apartments to implement integrated pest management practices.

Provided HABC with policy recommendations regarding the expansion of the pilot to other sites.

**Medical/Surgical RN, 09/06 – 07/07**

Union Memorial Hospital Baltimore, MD

Provided tailored, patient-centered care as part of interdisciplinary team at a community hospital in an impoverished area.

Research Committee member, translated research into evidenced-based nursing practice and worked with manager to decrease the spread of nosocomial infections.

**Research Assistant, 10/02 – 05/05**

Oregon Health Sciences University,

Center for Occupational & Environmental Toxicology Portland, OR

Designed, conducted and analyzed experiments, assisted in preparing manuscripts for publication and grant writing.

Maintained transgenic mouse colony, and performed primary tissue culture.

Developed primary cell lines and trained new lab members in research protocols/techniques.

**Peace Corps Volunteer, Environmental Education** 06/00 – 09/02

Programme for Belize, Belize

Coordinated the first aquatic biodiversity studies performed on the New River Lagoon, assisted in training international team of interns in research methodology, co-wrote reports on findings.

Coordinated a two-year environmental education outreach campaign to 65 rural high schools.

Assisted 21 communities in their development of culturally appropriate, environmentally-sustainable cottage industries, including: beekeeping, agro-forestry, hydroponics and eco/ethno- tourism.

Created a sustainable development outdoor classroom including: medicinal garden, timber species nursery and agro-forestry plot, on the Rio Bravo Conservation and Management Area.

Assisted in the planning, implementation and evaluation of the United Nations Central American Ecotourism Summit, in Belize City, Belize.

**Research Assistant**, 01/97 – 05/00

Wesleyan University Middletown, CT

Honors thesis in Biology, investigated the role of a class of patterning genes in embryonic angiogenesis using mouse embryonic stem cells as a model.

Conducted experiments, trained new students, assisted with manuscript and poster preparation.

LICENSES, CERTIFICATIONS & ADDITIONAL SKILLS

**Registered Nurse**, Maryland State Board of Nursing

**Healthy Homes Specialist**, National Center for Healthy Housing

**Visual Inspector for Lead**, Maryland State Department of the Environment

**Proficient in Spanish:** 2 years living and working in Spanish speaking communities, 8 years of course work

**Computer Skills:** STATA, Microsoft Office, Adobe Photoshop & In-Design

**Teaching:** Teaching assistant (graduate & undergraduate, taught ESL as Peace Corps volunteer

PUBLICATIONS, POSTERS & PROFESSIONAL REPORTS

Environmental Health and Nursing, contributing author. Undergraduate textbook regarding the role of the environment in our health. FA Davis, Philadelphia, PA, *in press*

Your Home, Your Health, co-author with Dion Lerhman. A photobook for low-income urban parents on how to prevent and eliminate pest infestation using integrated pest management, sponsored by the US EPA and the National Center for Healthy Housing, *in press*

Evaluation of an Integrated Pest Management Pilot in Elderly and Disabled Public Housing (2009). Final report and policy recommendations provided to the Baltimore City Health Department and the Housing Authority of Baltimore City.

Kasameyer, E., Connolly, L., Lasarev, M. & Turker, M.S., (2008). The spectra of large second-step mutations are similar for two different mouse autosomes. *Mutation Research/ Fundamental and Molecular Mechanisms of Mutagenesis*. 637(1-2):66-72

Turker, M.S., Lasarev, M., Connolly, L., Kasameyer, E. & Roessler, D., (2007). Age-related accumulation of autosomal mutations in solid tissues of the mouse is gender and cell type specific. *Aging Cell*. Feb;6(1):73-86

Turker, M.S., Schwartz, J.L., Jordan, R., Ponomareva, O.N., Connolly, L., Kasameyer, E., Lasarev, M. & Clepper, L., (2004). Persistence of chromatid aberrations in the cells of solid mouse tissues exposed to <sup>137</sup>Cs gamma radiation. *Radiation Research*. Oct;162(4):375-64

French, A. & Kasameyer, E., (2001). A Preliminary Study on the Fish Biodiversity of the New River Lagoon. Belize City District, Belize Central America. Programme for Belize

Maye, P., Becker, S., Kasameyer, E., Byrd, N. & Grabel, L., (2000). Indian hedgehog signaling in extra-embryonic endoderm and ectoderm differentiation in ES embryoid bodies. *Mechanisms of Development*. 94:117-132

Maye, P., Becker, S., Kasameyer, E., Byrd, N., & Grabel, L., Wesleyan University, Middletown, CT. Indian Hedgehog is required for normal differentiation of ES cell embryoid bodies. Poster presented at the Society for Developmental Biology annual meeting May 7, 1999, Woods Hole, MA

#### PRESENTATIONS & LECTURES

“Bedbugs and the Home-visiting Nurse: Staying Safe While Caring for Others” (2013). Guest lecture for community health nursing preceptors, Johns Hopkins School of Nursing, Baltimore, MD

“Baltimore City Health Department’s Response to the Bedbug Epidemic: A Case Study in the Application of Risk Assessment Techniques” (2012). Guest lecture for undergraduate nursing students, Johns Hopkins School of Nursing, Baltimore, MD

“Bedbugs: Biology, Inspection and Elimination” (2011). Trained staff at the Housing Authority of Portland how to inspect for and effectively eliminate bedbugs, Portland, OR

“Healthy Housing Resources: Using the Law to Improve Health” (2011). Guest lecture for graduate-level nursing students regarding state and federal laws that can be used to reduce health risks in homes, Johns Hopkins School of Nursing, Baltimore, MD

“Novel Model for Bedbug Control: Subsidized Integrated Pest Management Extermination, Evaluation and Lessons Learned” (2011). Presenter at the 75<sup>th</sup> National Environmental Health Association, Columbus, OH

“Environmental Public Health for the Modern RN: Healthy Homes Assessments & Vulnerable Populations” (2011). Guest lecture for undergraduate nursing students in Community Health Nursing course, Johns Hopkins School of Nursing, Baltimore, MD

“Integrated Pest Management: Improving Health and Safety of In-home Daycare” (2010). Continuing Educational Credit lecture given to daycare inspectors for the Maryland State Department of Health and Mental Hygiene.

“Bedbugs in Context: Potential Impacts on Today’s Vulnerable Populations” (2009). Presented at the 6<sup>th</sup> International Integrated Pest Management Symposium, Portland, OR

“An Integrated Pest Management Pilot in its First Year: Building Strategic Partnerships” (2008). Presented at the 8<sup>th</sup> Annual National Healthy Homes Conference, Baltimore, MD