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# Personal Protective Equipment Use and Handwashing Among Animal Farmers: A Multi-site Assessment

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*The goal of this study was to compare and contrast the use of personal protective equipment (PPE) and the practice of handwashing among participants of four studies assessing poultry and swine farms in the midwestern United States and in Thailand. This largely descriptive exercise was designed to assess and compare the frequency of these protective practices among the study populations. There were a total of 1113 surveys analyzed across the four studies. The respondents included workers in direct contact with animals as well as flock owners and veterinarians tending to farms. Handwashing was the most common practice observed among all participants with 42% “always” and 35% “sometimes” washing their hands after contact with the animals. This practice was least common among Minnesota swine workers. Even Thai poultry farmers, who demonstrated the lowest overall PPE use, reported a higher frequency of handwashing. Mask use during animal farming activities (“always” or “sometimes”) was least commonly practiced, ranging from 1% in Thailand to 26% among backyard poultry farmers in Minnesota. Minnesota poultry and swine farmers had similar frequencies of mask (26%) and glove use (51% and 49%). All other comparisons differed significantly across the four sites ( $p$ -values  $<0.05$ ). The use of PPE in animal farming differed by study location and is likely related to prevalent norms in the respective regions. Overall, the use of PPE did not appear to be influenced by the particular animal (poultry or swine) being farmed. These findings may prove useful to regulating bodies and farm owners in formulating policy or planning strategies for improving personal hygiene practices in animal farming and preparing for influenza and other potential zoonotic disease outbreaks.*

**Keywords** animal agriculture, handwashing, influenza, personal protective equipment, poultry, swine

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## INTRODUCTION

Emerging viruses such as the H5N1 highly pathogenic avian influenza (HPAI) virus, the novel 2009 H1N1 influenza virus, and the 2012 H3N2 variant influenza virus have posed real or potential risks to workers and the public.<sup>(1–3)</sup> Pigs have receptors for both human and avian influenza A viruses, giving them the potential to play a critical role in interspecies transmission of influenza.<sup>(4)</sup> Swine have been referred to as a “mixing vessel” for influenza virus reassortment, from which novel viruses may then spill back into susceptible human populations.<sup>(5)</sup> By January 2014, the World Health Organization (WHO) reported 650 confirmed cases and 386 deaths worldwide from the H5N1 avian influenza virus.<sup>(6)</sup> Most of these cases occurred in Asia and northern Africa, including Bangladesh, China, Egypt, India, Indonesia, and Vietnam, areas now identified as endemic for HPAI.<sup>(6,7)</sup>

Although animal production is a large enterprise in the United States and worldwide, precise estimates of the number of people working in these operations are not available because many of these workers are family members of owner-operators or hired workers employed for only a short while before leaving the job.<sup>(8)</sup> The U.S. Environmental Protection Agency (EPA) estimates that there are about 450,000 animal feeding operations in the United States.<sup>(9)</sup> With multiple workers expected at many of these operations, there are likely many hundreds of thousands to more than 1 million animal production workers in the United States.

Workers in animal production operations are exposed to a variety of potentially harmful agents including acute and chronic injury hazards, gases like ammonia and hydrogen sulfide, dusts that contain organic matter and endotoxins, and infectious agents such as zoonotic influenza viruses.<sup>(10–12)</sup> Workers who may be exposed to animals that are infected

with influenza viruses are advised to wear personal protective equipment (PPE) including gloves, protective footwear, protective clothing, eye protection, and respiratory protection.<sup>(7,10–12)</sup> These same guidelines recommend that workers wash their hands frequently with soap and water when working with animals.<sup>(7,10–12)</sup>

Studies conducted to assess the use of PPE by animal farmers show that when farmers are exposed to occupational hazards, utilization of PPE is suboptimal. In a study conducted in the U.S. Midwest, few farmers reported utilizing PPE for protection from injury when handling large animals or using chainsaws.<sup>(13)</sup> Use of respiratory protection, eye protection, heavy gloves, and protective footwear was also uncommon inside animal containment buildings, and farmers rarely used PPE when mixing and applying pesticides.<sup>(13)</sup> However, face shields, welding masks, or goggles and protective gloves were used frequently during welding maintenance of farm implements. In a study from California, 93% of responding farmers indicated that they wore PPE when using pesticides, but less than 33% of the farmers used PPE for other tasks.<sup>(14)</sup> When exposed to agricultural dust, only 24.4% of farmers wore respiratory protection of any kind more than 50% of the time. Younger farmers were more likely to utilize respiratory protection than older farmers. In Brazil, about 67% of swine farmers wore some type of PPE regularly.<sup>(15)</sup> However, only 2.8% used respiratory protection.

Transmission of influenza viruses from swine and poultry to humans and from humans to these animal populations facilitates reassortment and the development of novel viruses, which have serious implications for human and animal health. Persons working in animal agriculture settings represent a front line for such transmission, and personal protective practices serve as an important defense. Gray et al. asserted that reduction of viral exposures is essential for poultry and swine workers because “confinement buildings could facilitate the generation of novel influenza viruses, as well as accelerate human influenza epidemics.”<sup>(16)</sup>

After the emergence of H5N1 avian influenza as an occupational hazard for poultry farmers, adherence to PPE recommendations varied in different parts of the world. In rural Thailand, 39% of poultry farmers handled dead birds without gloves before hearing about avian influenza, whereas only 11% handled dead birds without gloves after hearing about it.<sup>(17)</sup> Poultry workers in Italy exhibited a relatively high level of use of PPE and hygiene practices.<sup>(18)</sup> Surveys indicated that 83% of the workers wore protective clothing, 83% wore protective footwear, 60% wore gloves, 60% wore face masks, 25% wore eye protection, and 88% washed their hands regularly.<sup>(18)</sup> In Hong Kong, a similar survey indicated that 62% of poultry workers always used gloves when handling dead chickens, 35% always used gloves when handling live chickens, 7% always wore eye protection, 25% always wore face masks, and 65% always washed their hands with soap after killing chickens.<sup>(19)</sup>

Studies suggest that compliance with PPE recommendations is higher when workers are responding to outbreaks

of influenza among domesticated and wild birds. During an outbreak of H7N7 avian influenza among poultry in the Netherlands, 74% of workers involved in outbreak control used masks some of the time and 45% wore goggles some of the time.<sup>(20)</sup> Consistent use was practiced by only 25% of the workers for masks and 13% for goggles. The poultry farmers themselves used PPE less frequently than the response workers. During an H5N1 outbreak among wild birds in Germany, only 13% of workers collecting dead birds wore all recommended PPE all of the time.<sup>(21)</sup> Highest compliance was for gloves and protective boots; lowest was for respiratory protection. During the response to an H7N3 avian influenza outbreak among poultry in British Columbia, Canada, 85% of response worker participants reported that they always wore gloves, 83% indicated that they always wore a mask, and 55% said they always wore goggles.<sup>(22)</sup> In England, 54% of workers responding to an H7N3 outbreak in poultry reported complete compliance with PPE recommendations.<sup>(23)</sup> Statistical analyses suggested that complete compliance with PPE recommendations significantly reduced the risk of developing a possible or confirmed case of H7N3 infection.<sup>(23)</sup>

Relatively little has been reported about protective practices, defined here as the use of PPE and hand hygiene, among people working with animals in non-emergency situations. In addition, PPE use has been repeatedly emphasized in literature as important to the reduction of influenza transmission in farm settings.<sup>(10–12)</sup> In this study, we compared personal protection practices in different animal farming settings across different geographical locations. We also identified the practices that appear to be best accepted in each setting.

## METHODS

### Individual Studies

For this study, data regarding the use of PPE and hand hygiene by poultry and swine workers were consolidated from four studies conducted through the International Cooperative Zoonotic Influenza Research Center, funded by the Centers for Disease Control and Prevention (CDC).<sup>(24–27)</sup> These analyses of data collected by previous studies received an exemption from review under federal guidelines from the University of Minnesota Institutional Review Board under protocol #0904E62963. The goal of this article is to describe, compare, and contrast the use of PPE and hygiene practices among respondents in the four studies. Researchers asked questions about personal protection practices in a similar manner in the four studies. Participant selection methods varied by study and are described elsewhere.<sup>(24–27)</sup>

A Minnesota poultry study (MPS) assessed the prevalence of low-pathogenicity avian influenza (LPAI) antibodies among backyard poultry and their caretakers.<sup>(25)</sup> One hundred participants were recruited after routine surveillance of their flocks at custom-processing plants by the Minnesota Board of Animal Health. Standardized questionnaires were administered to these flock owners by telephone. The remaining 50 participants

were flock owners recruited through poultry organizations and advertisements; their surveys were administered in person. Participants were asked about protective practices, including PPE use and handwashing during August 2007 – December 2008.

In the Wisconsin poultry study (WPS), researchers prospectively assessed avian influenza infection among backyard flocks and flock handlers with regular poultry contact over a 15-month period starting in July 2007.<sup>(24)</sup> A backyard flock was defined as having between 5 and 1000 poultry birds on the premises. Participants, from a six-county area surrounding Marshfield, Wisconsin, were among those responding to an invitation to participate sent to them by the Wisconsin Division of Animal Health. At the beginning of the study, information about protective practices was gathered from 127 participants in baseline telephone interviews.

The Thai poultry study (TPS), was a 2008 analysis of poultry contact activities and personal protective practices of poultry-owning households in Suphan Buri Province, Thailand.<sup>(26)</sup> Households were eligible to participate in the study if they owned poultry (backyard and/or farmed) at the time of the 2005 H5N1 outbreaks in Suphan Buri or at the time of the interview, or held a job that specifically involved poultry transport, slaughter, or cooking. In each village, potential participants were identified with the help of a local public health officer or village health volunteer. Trained data collectors administered surveys to one person in each of 968 households with backyard poultry. The household member with the highest frequency of poultry contact was the recipient of the survey in each household. Data used in this multi-site analysis reflect PPE use and hygiene practices at the time of the study in 2008 ( $n = 683$ ).

The Minnesota swine study (MSS), was conducted during October 2007 – May 2009 and characterized influenza infections in Minnesota and Iowa pigs while also assessing protective practices used by swine workers.<sup>(27)</sup> The 45 participating Minnesota veterinarians were recruited from among all veterinarians who submitted specimens to the Minnesota Veterinary Diagnostic Laboratory that tested positive for influenza virus during the study period. Surveys for 153 sites were completed by the participating veterinarians, who provided their impressions of the personal protective practices on each site. Responses were validated through a survey of a subset of 16 producers. The MSS was different because it surveyed veterinarians who reported their observations of the practices used by others, whereas participants in the other three studies reported their own practices.

Data on PPE use in the four individual studies were collected by means of survey questionnaires in a cross-sectional approach. The TPS used in-person surveys exclusively, while the other three studies utilized telephone-administered surveys. The surveys from the individual studies differed from one another; only practices included on all four questionnaires—use of face masks, gloves, and footwear and handwashing after contact with poultry or swine—were analyzed.

## Data Reduction

The PPE use variables were measured differently among the four studies. All responses were consolidated into common categories of “always,” “sometimes,” and “never.” The rationale of this combination of data is aimed at increasing inference value of the data for understanding personal protection practices among animal farmers.<sup>(28)</sup> For the MPS and MSS, the frequency of protective practices was recorded as “always,” “sometimes,” or “never.” Therefore, no changes were required in the coding of these responses. For the WPS, the frequency of practice of each protective measure was recorded as “always,” “> half the time,” “half the time,” “< half the time,” or “never or almost never.” These categories were reassigned in the overall data set with “always” and “never or almost never” recorded as “always” and “never,” respectively, and the remaining three categories recorded as “sometimes.” For the TPS, the frequencies of use of the protective practices were recorded as “never,” “hardly ever,” “sometimes,” “usually,” or “always” on the survey questionnaire. For the overall data set, “never” and “hardly ever” were categorized as “never,” “sometimes,” and “usually” were recorded as “sometimes,” and “always” was recorded as “always” to match the rest of the data set. Where multiple tasks were assessed in a study for a type of PPE, e.g., feeding, handling poultry, or collecting eggs, the task reported as most frequently conducted was used as representative of the PPE use frequency for that respondent. A summary variable for PPE activity, called “overall PPE use,” was included in the data set to indicate any use of PPE at the corresponding animal farm. This was either “ever” or “never” use, with “ever” being the use of at least one kind of PPE at least some of the time.

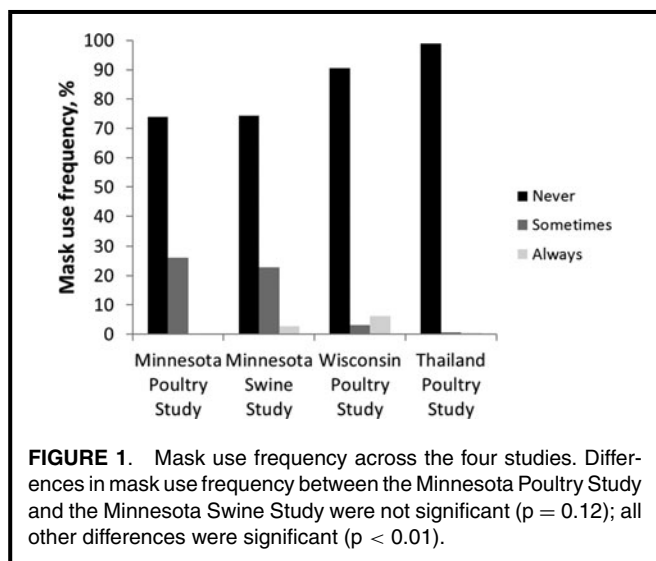
## Data Analysis

Data analysis was performed using SAS version 9.2 (SAS Institute, Inc., Cary, NC). From the four individual studies, 1113 completed surveys were pooled together. The percentage of participants using the protective practices (“always,” “sometimes,” and “never”) was determined for all study groups and compared among the four groups. Comparisons were made by chi-square analyses or Fisher’s exact tests, as appropriate. Differences with a  $p$ -value  $< 0.05$  were considered statistically significant.

## RESULTS

Handwashing after exposure to swine or poultry was the most common protective practice, while mask use during farming activities was least common (Figures 1–4). Aside from similar mask and glove use among Minnesota poultry and swine farmers ( $p = 0.12$  and  $0.23$ , respectively), the study populations differed statistically in the frequency of use of PPE and hand hygiene practices.

Across all groups, 27.9% of respondents “ever” used some form of PPE (Table I). Overall “ever” PPE use ranged from

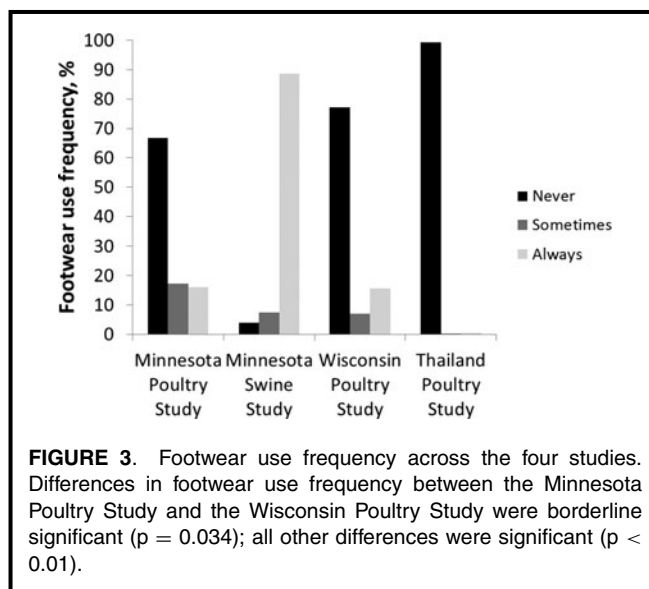


1.8% in poultry farming in Thailand to 94.1% in Minnesota swine farmers.

## DISCUSSION

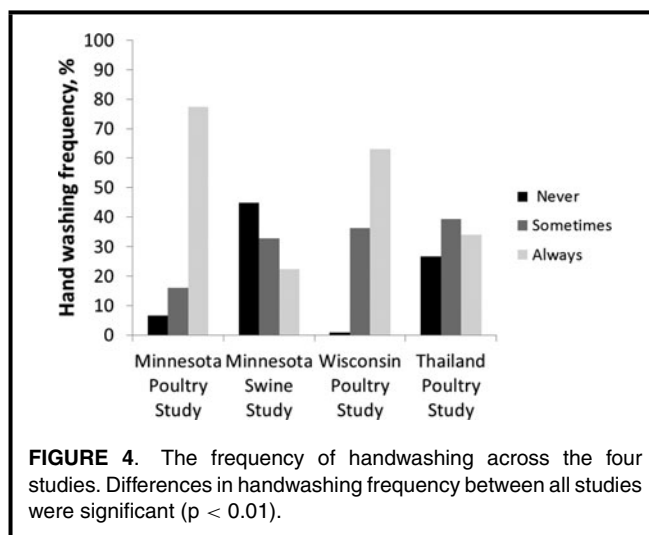
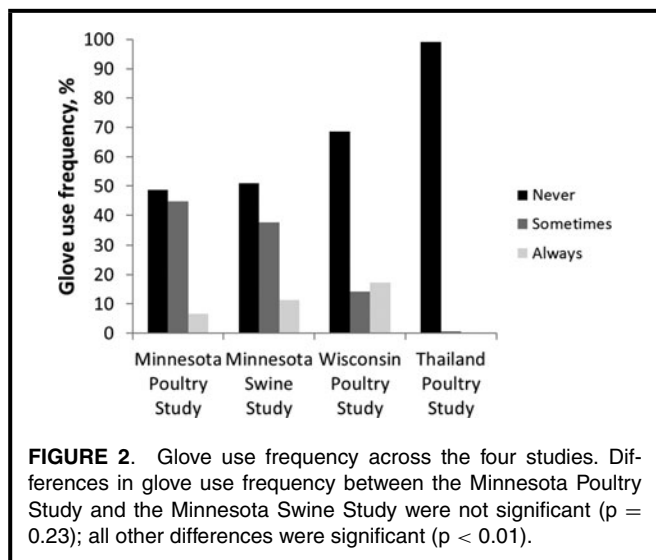
This analysis pooled data from four studies assessing personal protection practices by swine and poultry farmers in multiple geographic locations. Our objective was to compare the practice of personal protection among a broader array of study sites than has been previously reported in the scientific literature. Using studies assessing the risk of zoonotic influenza was most logical because interspecies transmission of influenza viruses has been and remains a significant occupational health concern in animal production settings.<sup>(16,29,30)</sup>

The overall frequency of personal protective practice was observed to be low. This result is mainly due to the low practice



of PPE use in Thailand. Given this low overall frequency of practice, it is important to interpret the results in studies individually and as part of the whole group. The observation of overwhelming practice of footwear usage in the MSS is likely different from the other sites in the U.S. Midwest due to unique protective practices on the swine farms. This inference is supported by the results that showed only small differences in footwear usage between MPS and WPS farmers. Handwashing after contact with animals was practiced more widely than PPE use and is considered essential for prevention of virus transmission.<sup>(7,10-12)</sup>

Personal protection practices, particularly the use of PPE, were observed to be higher in commercial production settings. This finding, seen in the high frequency of footwear use among Minnesota swine industry workers, may be due to enforceable company biosecurity policies. While the nature of backyard and small holder farming precludes enforced implementation



**TABLE I. Overall PPE Use in Each Study, Indicating if Masks, Gloves, or Footwear Were Ever or Never Used at a Site**

Study	Ever used PPE, number (%)	Never used PPE, number (%)
Minnesota Poultry Study	101(67.3)	49(32.7)
Minnesota Swine Study	144(94.1)	9(5.9)
Wisconsin Poultry Study	54(42.5)	73(57.5)
Thailand Poultry Study	12(1.8)	671(98.2)

Note: All differences between the studies were significant ( $p < 0.01$ ).

of biosecurity policy recommendations, it is important that materials outlining the best biosecurity recommendations are made available to individuals on such premises.

With the exception of footwear use among Minnesota swine workers, even occasional use of any one type of PPE among workers in poultry and swine rearing was no greater than 51.3%, as shown in Figures 1–3. Handwashing after contact with animals was more frequent across the different studies, as shown in Figure 4, and appears to be the most accepted practice in the poultry and swine operations. PPE usage and handwashing varied significantly from study to study except in the practices of mask use and glove use between the MPS and the MSS. This may be explained by the similarity of knowledge, attitudes, and practices of mask and glove use on animal farms in Minnesota.

The reported use of personal protection practices in the studies examined in this article was less frequent than the results reported in other papers. Abbate et al.<sup>(18)</sup> and Kim et al.<sup>(19)</sup> described much higher usage rates of various types of PPE among poultry workers in Italy and Hong Kong, respectively, than we found in the United States and Thailand. An earlier study in Nakhon Phanom Province in Thailand indicated that about 39% of respondents raising backyard poultry handled sick or dead birds without gloves before training about the importance of glove use.<sup>(17)</sup> However, the results from our study indicated that more than 99% of respondents in Suphan Buri Province in Thailand had never or hardly ever used gloves when handling their poultry.

Although the reasons for differences in personal protective practices between the TPS reported here and earlier studies are uncertain, possible explanations include differences in knowledge of personal protection practices, differences in availability of and access to PPE, and biases in reported use rates. One notable bias is the time period in which the questions were asked: the data in the TPS were collected in 2008, two years after the last outbreak in Suphan Buri, while the report by Olsen et al.<sup>(17)</sup> describes findings during an active outbreak. It is possible that attitudes towards PPE are different during an outbreak. There might also be a greater supply of gloves and other PPE and better promotion strategies around biosecurity during an outbreak.

Respondents in the TPS were motivated to practice handwashing after contact with livestock and almost none practiced any other form of personal protection. These attitudes and practices have been reported to improve in areas with greater media reporting about risks of infections<sup>(31)</sup> and in regions with high infection rates.<sup>(32)</sup> Overall, barriers to PPE use in Thailand have been identified as cultural, knowledge, comfort, availability, and cost.<sup>(32)</sup> This is evident in our results as the most acceptable, available, comfortable, and cheapest practice—handwashing—is most prevalent.

The strengths of this study include the diversity of the regions covered and the two types of livestock that could be compared side by side in our assessment. However, this study has several limitations. Differences in the surveys used by the four individual studies prevented the analysis of covariates such as age, gender, race, and education that might be associated with hand hygiene and PPE use. The Thai study results may not accurately represent the animal handling practices of household members with less frequent poultry contact. Such individuals may have had different practices. We cannot draw any conclusions about the efficacy of the PPE used by study participants. For example, although attempts were made to exclude bandanas as a type of face mask, no attempt was made to differentiate between surgical masks, dust masks, and National Institute for Occupational Safety and Health (NIOSH)-certified filtering facepiece respirators. Surgical masks and dust masks do not provide substantial protection against airborne influenza viruses, and while N95 respirator “masks” are protective, they must be fit-tested to assure that they will work effectively. Similarly, no attempt was made to differentiate between work gloves and chemical protective gloves. The latter type is expected to provide a better barrier to influenza virus.

Comparisons among groups assume representativeness of the samples. Given the participant selection methods used in each study, this is considered a fair assumption. With the onset of the novel avian-origin influenza A (H7N9) in Asia in March 2013 and the more recent onset of the Middle Eastern respiratory syndrome (MERS) potentially associated with exposure to camels,<sup>(33,34)</sup> the need is ever more paramount for further comprehensive studies to broadly assess the possible determinants of protective practices activity among different groups of workers who handle animals. Our study also showed that handwashing is a more widely accepted protective measure across animal farms in different geographical locations.

## CONCLUSION

PPE use in animal farming varies by location and prevalent norms in the respective populations studied. In addition, enforcement of protective protocols possibly enhances compliance with specific practices. However, PPE use seems to increase with health education and media messages that occur during outbreaks. These findings may prove useful to regulating bodies and farm owners in formulating policy or planning strategies. The strategies may eventually improve personal

hygiene practices in animal farming and improve emergency preparedness in public health prevention and control of influenza and other potential zoonotic disease outbreaks.

## FUNDING

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