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Pandemic Influenza Planning: Shouldn't Swine and Poultry Workers Be Included?

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Abstract

Recent research has demonstrated that swine and poultry professionals, especially those who work in large confinement facilities, are at markedly increased risk of zoonotic influenza virus infections. In serving as a bridging population for influenza virus spread between animals and man, these workers may introduce zoonotic influenza virus into their homes and communities as well as expose domestic swine and poultry to human influenza viruses. Prolonged and intense occupational exposures of humans working in swine or poultry confinement buildings could facilitate the generation of novel influenza viruses, as well as accelerate human influenza epidemics. Because of their potential bridging role, we posit that such workers should be recognized as a priority target group for annual influenza vaccines and receive special training to reduce the risk of influenza transmission. They should also be considered for increased surveillance and priority receipt of pandemic vaccines and antivirals.

Medical subject headings (MeSH)

influenza; zoonoses; occupational exposure; communicable diseases; emerging; agriculture

Many nations have drafted pandemic influenza plans. Like the US national strategy, these plans are designed "to decrease health impacts including severe morbidity and death" and to minimize the "societal and economic impacts" of a pandemic [1]. However, planners have given little attention to workers who may be at very high risk of zoonotic influenza virus infection, namely those daily exposed to thousands of swine or poultry in modern animal confinement facilities. Considering recent research findings, we posit that failing to include swine and poultry workers in influenza prevention plans could result in an increased probability of generating novel viruses, acceleration of pandemic morbidity and mortality among humans in rural communities, reduction in protein supplies, and exacerbation of a pandemic's tremendous economic impact. We present these points from a United States perspective but they may have application for other nations as well.

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Influenza Pandemics and Concomitant Epizootics in Swine and Domestic Birds

Influenza is a zoonotic disease that often involves cross-species viral infections between domestic swine, avian species, and man. The 1918, 1957, and 1968 pandemic influenza viruses all had structural components from an avian influenza virus [2]. During the 1918 pandemic, a concomitant epizootic of swine influenza spread across the US Midwest [3]. Numerous anecdotal accounts described farmers and their families developing influenza-like illnesses after contact with ill swine and episodes where swine developed symptoms of influenza after contact with ill farmers [4]. Subsequent to the 1918 pandemic, human influenza viruses have caused considerable morbidity among swine [5] and swine influenza viruses have caused occasional morbidity among humans [6,7]. While swine influenza viruses are commonly found among domestic avian species, avian influenza viruses are only occasionally detected among swine [8]. It has been fortunate that recent highly pathogenic H7N7 and H5N1 avian strains have not manifested efficient transmission from swine-to-swine [9,10]. However, like the 1918 experience, when the next pandemic virus emerges, it is possible that efficient swine-to-swine transmission of the influenza virus may occur, thus complicating control efforts.

Challenges Posed by Influenza A Infections Among Swine and Poultry Workers

The most important risk factor for humans acquiring swine influenza infection is exposure to pigs. Similarly, exposure to diseased birds has been the key risk factor for numerous cases of avian influenza virus infections in man (Table 1) [11]. A number of recent US research studies have helped us better understand the epidemiology of zoonotic influenza virus infections, especially in settings where the small farm has given way to large agricultural production facilities. Olsen et al. found that modern swine workers were much more likely to have antibodies against new swine viruses as compared to nonexposed controls [12]. Myers et al. demonstrated that swine farmers, swine veterinarians, and meat processing workers who handle pork had markedly increased odds of elevated antibodies against swine H1N1 and H1N2 viruses, that was not explained by exposure to human H1 virus or human influenza vaccines [7]. The adjusted odds ratio for swine farmers having elevated antibodies to a classic swine H1N1 virus was 35.3 (95% CI 7.7–161.8) compared to non-exposed controls. In another recent work, Ramirez et al. documented that swine workers' similar risk (OR=30.3; 95% CI 3.8–243.5) of elevated antibody titer to swine H1N1 virus is reduced almost to that of non-exposed controls if the workers reported using gloves during their occupational exposures [13].

We have recently validated these reports with a prospective study of 800 rural Iowans and documented serological as well as viral culture evidence of swine influenza virus infections [14]. Importantly, these infections occurred not only among swine-exposed workers, but also among their spouses who reported no direct contact with swine. The source of virus for the spouse infections is uncertain. Infections may have occurred through secondary transmission, fomite or other indirect contact. However, the spouse infections illustrate the important potential for zoonotic pathogens to move from the occupational workers to their families. It seems equally important to note that these infections may result in severe disease or death. Myers et al recently reviewed the 50 human swine influenza infection cases in the medical literature [15], recording a case-fatality percentage of 14 percent. Hence, should a novel influenza virus emerge in a swine population, such workers have potential to introduce the virus to their family members, their medical clinic, and their communities, causing considerable morbidity.

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Studies of avian influenza virus transmission among the poultry-exposed have been more technically difficult to conduct due to the poor performance and complexity of serological assays [16,17]. Serologic studies of humans exposed to diseased poultry have often been negative. However, available studies demonstrate that infections do occur. Retrospective seroprevalence studies among Hong Kong bird market workers in 1997 and 1998 showed that 10% had evidence of H5N1 infection [18]. In addition, 49% of 508 poultry cullers, as well as 64% of 63 persons exposed to H7N7 infected humans, had serological evidence of H7N7 infection following the 2003 Netherlands poultry outbreak [16]. A recent serological study of US duck hunters and wildlife biologists exposed to ducks and geese identified several subjects with elevated antibody titers against H11 viruses [19]. A controlled, 2002 cross-sectional study of US poultry-exposed veterinarians revealed serological evidence of previous infections with avian H5, H6, and H7 viruses [20]. While such epidemiological studies are relatively few, it seems clear that human avian influenza virus infections often follow exposure to dead or sick birds. Considering the recently emergent highly-pathogenic H5N1 viruses, the exposure most commonly implicated has been free-ranging poultry and small poultry flocks [21].

With these observations in mind, there are three interrelated, arguments for considering swine and poultry workers in influenza control plans: 1) The threat of the generation of novel viruses. 2) The threat of workers serving as a bridging population to share influenza viruses across species. 3) The potential for workers to accelerate a pandemic in their communities.

Generation of novel viruses

Each influenza season there is potential for workers to introduce human viruses to animal populations, especially swine, and in doing so, facilitate the generation of novel influenza viruses. Such novel viruses are thought to be generated through a reassortant event when a host (swine or human) is infected with two different viruses and progeny viruses emerge with genetic components of both human and swine origin. In recent years a number of such novel viruses have emerged to cause epidemics among swine. [22–24]. It is important to note that while avian influenza viruses are rarely detected among swine, swine influenza viruses are rather commonly detected among domestic avian species. Hence, it seems quite possible that reassortant viruses could emerge with genetic components of human, swine, and poultry viruses as facilitated by workers' man's intense occupational exposures to domestic animals. For these reasons the US swine industry and subsets of the poultry industry have recommended that their workers receive annual human influenza vaccines. However, US agricultural workers have yet to be recognized as priority target groups for annual influenza vaccine receipt and compliance with the agricultural industry's vaccine recommendations are likely poor.

Swine and Poultry Workers as Bridging Populations

In the United States agriculture has markedly changed over the last 50 years. Largely for economic reasons, small independent swine and poultry farms have yielded to modern agriculture industries for swine and poultry production [7]. Fifty years ago a US farmer might be exposed to his small herd of pigs or small flock of chickens for several minutes each day but today's agricultural workers may be exposed to thousands of pigs or tens of thousands of chickens for more than 8 hours each day. These intense and prolonged exposures provide much greater opportunity for man to serve as a bridging population in the cross-species sharing of viruses. As was mentioned before this bridging role may introduce human influenza viruses to swine or introduce communities to swine or poultry influenza virus infections. There is potential for not only the swine- or poultry-exposed workers to be infected with zoonotic influenza viruses but also for secondary transmission to occur. Myers et. al. recently documented several clusters of human-to-human swine influenza virus infections [20]. Similarly, although likely rare, there have been a number of reports of human-to-human transmission of highly pathogen avian influenza virus infections [25–27]. Infected with a virus efficient in human-to-human transmission, such agricultural workers would like serve as bridging population to infect their families and possibly their medical care providers.

Swine and Poultry Workers Accelerating a Pandemic

Recent modeling studies were conducted to evaluate influenza transmission risk associated with modern animal confinement facilities [28]. Assuming an influenza virus has similar transmission characteristics within and between species, in communities with a high proportion of swine or poultry workers working in large animal confinement facilities, the workers may more readily spread the virus to others in their communities and thus accelerate the epidemic. In settings where agricultural workers make up as much as 45% of the employed, these workers would increase influenza infections among community members by as much as 86% [28]. This scenario is similar to parents sending a child to a crowded day care center where an explosive epidemic of a viral respiratory pathogen is in progress. Such a child is at increased risk of acquiring the pathogen in the daycare facility compared to non-daycare children in the community [29,30]. The exposed child similarly puts his or her parents and other siblings at increased risk of infection.

Confinement feeding operations in many developed nations are heavily monitored and these operations likely provide the world's safest and most efficient sources of animal protein. However, when large numbers of susceptible pigs or poultry are maintained in close proximity in a confined space, animal housing conditions are epidemiologically equivalent to the crowding of humans associated with military training camps or schools, where viral loads can be extremely high, morbidity severe, and explosive outbreaks of respiratory disease common [31].

The reader might ask "Wouldn't a pandemic virus be recognized in the herd or flock and the animals be immediately depopulated thus reducing transmission risk to the community?" When highly pathogenic H5N1 strains have entered most poultry facilities, the answer has been "yes" because the sudden onset of high mortality is immediately obvious. However, in domestic ducks and geese novel influenza virus infections may be better tolerated and not readily identified. Similarly, should the United States begin vaccinating poultry flocks like China, Vietnam, France, Russia, and the Netherlands have done, birds actively infected with highly pathogenic strains may be asymptomatic, yet shed large numbers of virus particles in feces and secretions from the nares and mouth. Caretakers of these flocks could be at increased risk of infection due to exposure to the zoonotic virus.

Similarly, if the current H5N1 virus entered a swine facility today, pig-to-pig transmission seems unlikely [10]. Like the 1918 pandemic strain, however, the H5N1 virus could mutate and develop efficient transmission between pigs. If an H5N1 virus adapted to swine and caused only mild disease among pigs, this disease would be clinically indistinguishable from other endemic respiratory diseases of swine. Infection of swine by a novel influenza virus, highly pathogenic to humans but not to swine, could conceivably remain undetected for a significant period of time and result in the exposure of swine caretakers.

Recommended Protections for Swine and Poultry Workers

How long would it take to recognize novel influenza virus human disease among workers in animal confinement facilities? Detection among US agricultural workers is likely to be markedly delayed as many workers have little access to medical care, live in rural communities with sparse laboratory capabilities, and speak English as second language. Assuming the >30-fold increase in zoonotic influenza infection risk [7,13,14] we have repeatedly calculated for swine workers is real, for what other population at such a risk for disease would we not strongly recommend available vaccines? Hence, it seems both prudent and ethically correct to protect these workers.

For the reasons we outlined above, we believe that swine and poultry workers should be included in influenza prevention programs. However, we can find no US government policy or recommendation to that effect. The workers are not mentioned in annual influenza vaccine recommendations nor are they on the proposed priority lists for access to pandemic influenza vaccines, or pandemic antivirals.

Hence, we argue that swine and poultry workers, especially those whose work involves intensive exposure through modern confinement agriculture, should be trained in hygienic measures to prevent influenza transmission including the use of gloves to reduce skin contact with animal secretions, and where appropriate, use of fit-tested N-95 filtering facepiece respirators to reduce airborne inhalation.

Swine and poultry workers should be added to the annual influenza vaccine priority target groups list. Similar to requirements that military trainees and students receive a battery of vaccines before their training, we argue that swine and poultry workers should, perhaps as a condition for employment, agree to annually receive influenza vaccine and to seek medical screening should they develop influenza-like-illness symptoms. These interventions may require the creation of new health partnerships and influenza surveillance programs involving collaboration between US agricultural industries and public health.

We further posit that these workers, because of their potential to accelerate a pandemic should be high on the US priority lists for the receipt of pandemic vaccines and antivirals. The World Health Organization suggests such a vaccination policy [32] and modeling study mentioned above demonstrated that if one only vaccinated 50% of the animal workers against the pandemic virus, the increased risk of viral transmission to the workers' communities would be totally mitigated [28].

How many swine and poultry workers should be included in influenza prevention programs? While others may have similar intensive animal exposures, the focus in this paper has been upon the confinement worker. The number of US confinement workers is difficult to estimate as they have no unifying membership organization. However, animal production statistics are available and extrapolating from these data (Table 2) we estimate that US swine and poultry industry workers currently number approximately 54 thousand. Hence, considering other high risk groups in US national plans targeted for special access to pandemic vaccines and antivirals (e.g. 8–9 million US medical and public health workers [28]), the number of swine and poultry workers is relatively few. Hence, the investment in protecting them is relatively small and very likely cost-effective.

When one considers the importance of the agricultural industry it again makes very good sense to do all that we can to reduce the probability of the emergence and spread of novel influenza viruses. The United Nations Food and Agricultural Organization estimated that poultry (chickens, turkeys, and ducks) comprised 46.9% and pigs 23.8% of US meat production in 2005. In countries where H5N1 has been introduced, the combination of bird culling, loss of exports, and reductions in sales has greatly damaged the poultry industry. After suffering numerous epidemics, Romania's poultry industry experienced an 80% reduction in sales and many producers were near bankruptcy [33]. Losing either the poultry or the swine industry, even for a short time, could greatly reduce animal protein supplies and significantly damage local economies, especially those rural areas that rely heavily upon agriculture. Nationally, prolonged agricultural losses would be economically profound. The World Bank has recently estimated that a severe influenza pandemic could cost the world economy around US$1.25 to $2 trillion [33]. Hence, in addition to concerns about protecting the health of workers and their communities, protecting agricultural workers will also help to protect the nation's food supply and economy.

In summary, agricultural workers should be trained to reduce the likelihood of cross-species influenza virus transmission and required to seek medical screening should they develop influenza-like-illness. They should be recognized as a priority group for the receipt of annual influenza vaccines, pandemic influenza vaccines, pandemic use of antivirals, and included in influenza surveillance efforts. Not only are such interventions morally "the right thing to do," but implementing them makes good public health and economic sense.

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Table 1

Recent avian influenza outbreaks that have infected man.

Years	Avian influenza A type	Country	Number of human infections	Number of human deaths
1997	H5N1	Hong Kong	18	6
1999	H9N2	Hong Kong	2	
2002	H7N2	Virginia	1	
2003	H5N1	Hong Kong	2	1
2003	H7N7	The Netherlands & Belgium	89	1
2003	H9N2	Hong Kong	1	
2003	H7N2	New York	1	
2004	H7N3	Canada	2	
2004	H10N7	Egypt	2	
2004/7	H5N1	Numerous	277	167

Table data were derived from various World Health Organization presentations and reports (www.who.int) as of March 8, 2007

Table 2

Estimated Numbers of US Swine and Poultry Caretakers Based Upon Animal Productivity Counts.

Animal types	Average number of animals in US inventory at any one time	Number of needed (full time equivalent) animal caretakers with direct contact	Estimated Number of workers*
Breeding sows	6,060,000†	1 FTE/300 breeding sows‡	20,200
Finishing pigs	34,270,000†	1 FTE/8000 finishing pigs‡	4,284
Nursery pigs	20,598,000†	1 FTE/5000 nursery pigs‡	4,120
Broiler chickens	1,500,000,000§	0.07 FTE/10,000 broilers§	10,500
Egg layers	290,000,000§	0.06 FTE/10,000 egg layers§	1,740
Turkeys	120,000,000§	0.03 FTE/1000 turkeys§	3,600
---	---	Veterinarians and veterinary technicians involved in swine production‖	9,830
---	---	Veterinarians and veterinary technicians involved in poultry production‡	200
		Total workers	54,474

*These numbers represent an estimate of the number of workers providing daily care for the animals. They do not reflect the actual number of people working in swine or poultry processing plants, and they do not include estimates of the number of people working with or caring for backyard poultry or swine.

†US Hog Report statistics, 2006

‡Personal communication Alex Ramirez, DVM, MPH, Veterinary Diagnostic and Production Animal Medicine, Iowa State University, Ames, IA

§D.W.T.'s estimates through consultations with poultry industry representatives

‖American Veterinary Medical Association market statistics report, 2006