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Assessing COVID-19 Pandemic Risk Perception and Response Preparedness in Veterinary and Animal Care Workers

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Veterinary and animal care workers perform critical functions in biosecurity and public health, yet little has been done to understand the unique needs and barriers these workers face when responding during a pandemic crisis. In this article, we evaluated the perceived risks and roles of veterinary and animal care workers during the COVID-19 pandemic and explored barriers and facilitators in their readiness, ability, and willingness to respond during a pandemic. We deployed a survey targeting US veterinary medical personnel, animal shelter and control workers, zoo and wildlife workers, and other animal care workers. Data were collected on respondents' self-reported job and demographic factors, perceptions of risk and job efficacy, and readiness, ability, and willingness to respond during the pandemic. We found that leadership roles and older age had the strongest association with decreased perceived risk and improved job efficacy and confidence, and that increased reported contact level with others (both coworkers and the public) was associated with increased perceived risk. We determined that older age and serving in leadership positions were associated with improved readiness, willingness, and ability to respond. Veterinary and animal care workers' dedication to public health response, reflected in our findings, will be imperative if more zoonotic vectors of SARS-CoV-2 arise. Response preparedness in veterinary and animal care workers can be improved by targeting younger workers not in leadership roles through support programs that focus on improving job efficacy and confidence in safety protocols. These findings can be used to target intervention and training efforts to support the most vulnerable within this critical, yet often overlooked, workforce.

Keywords: COVID-19, Pandemic preparedness, Ready, Willing, and Able model, Veterinary and animal care occupation, Occupational health, Public health preparedness/response

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Introduction

The COVID-19 pandemic has caused extensive detrimental worldwide impacts. In the United States alone, over 830,000 people have died as of January 6, 2022, almost 2 years since the pandemic was declared a national emergency.[1] In times of crisis, the veterinary medicine and animal care workforce is a source of unique knowledge and skills essential to national biosecurity and biological risk assessment and response.[2] One of the functions of veterinary and animal care workers is to control infections within animal populations, including those that can transmit to people, therefore serving as a first line of defense against zoonotic diseases.[3] In addition, they provide expert guidance on public health issues for their clients, visitors, and the public at large, such as communicating risks from exposure to pets.[3] In addition to this distinctive role, veterinary and animal care workers are part of human response programs due to their knowledge of comparative medicine and public health, which is part of the veterinary oath and training; they have been employed in COVID-19 response efforts from human vaccination clinics to donation of medical supplies.[4,5] Yet, veterinary and animal care workers themselves are at risk for exposure to diseases from human-to-human transmission pathways that exist during normal business operations, and may also be exposed to zoonotic agents from animal patients. According to the US Bureau of Labor Statistics, in 2020 there were 282,010 veterinarians and veterinary support staff, and 237,320 animal care, control, and other animal-related workers, representing a notable proportion of the US workforce at risk.[6] These workers may be reluctant to respond to work during a pandemic if they perceive it could put themselves and their families at risk.

To identify underlying causes of potential reluctance and the likelihood of response to work among veterinary and animal care workers during a pandemic, we used the Ready, Willing, and Able model to characterize response preparedness.[7] These components are differentiated by *readiness* relating to the external infrastructure of personnel and material resources necessary to perform a task, *willingness* as the predilection and desire to perform a task, and *ability* referring to the skills and knowledge needed to perform the task. While perception of risk and actual risk are expected to be correlated, a growing body of research points to variable response rates based on scenario context, not just rates of disease, indicating that workforce absenteeism and diminished response is due in substantial part to attitudinal and related perceptual factors apart from direct disease exposure and illness.[8-15] Research using the preparedness Ready, Willing, and Able model has been conducted on public health workers, healthcare employees, first responders, and other vital occupations for natural and biological disasters, where the perception of an individual's risk and role directly impacts disaster response preparedness, independent of actual disease exposure or health risk.[8-15] However, there are no data on risks and needs within the veterinary and animal care professions. No systematic research has been done to understand their individual perceptions of needs, barriers, and facilitators related to working during a pandemic crisis, despite the importance of veterinary and animal care workers to disaster response and the US Centers for Disease Control and Prevention One Health surveillance efforts for disease emergence. The current COVID-19 pandemic, and its profound ramifications for public health, provides a rationale for the importance of disaster preparedness and a resilient workforce. This is especially true for the unique veterinary and animal care workforce since animal vectors have shown to be critically important in past coronavirus outbreaks, and at least 1 SARS-CoV-2 strain (ie, mink variant) has been identified with the potential to spread into animal care workers and human communities from an animal reservoir.[16-18] It can also serve as a natural experiment to address preparedness and response for this pandemic, as well as future biological and natural crises.

As such, the objectives of this research were to assess the perceived risk of COVID-19 for veterinary and animal care workers and their perception of their roles during this crisis. We explored barriers and facilitators to their readiness, willingness, and ability to respond during a crisis and determined factors that affected these outcomes. The findings from this research can be used to address risk communication needs, and to design and implement response interventions, including preparedness training and support systems for this vulnerable yet critical worker population. The ultimate goal of this research is to build an animal care workforce that is not only capable, but willing to respond during this pandemic and future crises.

Methods

Approval for this study was received from the Johns Hopkins Bloomberg School of Public Health Institutional Review Board (IRB00012854). As primary data collection for the survey instrument was anonymous, the Institutional Review Board did not require written consent. Nonetheless, all respondents received an electronic disclosure statement, which described the study and emphasized voluntary participation, and agreed to participate before beginning the survey.

Data Collection

We targeted adult (over 18 years of age) animal care worker populations in the United States. This encompassed veterinary medical personnel—veterinarians, veterinary technicians, veterinary assistants, hospital managers, and other animal hospital support staff—who serve any patient type, including companion (eg, dogs, cats), equine, laboratory, exotic, and food animals. Other target populations were animal shelter and animal control employees, laboratory

animal personnel, zoological and wildlife facility workers, and those who self-identified in animal-related workforces, such as industry, government/advocacy, and academic research. We recruited study respondents via email or phone through state licensing agencies, professional organizations, professional conference attendees, professional group email lists, social media, and existing contacts.

Survey data were collected and managed using REDCap electronic data capture tools hosted at the Johns Hopkins Bloomberg School of Public Health.[19] Survey data were collected from July 6 to October 25, 2020. The survey was an anonymous online questionnaire that consisted of 2 main sections: a demographic section and an attitude/belief section that focused on workers' perceptions on their risk of exposure to COVID-19, the role they play in response efforts, and their response preparedness. Questions were developed based on feedback from experts and leaders within our target populations. Demographic and professional information included job title and role, years of employment, contact level with coworkers and the public (eg, clients, visitors), geographic region, gender, age, race, marital status, household dependents, and annual household income. Key job and demographic questions can be found in Tables 1 and 2 and in Supplemental Table 1 (all of the supplemental tables are available at www.liebertpub.com/doi/suppl/10.1089/hs.2021.0091). Because the survey was anonymous and respondents were able to access it multiple times, we included data only from respondents who completed all sections of the survey to minimize duplicate entries, although respondents were allowed to skip questions within each section.

Table 1. Job and Demographic Characteristics (N = 1,577)

Characteristics	*n (%)*
Job role	
Small animal medicine veterinarian	600 (38)
Small animal medicine technician/assistant	496 (32)
Small animal medicine support staff	77 (5)
Medicine – other veterinarian	80 (5)
Medicine – other technician/assistant	0 (0)
Medicine – other support staff	3 (0)
Animal shelter/control	122 (8)
Zoo/wildlife	47 (3)
Other[a]	129 (8)
Time in job, years	
Minimum	0
Median (IQR)	5 (2 to 12)
Maximum	46
Leadership role	
Yes	895 (57)
Age, years	
Under 40 years	816 (52)
40 years or older	755 (48)
Prefer not to say	4 (0)
Gender	
Male	156 (10)
Female	1,395 (89)
Other/prefer not to say	23 (1)

[a]Laboratory animal, industry, government, academia, or other professions.
Abbreviations: IQR, interquartile range.

Table 2. Contact Level Distribution

	Coworkers n (%)	*Public n (%)*
Average daily contact		
No contact	53 (3)	295 (19)
Rarely (1% to 15%)	89 (6)	669 (43)
Intermittent (16% to 50%)	181 (12)	355 (23)
Most of the workday (50% to 85%)	267 (17)	174 (11)
Almost the entire workday (85% to 100%)	983 (62)	81 (5)
Total people contacted daily		
1 to 2 people	99 (7)	334 (26)
3 to 5 people	362 (24)	233 (18)
6 to 10 people	594 (39)	200 (16)
11 to 24 people	319 (21)	267 (21)
25 or more people	132 (9)	227 (18)
Contact aggregate score quantile[a]		
Minimal contact (Q1)	454 (31)	374 (30)
Low contact (Q2)	362 (24)	343 (27)
Moderate contact (Q3)	424 (29)	235 (19)
High contact (Q4)	247 (17)	296 (24)

[a]Sum of average daily contact and total people contacted daily, as ranked categorical variables (score 0 to 5), then split at 25%, 50%, and 75%.

Respondents then answered questions regarding their attitudes and beliefs on their knowledge of the pandemic, confidence regarding safety protocols, perceived threat, job efficacy, likelihood of response barriers, and readiness, willingness, and ability to respond to the COVID-19 pandemic. We presented questions on a 5-point Likert scale, with a response of 5 indicating strong agreement with the statement and a response of 1 indicating strong disagreement. The distribution of responses is provided in Supplemental Table 2. Additional questions included perceived primary sources of SARS-CoV-2 exposure, perceived consequences from the COVID-19 pandemic, and reported personal and professional barriers to working during the pandemic.

Data Analysis

To assess potential risk to workers from contact with coworkers, clients, and the public, an aggregated contact level score was created by summing responses to the questions related to average daily contact and total people contacted and dividing the results into quartiles (ie, minimal contact, low contact, moderate contact, high contact).

We grouped Likert-scale questions into a priori topic areas to produce 8 outcomes across 3 categories: risk (ie, knowledge, confidence, threat), role (ie, job efficacy, barriers), and response (ie, ready, willing, able). Threat and job efficacy were adapted from Witte's Extended Parallel Process Model,[20] while other outcomes were chosen based on their importance to preparedness in other occupational

cohorts. Outcome variables were created by summing the responses to the respective questions within each topic area and dichotomized at the median to create a "high" and "low" score for each outcome (details in Supplemental Table 2). Some outcome topic areas combined multiple questions, while some included only 1 Likert-scale question, but they were treated similarly.

We performed multivariate logistic regression to evaluate associations between job role, job experience, leadership, age, gender, and contact level on each of the 8 outcomes, adjusting for geographic region, race, number of dependents, living with an essential worker, and income. Associations for job role variables are presented as odds of a high score compared with a low score within each individual job role (no reference group; eg, odds of high knowledge within small-animal veterinarians). Results for other variables are presented as comparison odds ratios; for example, the odds ratio for high scores for those with years in job greater than the median compared with less than the median. We assessed for collinearity between job and demographic variables to determine if our model variables were correlated (Supplemental Table 3). A final multivariate logistic regression was developed to explore the effect of risk (ie, knowledge, confidence, threat) and role (ie, job efficacy, barriers) as independent variables on response (ie, ready, willing, able) outcome variables. Analysis was conducted using the R software program (R Core Team, Vienna, Austria).

Results

Study Population Characteristics

Overall, 2,415 individuals accessed the survey using the link we provided, and 1,577 respondents consented and completed the survey, yielding a 65% response rate. Statistical differences in demographics between respondents included and excluded in the analysis are shown in Supplemental Table 4. Respondent job and demographic characteristics are shown in Table 1. The majority (75%) of respondents worked in veterinary medical clinics treating small companion animals. Within this group, most (38%) were veterinarians, followed by veterinary technicians and assistants (32%) and other support staff (eg, office managers, receptionists, kennel workers; 5%). Eighty-three (5.3%) respondents worked in other veterinary medical clinics (eg, equine, exotic, food animal), with most being veterinarians (5%). Animal rescue/control (8%), zoo/wildlife (3%), and other jobs (8%) made up the remaining respondent job roles. The median job experience was 5 years, and 57% reported being in leadership roles. The median age was 40 years old; a detailed age distribution is included in Supplemental Table 1. Most (89%) respondents were female. Additional job and demographic variables are shown in Supplemental Table 1.

Contact level was assessed for both coworkers and the public (ie, clients, visitors), as shown in Table 2. Respondents reported more contact with coworkers than with the public. Most (62%) respondents reported coworker contact almost the entire workday, compared with public contact where the majority (43%) reported only rare daily public contact. Most respondents reported interacting with 6 to 10 coworkers (39%), but only 1 to 2 clients or visitors (26%) per day. Aggregated contact quartile scores were roughly evenly distributed, ranging from 17% to 31%.

Table 3. Sources of and Consequences from COVID-19

	n (%)
Perceived most likely source for SARS-CoV-2 exposure[a]	
Coworkers	615 (39)
The public as part of my job (clients/ visitors)	508 (32)
The general public outside of my job	396 (25)
Family/friends at home	56 (4)
The animals I care for	2 (0)
Perceived secondary consequences as a result of the COVID-19 pandemic[a]	
Any secondary concerns	1,513 (96)
Mental health implications of the veterinary and animal care fields	1,399 (89)
Support of human healthcare professionals during and after the pandemic	1,278 (82)
Animal health and welfare during and after the pandemic	1,115 (71)
Economic resilience of the veterinary and animal care fields as a whole	806 (51)
Economic resilience of your personal profession	718 (46)

[a]Participants were allowed to select only 1 response for likely source of COVID-19 but could choose multiple secondary consequences.

Study Population COVID-19 Perceptions

Table 3 shows that most (39%) respondents considered coworkers the most likely source of SARS-CoV-2 exposure, followed by clients/visitors (32%) and the general public (25%). While respondents were allowed to select

Table 4. Reported Personal and Professional Barriers

	n (%)
Personal barriers	
None	893 (57)
Family/dependents needs	402 (25)
Health (physical)	256 (16)
Health (mental)	235 (15)
Transportation	27 (2)
Other	43 (3)
Professional barriers	
None	1,161 (74)
Lack of management support	297 (19)
Lack of communication channels	148 (9)
Lack of peer support	101 (6)
Other	50 (3)

only 1 response for the most likely source, they could choose multiple answers for secondary consequences from the COVID-19 pandemic. Most (96%) respondents felt there was at least 1 secondary consequence from the pandemic. The most frequently reported concerns were related to mental health implications for the profession (89%), the human healthcare profession (82%), and animal health and welfare (71%).

Most respondents reported having no barriers to responding to work during the COVID-19 pandemic (57% for no personal barriers; 74% for no professional barriers), as shown in Table 4. For those who did report barriers, the most common personal concern was for family/dependent needs (25%) and physical health barriers (16%) or mental health barriers (15%); the most common professional concern was a lack of management support (19%).

Association Between Job and Demographic Factors and Outcomes

We examined barriers and facilitators to veterinary and animal care workers' preparedness to respond during a crisis by determining the associations between job and demographic factors and 8 outcomes—knowledge, confidence, and threat (Table 5), job efficacy and barriers (Table 6), and ready, willing, and able (Table 7). There were minimal differences in the odds across job roles, as they had similar trends within outcome groups (those with higher odds were biased from a low number of respondents). Respondents in leadership roles had greater odds of reporting high knowledge (odds ratio [OR] 1.66, 95% confidence interval [CI], 1.37 to 1.94), high confidence (OR 1.89, 95% CI, 1.60 to 2.19), and high job efficacy (OR 2.26, 95% CI, 1.97

Table 5. Odds and Odds Ratios for Perceived Risk Outcomes

	Knowledge	*Confidence*	*Threat*
	OR (95% CI)	*OR (95% CI)*	*OR (95% CI)*
Job role – odds			
Small animal medicine veterinarian	1.147 (0.369 to 1.925)	0.476 (0.031 to 1.260)	0.845 (0.035 to 1.654)
Small animal medicine technician/assistant	1.078 (0.229 to 1.928)	0.816 (0.038 to 1.671)	0.581 (0.031 to 1.469)
Small animal medicine support staff	0.697 (0.029 to 1.686)	0.705 (0.029 to 1.700)	0.413 (0.062 to 1.445)
Medicine – other veterinarian	1.338 (0.443 to 2.233)	0.707 (0.019 to 1.605)	0.416 (0.051 to 1.338)
Medicine – other technician/assistant	1.072 (0.045 to 2.598)	0.660 (0.092 to 2.242)	0.531 (0.105 to 2.168)
Animal shelter/control	1.156 (0.280 to 2.032)	0.626 (0.025 to 1.505)	0.736 (0.177 to 1.650)
Zoo/wildlife	2.454 (1.322 to 3.586)	1.006 (0.086 to 2.097)	0.281*(0.089 to 1.461)
Other job	1.287 (0.375 to 2.199)	0.591 (0.032 to 1.503)	0.392 (0.056 to 1.349)
Job experience, years			
More than median	0.925 (0.639 to 1.211)	0.858 (0.564 to 1.152)	0.843 (0.541 to 1.144)
Less than median	*1 reference*	*1 reference*	*1 reference*
Leadership			
In leadership role	1.656*** (1.368 to 1.944)	1.894*** (1.596 to 2.192)	0.761 (0.456 to 1.066)
Not in leadership role	*1 reference*	*1 reference*	*1 reference*
Age, years			
40 years or older	1.549*** (1.258 to 1.839)	1.760*** (1.462 to 2.058)	0.549*** (0.244 to 0.854)
Under 40 years	*1 reference*	*1 reference*	*1 reference*
Gender			
Female	0.831 (0.329 to 1.334)	0.714 (0.219 to 1.210)	1.243 (0.729 to 1.757)
Male	*1 reference*	*1 reference*	*1 reference*
Contact level			
Coworker contact – minimal	*1 reference*	*1 reference*	*1 reference*
Coworker contact – low	1.067 (0.696 to 1.437)	0.817 (0.442 to 1.191) +	1.878*** (1.495 to 2.262) ++
Coworker contact –moderate	0.871 (0.503 to 1.239)	0.783 (0.410 to 1.156) +	2.187*** (1.805 to 2.569) ++
Coworker contact – high	1.249 (0.831 to 1.666)	0.664 (0.235 to 1.093) +	2.664*** (2.222 to 3.105) ++
Public contact – minimal	*1 reference*	*1 reference*	*1 reference*
Public contact – low	1.103 (0.754 to 1.451)	0.873 (0.519 to 1.226) +	1.656** (1.289 to 2.023) ++
Public contact – moderate	0.725 (0.336 to 1.115)	0.779 (0.405 to 1.154) +	2.100*** (1.687 to 2.512) ++
Public contact – high	0.851 (0.486 to 1.216)	0.599* (0.194 to 1.004) +	2.123*** (1.733 to 2.513) ++

Controlled for job years, region, leadership, stay-at-home orders, age, gender, race, dependent number, living with an essential worker, income, and coworker and public contact.

*$P < .05$; **$P < .01$; ***$P < .005$

+P value for trend = .08; ++ P value for trend < .005; when contact level treated as ordinal variable.

Abbreviations: CI, confidence interval; OR, odds ratio.

Table 6. Odds and Odds Ratios for Perceived Role Outcomes

	Efficacy	*Barriers*
	OR (95% CI)	*OR (95% CI)*
Job role – odds		
Small-animal medicine veterinarian	0.444 (0.037 to 1.260)	0.592 (0.018 to 1.367)
Small-animal medicine technician/assistant	0.624 (0.026 to 1.512)	0.547 (0.031 to 1.395)
Small-animal medicine support staff	0.639 (0.039 to 1.672)	0.613 (0.037 to 1.598)
Medicine – other veterinarian	0.456 (0.049 to 1.399)	0.643 (0.024 to 1.524)
Medicine – other technician/assistant	0.251 (0.014 to 1.867)	0.512 (0.012 to 2.047)
Animal shelter/control	0.596 (0.033 to 1.523)	0.824 (0.049 to 1.696)
Zoo/wildlife	0.637 (0.051 to 1.776)	0.335 (0.079 to 1.460)
Other job	0.650 (0.029 to 1.598)	0.424 (0.049 to 1.339)
Job experience, years		
More than median	1.052 (0.762 to 1.342)	0.705* (0.423 to 0.988)
Less than median	*1 reference*	*1 reference*
Leadership		
In leadership role	2.258*** (1.966 to 2.549)	0.839 (0.552 to 1.126)
Not in leadership role	*1 reference*	*1 reference*
Age, years		
40 years or older	2.110*** (1.808 to 2.412)	0.664** (0.374 to 0.955)
Under 40 years	*1 reference*	*1 reference*
Gender		
Female	0.841 (0.302 to 1.380)	1.189 (0.690 to 1.688)
Male	*1 reference*	*1 reference*
Contact level		
Coworker contact – minimal	*1 reference*	*1 reference*
Coworker contact – low	1.039 (0.654 to 1.424)	1.015 (0.646 to 1.385)
Coworker contact – moderate	0.677* (0.296 to 1.057)	1.112 (0.743 to 1.482)
Coworker contact – high	0.763 (0.332 to 1.194)	1.094 (0.677 to 1.511)
Public contact – minimal	*1 reference*	*1 reference*
Public contact – low	1.281 (0.921 to 1.641)	1.179 (0.832 to 1.526)
Public contact – moderate	1.074 (0.672 to 1.475)	0.975 (0.584 to 1.365)
Public contact – high	1.118 (0.743 to 1.494)	0.927 (0.562 to 1.292)

Controlled for job years, region, leadership, stay-at-home orders, age, gender, race, dependent number, living with an essential worker, income, and coworker and public contact.

*$P < .05$; **$P < .01$; ***$P < .005$, + P value for ordinal trend < .05, ++ P value for trend < .005.

Abbreviations: CI, confidence interval; OR, odds ratio.

to 2.55). Leadership was associated with increased odds of readiness (OR 1.33, 95% CI, 1.03 to 1.62), willingness (OR 1.39, 95% CI, 1.10 to 1.68), and ability (OR 1.35, 95% CI, 1.05 to 1.66) to respond. Age also was associated with the outcomes, as respondents 40 years and older had greater odds of high knowledge (OR 1.55, 95% CI, 1.26 to 1.84), high confidence (OR 1.76, 95% CI, 1.46 to 2.06), and high job efficacy (OR 2.11, 95% CI, 1.81 to 2.41), with lower odds of high perceived threat (OR 0.55, 95% CI, 0.24 to 0.85) and lower odds of reported barriers (OR 0.66, 95% CI, 0.37 to 0.95), independent of leadership role. Age correlated with response outcomes, as older respondents had higher odds of readiness (OR 1.56, 95% CI, 1.26 to 1.86), willingness (OR 1.43, 95% CI, 1.13 to 1.72), and ability (OR 1.41, 95% CI, 1.10 to 1.72) to respond during the COVID-19 pandemic.

The effect of contact level, with both coworkers and the public, was independently associated with the perceived threat outcome. Compared with respondents in the lowest contact quartile, those with higher coworker contact had greater odds of reporting high threat, with a dose-response increase (low contact OR 1.88, 95% CI, 1.49 to 2.26; moderate contact OR 2.18, 95% CI, 1.81 to 2.57; high contact OR 2.66, 95% CI, 2.22 to 3.11; P value for trend <.005), controlling for other job and demographic variables. The same dose-response association was also observed for higher public contact with increased perceived threat (low contact OR 1.66, 95% CI, 1.29 to 2.02; moderate contact OR 2.1, 95% CI, 1.69 to 2.51; high contact OR 2.12, 95% CI, 1.73 to 2.51; P value for trend <.005). A higher contact level was slightly associated with reduced odds of confidence in safety protocols, although not statistically significant (P value for trend .08 for both coworkers and the public), and did not correlate with knowledge, job efficacy, barriers, or ready, willing, and able outcomes.

Table 7. Odds and Odds Ratios for Perceived Response Outcomes

	Ready	*Willing*	*Able*
	OR (95% CI)	*OR (95% CI)*	*OR (95% CI)*
Job role – odds			
Small animal medicine veterinarian	1.071 (0.278 to 1.863)	1.267 (0.482 to 2.052)	1.964 (1.144 to 2.785)
Small animal medicine technician/assistant	1.610 (0.740 to 2.480)	1.765 (0.905 to 2.625)	2.734*(1.831 to 3.636)
Small animal medicine support staff	1.373 (0.355 to 2.392)	1.835 (0.826 to 2.844)	2.686 (1.624 to 3.748)
Medicine – other veterinarian	1.940 (0.999 to 2.880)	2.349 (1.419 to 3.280)	3.920** (2.923 to 4.917)
Medicine – other technician/assistant	2.156 (0.525 to 3.786)	2.553 (0.940 to 4.166)	4.608 (2.804 to 6.412)
Animal shelter/control	1.817 (0.898 to 2.735)	2.006 (1.104 to 2.908)	2.826*(1.883 to 3.769)
Zoo/wildlife	2.392 (1.195 to 3.590)	3.174 (1.986 to 4.361)	5.664*(4.336 to 6.993)
Other job	1.649 (0.709 to 2.590)	1.960 (1.029 to 2.891)	3.269*(2.278 to 4.260)
Job experience, years			
More than median	1.026 (0.733 to 1.319)	1.069 (0.781 to 1.357)	0.964 (0.659 to 1.268)
Less than median	*1 reference*	*1 reference*	*1 reference*
Leadership			
In leadership role	1.325 (1.031 to 1.619)	1.387* (1.098 to 1.676)	1.352 (1.046 to 1.658)
Not in leadership role	*1 reference*	*1 reference*	*1 reference*
Age, years			
40 years or older	1.563*** (1.262 to 1.865)	1.428* (1.131 to 1.725)	1.410* (1.097 to 1.723)
Under 40 years	*1 reference*	*1 reference*	*1 reference*
Gender			
Female	1.150 (0.634 to 1.665)	1.042 (0.530 to 1.554)	1.135 (0.601 to 1.670)
Male	*1 reference*	*1 reference*	*1 reference*
Contact level			
Coworker contact – minimal	*1 reference*	*1 reference*	*1 reference*
Coworker contact – low	1.003 (0.618 to 1.388)	0.994 (0.614 to 1.374)	1.074 (0.673 to 1.474)
Coworker contact – moderate	0.702 (0.325 to 1.080)	0.719 (0.345 to 1.093)	0.754 (0.362 to 1.146)
Coworker contact – high	1.054 (0.620 to 1.487)	1.069 (0.641 to 1.497)	1.190 (0.734 to 1.645)
Public contact – minimal	*1 reference*	*1 reference*	*1 reference*
Public contact – low	0.987 (0.626 to 1.348)	0.951 (0.598 to 1.304)	1.030 (0.656 to 1.403)
Public contact – moderate	1.020 (0.619 to 1.421)	1.001 (0.606 to 1.395)	0.956 (0.542 to 1.371)
Public contact – high	1.019 (0.646 to 1.392)	1.209 (0.837 to 1.582)	1.113 (0.722 to 1.505)

Controlled for job years, region, leadership, stay-at-home orders, age, gender, race, dependent number, living with an essential worker, income, and coworker and public contact.

*$P<.05$; **$P<.01$; ***$P<.005$.

Abbreviations: CI, confidence interval; OR, odds ratio.

Perceived Risk and Role on Response Outcomes

The associations between knowledge, confidence, threat, job efficacy, and barriers, and the odds of high ready, willing, and able scores (response outcomes) were examined, as shown in Table 8. Job efficacy had the most substantial positive correlation with response outcomes, with respondents who reported high efficacy having increased odds of higher response outcomes, compared with those who reported low efficacy (Ready OR 2.82, 95% CI, 2.58 to 3.06; Willing OR 2.34, 95% CI, 2.10 to 2.57; Able OR 2.22, 95% CI, 1.98 to 2.47). The same association was observed in those with high confidence (Ready OR 1.94, 95% CI, 1.67 to 2.20; Willing OR 2.05, 95% CI, 1.79 to 2.31; Able OR 1.53, 95% CI, 1.25 to 1.80). Respondents who reported having more barriers had lower odds of response (Ready OR 0.28, 95% CI, 0.04 to 0.52; Willing OR 0.31, 95% CI, 0.08 to 0.54; Able OR 0.25, 95% CI, 0.00 to 0.49). Perceived threat correlated with decreased willingness to respond (OR 0.72, 95% CI, 0.47 to 0.97) but was not associated with other response outcomes. Knowledge did not significantly correlate with response outcomes.

Discussion

In this study, we evaluated perceived risks and roles during the COVID-19 pandemic among veterinary and animal care workers and found that leadership and older age had the strongest associations, independent of each other, with decreased perceived risk and increased job efficacy. We observed that increased reported contact level with others (both coworkers and the public) was associated with increased perceived risk. We further explored barriers and facilitators to the readiness, willingness, and ability of veterinary and animal care workers to respond during a pandemic crisis.

Table 8. Odds Ratios for Perceived Risk and Role on Response Outcomes

	Ready	*Willing*	*Able*
Risk/Role	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*
Knowledge	1.195 (0.954 to 1.436)	1.063 (0.826 to 1.301)	1.029 (0.783 to 1.275)
Confidence	1.935*** (1.668 to 2.203)	2.049*** (1.787 to 2.312)	1.527*** (1.252 to 1.802)
Threat	0.851 (0.597 to 1.105)	0.721** (0.472 to 0.969)	0.954 (0.694 to 1.214)
Efficacy	2.822*** (2.582 to 3.061)	2.337*** (2.101 to 2.573	2.222*** (1.976 to 2.468)
Barriers	0.282*** (0.044 to 0.520)	0.309*** (0.076 to 0.542)	0.245*** (0.003 to 0.493)

Low levels of knowledge, confidence, perceived threat, efficacy, and barriers as reference.
*$P < .05$; ** $P < .01$; *** $P < .005$.
Abbreviations: CI, confidence interval; OR, odds ratio.

Increased coworker and public contact were associated with higher odds of perceived threat, yet increased contact was not correlated with response outcomes. Response outcomes were impacted by older age and leadership, as both were associated with improved readiness, willingness, and ability to respond, with lowered odds of reported barriers to response. These findings can be used to target intervention and training efforts to support this critical workforce, resulting in improved preparedness as the pandemic progresses.

Our survey data indicated that respondents considered coworkers and clients/visitors their most likely source of SARS-CoV-2 exposure, even more than the general public. This finding reinforces the concept that occupational exposures are essential to consider in the context of infectious disease risk, including for COVID-19.[21] Curiously, a low percentage of respondents felt that family and friends were a significant source of SARS-CoV-2 exposure, yet data from contact tracing shows that gatherings of friends and families from separate households are a significant risk factor for COVID-19.[22] Appropriate information on risk factors at home, and strategies to reduce transmission, based on up-to-date epidemiological data, should be included in workplace training and support plans, as this will aid in minimizing occupational exposure and spread. While it is possible that this workforce underestimates the potential risk from personal sources of exposure, it is also possible that this workforce—which includes professionals who are both well-trained in infectious disease management and are exposed to zoonotic pathogens routinely at work[3,23-25]—may use extensive measures to manage these exposures. It may also be the case that individuals feel they have more control over their exposures at home or in public (eg, they can elect to avoid crowds), while occupational exposures may be unavoidable, or even a necessary part of their job function, and is outside of their control.

Reported contact level, both with coworkers and the public (eg, visitors, clients), was positively associated with increased perceived threat of COVID-19, and a slight decrease in the confidence in safety protocols used for COVID-19. This association increased in a dose-response fashion, where every increase in contact quartile group was associated with increased perceived threat and decreased confidence. Contact level with coworkers or the public is less frequently evaluated or reported in studies on preparedness in occupational cohorts. Previous research in other occupations, such as human medicine, first responders, and public health workers, has assessed variables that are related to contact with others, such as hours worked per week,[9] employment status (full or part time),[11,12] shift (day or night),[11,12] hospital size,[12] or position/role (eg, nurse or physician).[11,13,14] Nonetheless, no studies to our knowledge explicitly depict the association of self-reported contact level, either overall or divided by coworkers and the public, on response outcomes. At the same time, what is most noteworthy is that, while contact level was correlated with perceived risk, it was not correlated with response outcomes (ie, ready, willing, able). Respondents reporting higher contact levels, both with coworkers and with the public, had higher odds of reporting increased perceived threat from COVID-19, yet they did not report that this would make them less willing, ready, or able to respond during the pandemic.

This remarkable finding demonstrates that veterinary and animal care workers may accept even high-risk scenarios in order to deliver animal health and public health services. It is possible that this workforce is acclimated to risks due to their higher risk for exposure to zoonotic diseases.[24-25] Nonetheless, the high levels of response outcomes, regardless of threats, for these workers have intriguing implications for those designing public health interventions, who may otherwise overlook them as a valuable resource to aid in comprehensive response efforts, as our research highlights their commitment and perseverance toward public health. Veterinary and animal care workers have already been shown to enhance community pandemic response, not just through their work in infection control and expert consultation, but also through involvement in human health programs.[4,5] Furthermore, this dedication will be particularly meaningful if the SARS-CoV-2 pathogen's zoonotic potential increases as the pandemic progresses. If a new variant emerges that is more transmissible among animals or that has key animal reservoirs or vectors (conditions previously shown to be important to the epidemiology of coronaviruses),[16,17] then veterinary and animal care workers will likely be at the frontline of disease detection and risk. This has already proven to be true in COVID-19 outbreaks among Danish mink farms related to a mink-associated

variant.[4] Establishing appropriate support and communication systems now, before more zoonotic variants arise, will have widespread benefits for public health.

Additionally, we evaluated the association of knowledge, confidence, perceived threat, job efficacy, and barriers on our response outcomes (ie, ready, willing, able) and found that job efficacy had the strongest association with positive response. The same trend has been seen in other studies evaluating preparedness.[8,9,11,15,26,27] Confidence in safety protocols was also shown to be positively correlated with increased response outcomes, but to a lesser degree than efficacy. In previous studies, confidence in safety protocols was either not evaluated or was combined with an efficacy variable.[9,26] Future disaster response studies should consider evaluating the effect of confidence in safety protocols, independent of efficacy, which can direct training programs to improve this confidence.

Identifying that job efficacy and confidence enhanced pandemic response dispositions, we evaluated individual job and demographic factors that were associated with increased job efficacy and confidence. Being in a self-reported leadership role and being 40 years and older were associated with improved knowledge, confidence, and job efficacy, and reduced perceived threat. Interestingly, the years working within a job did not correlate with leadership roles and older age, and did not impact risk, role, or response outcomes. Similar trends for older age associated with improved response outcomes have been shown in other occupational groups,[9,11-13,26] while a minority of studies have shown the opposite effect.[14] This finding of a positive association was contradictory to our initial assumption that older respondents would report increased perceived risk, given the COVID-19 pandemic disproportionately affects older individuals for severe disease outcomes.[28] This contradiction in perception and empirical risk is fundamental to recognize in the design of support and training systems. Intervention efforts should target all age groups, not just those at risk based on epidemiologic data. Interventions that harness leaders' increased job efficacy and pandemic response may hold promise to both capitalize on the strengths of leadership and address gaps among nonleaders and younger workers. One such intervention is the train-the-trainer model, which uses subject-matter experts to disseminate knowledge to instructor-trainees, who then train other groups; this model is an effective and efficient way of training large groups of people in a relatively brief time period.[27,29-31] Additionally, pandemic preparedness could be incorporated into degree program training, such as veterinary doctorate or technician curriculum, which will aid in targeting younger and early career workers. Training should focus on issues beyond increasing knowledge, which did not impact response outcomes according to our findings, and should instead work to improve efficacy (ie, the importance of an individual's role in overall response efforts) and confidence in applied safety protocols.

While this study is the first to evaluate pandemic preparedness in a novel, yet critical, worker population, our study does have certain limitations. Like most volunteer questionnaire study designs, our research study is at risk of recall bias (ie, selective memory for certain experiences/information), social desirability bias (ie, respondent responses influenced by researchers' goals), and self-selection bias (ie, individuals who feel strongly about a topic are more likely to participate in a study). We experienced challenges specific to web-based surveys, including item nonresponse and the inability to compare potential with actual respondents, which limit generalizability; yet given in-person research limitations during the pandemic and the pressing need to document conditions facing essential workers, we consider our approach valuable and warranted. We saw a high number of respondents who did not complete all sections of the survey. Whether this is due to the design or technical aspects of the online questionnaire or to external factors (eg, respondents were interrupted while taking the survey during working hours) is uncertain. However, there was no significant difference in job and demographic characteristics between those who completed the survey compared with those who did not. Another limitation is that our study population may not reflect the target veterinary and animal care workforce, limiting the external generalizability of our findings, as in the case of our low racial diversity and high percentage of female respondents (the US veterinary medical field was estimated to be 63.9% female in 2020).[32]

Our findings suggest a need for future directions in preparedness response research within this critical worker population to address 2 main areas. First, there is a need to understand the relationship between changes in operational practices and procedures, at the organizational and individual levels, and previous biosecurity training on levels of perceived threat, efficacy, and response. Select job roles, such as food animal practitioners, may receive increased biosecurity training, which may impact their self-efficacy and pandemic preparedness. Our study population is skewed toward small-animal job roles, but this is reflective of the veterinary industry (ie, 75% of veterinarians were small-animal exclusive or dominant in 2020).[32] Practices identified as protective can be incorporated into widespread training and support programs to improve response preparedness in this workforce for COVID-19, and future pandemics and other disaster situations. The second area is further exploration of the secondary consequences from the pandemic among veterinary and animal care professionals. Results from this study underscore the mental health impacts from the COVID-19 pandemic in this workforce, a concept that is mirrored in the general population.[33] Our survey captured perceptions of mental health implications for the field as a whole; future studies should evaluate mental health effects—such as stress, anxiety, and depression—in individuals and relate that to job and demographic risk factors. Although we

hypothesize that those who report higher perceived risk from COVID-19 as a result of their job will also suffer higher rates of these secondary complications, such as mental health effects, this link should be explicitly evaluated in future studies.

Conclusion

Our findings highlight that perceived risk of veterinary and animal care workers, even among high-risk groups, does not impact their response to the pandemic. This dedication to public health reinforces these workers as valuable assets in comprehensive response efforts in the community, through their role in infection control, public counseling, and supporting human health efforts. Particularly, this will have important implications if COVID-19 develops a significant zoonotic component. To better prepare for their current and possible future roles, response to COVID-19 among veterinary and animal care workers can be improved by targeting younger workers who are not necessarily in leadership roles, and by designing support and communication programs that improve job efficacy and confidence in safety protocols. The results of this work, and future research stemming from it, can inform interventions facilitating a more resilient workforce that is better equipped to continue responding to the COVID-19 pandemic and to future crises.

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