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The Importance of Including Swine and Poultry Workers in Influenza Vaccination Programs

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Abstract

Sensing the threat of an influenza pandemic, many countries are developing influenza pandemic prevention and control strategies. Such plans often focus efforts on detecting outbreaks and protecting leaders, health-care workers, and outbreak responders. Considering recent research, we argue that prevention plans should also include swine and poultry workers. Ignoring these workers could result in an increased probability of generating novel viruses, as well as result in the acceleration of a pandemic's morbidity and mortality.

Influenza A zoonoses

Influenza pandemics occur when humans have little or no immunity against a novel influenza virus subtype that transmits efficiently from human to human. Often the human immune system is naive to such pathogens, because the viruses present with antigens of animal virus origin. Whereas the pandemics of 1918, 1957, and 1968 had genetic components from avian viruses, pandemic viruses may arise from any number of animal influenza viruses. Hence, exposure to animal species harboring influenza A viruses may play a role in the origination of a novel virus or its spread. During the 1918 pandemic, the US Midwest experienced a concurrent epizootic of swine influenza. Contemporary reports described incidents of cross-species infections, because farmers and their families developed influenza-like illnesses after contact with ill swine and swine developed clinical signs of influenza after contact with ill farmers.¹

Although swine influenza viruses are often detected among domestic bird species (primarily turkeys), pigs are not as readily infected with avian influenza viruses, and swine-to-swine transmission of these viruses is sporadic. This inefficient communicability has helped to check the spread of emergent highly pathogenic avian influenza viruses as well as reduced the opportunity for swine to serve as a "mixing vessel" in the genesis of novel reassortant virus strains with pandemic potential. However, if one of the currently circulating H5N1 avian virus strains, like the 1918 pandemic strain, were to become efficient in swine-to-swine transmission, pandemic control efforts will be further complicated by domestic and perhaps feral pigs.

Zoonotic influenza A infections among swine and poultry workers

The key risk factors for human infections with swine or avian influenza virus is exposure to diseased pigs or birds.² Recent US epidemiological studies suggest that agricultural workers, including veterinarians, are at increased risk of zoonotic influenza virus infection. A 2002 study reported that modern swine workers were considerably more likely to have antibodies against new swine viruses, in comparison with controls not exposed to swine.³ A recent study found that swine farmers, swine veterinarians, and porkprocessing workers were significantly more likely to have elevated antibodies against swine H1N1 and H1N2 viruses, which could not be

attributed to exposure to human H1 influenza virus or vaccines.⁴ This same study showed that the adjusted odds ratio (OR) for swine farmers having an elevated antibody titer to a classic swine H1N1 virus was 35.3 (95% CI 7.7-161.8) in comparison with controls not exposed to swine.⁴ In another recent publication, swine workers' high risk (OR = 30.3; 95% CI 3.8-243.5) of elevated antibodies to swine H1N1 virus decreased almost to that of nonexposed controls when the workers reported using gloves during their occupational exposures.⁵

We recently validated these cross-sectional study reports with a prospective 2-year study of 803 rural Midwesterners.⁶ Among the participants, those with swine exposures had markedly elevated odds or increased antibody titers against swine viruses, indicating previous occupational infection. In addition, their prospective data revealed serological and culture evidence of swine virus infection over the 2 years of follow-up. Surprisingly, many of the swine workers' spouses, who denied having direct contact with swine, also had increased antibody titers against swine influenza viruses.⁶ The spread of these viruses to spouses illustrates the precarious potential for zoonotic pathogens to move to the families of those occupationally exposed.

Demonstrating avian influenza virus transmission among poultry-exposed populations has been scientifically challenging because of the poor performance and complexity of serological assays; however, studies have shown that such infections do occur. Following the 2003 Netherlands outbreak of highly pathogenic avian influenza H7N7 in poultry, 49% of 508 poultry cullers, as well as 64% of 63 persons exposed to H7N7-infected persons, had serological evidence of influenza H7N7 infection (Table 1). In a cross-sectional study of US poultry-exposed veterinarians in 2002, serological evidence of previous infections with avian H5, H6, and H7 viruses was documented.⁷ Even with sparse epidemiological data, human infections are clearly associated with exposure to dead or sick birds (Table 1). In the developed world, those with the highest probability of such exposure are persons working in agricultural industries.

Considering this latest evidence, influenza-control plans should include swine and poultry workers, because they may (i) serve as an interface for the cross-species sharing of influenza viruses, (ii) facilitate the origination of novel reassortant viruses, and (iii) intensify a pandemic's morbidity within their communities.

Interface to share viruses

Modern agriculture industries daily expose workers to thousands of pigs and tens of thousands of chickens, presenting an opportunistic setting for humans to serve as an interface or bridging population for the cross-species sharing of viruses. Because there is potential for the occurrence of not only zoonotic influenza virus infections but also secondary transmission,⁶ the workers function as liaisons capable of both introducing human influenza viruses to swine and introducing swine or poultry influenza viruses to their communities.

Several clusters of human-to-human swine influenza virus infections have recently been documented.⁸ Similarly, although probably rare, there have been several reports of human-to-human transmission of highly pathogenic H5N1 avian influenza virus infections among family members.⁹ If, as a consequence of their occupation, agricultural workers become infected with a zoonotic virus efficient in human-to-human transmission, they may very well serve as an intermediary, passing the novel virus on to their families, community, and medical care providers.

Origination of novel viruses

Workers infected with seasonal influenza have the potential to introduce human viruses to animal populations, especially swine. Animal species infected with both human and animal influenza viruses may serve as a proverbial “mixing vessel” and thus beget a reassorted novel progeny virus with genetic characteristics of each. Reassortant progeny viruses may similarly originate in the human host. Because modern poultry workers have intense exposures to domestic avian species readily infected with swine influenza viruses, the mechanisms are in place for reassortant viruses to emerge with genetic components of human, swine, and avian viruses.

Acceleration of pandemic morbidity

When large numbers of susceptible pigs or poultry are confined in close proximity, conditions are epidemiologically equivalent to the crowding associated with military training camps or schools, with the potential for extremely high viral loads, subsequent severe morbidity, and explosive outbreaks. A novel virus emerging in a confined animal population would provide an opportunity for infected workers to initiate considerable morbidity in their communities, by introducing the virus to their families, neighborhoods, and medical practitioners. Recent epidemic modeling studies assessed influenza transmission risk related to modern animal confinement facilities. In rural areas where the agriculture sector constitutes as much as 45% of the employed, workers could augment influenza infections among community members by as much as 86%.¹⁰ A recent review of 50 human swine influenza infection cases recorded a case-fatality rate of 14%,⁸ illustrating the potential threat that zoonotic influenza viruses pose to communities.

Protecting swine and poultry workers

US agricultural workers have yet to be recognized as a pandemic planning priority group. To date, most government and industry recommendations target only poultry workers involved in avian influenza outbreak control and eradication efforts. Only in the event of an avian influenza outbreak at their facility would routine poultry workers receive preventive interventions. Because many agricultural workers have limited access to medical care, live in rural communities with limited laboratory capabilities, and speak English as a second language, their infection with a novel influenza virus could be undetected for some time. Given the >30-fold increase in zoonotic influenza infection risk,⁴⁻⁶ protecting these workers with available preventive measures, including vaccines and proper hygiene training, is good public health practice.

As a first line of defense, swine and poultry workers, especially those with intensive exposures via modern confinement agriculture, should receive mandatory training in effective hygienic measures to prevent influenza transmission. Such measures include the use of gloves to reduce contact with animal secretions and, where appropriate, fittested N-95 masks to reduce airborne inhalation. Workers should also learn to recognize clinical signs of influenza in animals and how to respond if a pathogenic influenza strain is found in their facilities.

Annual seasonal influenza vaccine priority lists should include swine and poultry workers, in an effort to thwart the generation of a novel virus subtype. Like military trainees, workers without contraindications should agree to annually receive the seasonal influenza vaccine, perhaps as an obligation for employment, and all workers should consent to seek medical screening in the event that they develop influenza-like-illness symptoms. Furthermore, agricultural industries and public health professionals should aggressively seek to partner in influenza-surveillance efforts.

In addition to seasonal vaccinations, swine and poultry workers should be included on US priority lists to receive pandemic vaccines and antivirals. Like medical workers, they have great potential to accelerate pandemic morbidity. Modeling has revealed that vaccinating only as few as 50% of the animal workers against the pandemic influenza virus would prevent the increased risk of introducing a virus into the workers' communities.¹⁰ The World Health Organization suggests an influenza pandemic vaccination policy that would include agricultural workers, but otherwise we have found no other such organizational endorsement in the United States or elsewhere.

In short, to reduce the likelihood of cross-species influenza virus transmission, employers should train agricultural workers in influenza prevention and response and require workers to seek medical screening upon development of influenza-like illnesses. National pandemic plans should acknowledge swine and poultry workers as a priority group for receiving annual seasonal influenza vaccines and pandemic influenza vaccines and antivirals, and also include such workers in influenza-surveillance efforts. If, like medical workers, US agricultural workers are at high risk of exposure to zoonotic influenza viruses of pandemic potential, shouldn't they, like medical workers, benefit from special education, influenza vaccines, and antiviral therapy?

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Table 1

Country (year)	Virus	Study type	Exposure/occupation	Comments	Reference
Hong Kong (1997)	H5N1	Case-control study	Exposure to live poultry	15 human H5N1 cases and 56 controls. Exposure to live poultry the week before illness onset was significantly associated with H5N1 disease (64% of cases vs. 29% controls, OR = 4.5)	Mounts <i>et al.</i> ¹¹
		Seroprevalence study	PW	Prevalences of elevated antibody against AI for 1,525 commercial PWs and government PWs were 10% and 3%, respectively	Bridges <i>et al.</i> ¹²
		Case study	PW	Following outbreak in 255 commercial poultry farms, H7N7 virus infection identified by RT-PCR in 86 PWs	Koopmans <i>et al.</i> ¹³
The Netherlands (2003)	H7N7		Household contact of PW	H7N7 virus infection identified by RT-PCR in household contacts of PCR-positive workers	Koopmans <i>et al.</i> ¹³
		Retrospective cohort study	Household member of infected PW	33 (58.9%) of 56 household members had positive H7 serology	Du Ry van Beest <i>et al.</i> ¹⁴
		Seroprevalence study	Exposure to poultry	49% of 508 persons exposed to poultry had H7-specific antibodies	Meijer <i>et al.</i> ¹⁵
Canada (2004)	H7N3		Exposure to H7-infected humans	64% of 63 persons exposed to H7-infected humans had H7-specific antibodies	Meijer <i>et al.</i> ¹⁵
		Case study	PW or culler	After outbreak in poultry, one PW and one culler had laboratory-confirmed H7N3 infections	Tweed <i>et al.</i> ¹⁶
Thailand (2004)	H5N1	Surveillance study	Exposure to ill poultry	Of the 12 confirmed human H5N1 cases, 8 reported direct exposures to ill poultry 2-8 days before onset (67%)	Chotpitayasunondh <i>et al.</i> ¹⁷
Vietnam (2004)	H5N1	Case-control study	Touching unexpectedly dead poultry	16 human H5N1 cases and 64 matched controls. Direct touching of unexpectedly dead poultry was the most significant risk factor (OR = 29)	Areechokchai <i>et al.</i> ¹⁸
		Case study	Direct exposure to poultry	Of 10 human H5N1 cases, 9 (90%) had clear history of direct contact with poultry. In all 10 cases, infection seemed to have been acquired directly from infected poultry	Tran <i>et al.</i> ¹⁹
		Case-control study	Sick or dead poultry in household	Study of 28 human H5N1 cases and 106 matched controls. Having sick or dead poultry in the household was a potential risk factor for human H5N1 infection (OR = 4.94)	Dinh <i>et al.</i> ²⁰
		Population-based ILI surveillance	Direct contact with sick poultry	Of 45,478 randomly selected inhabitants, 8,149 reported ILI. Having direct contact with sick poultry was significantly associated with ILI (OR = 1.73). ILI attributed to direct contact with poultry estimated to be 650-750 cases	Thorson <i>et al.</i> ²¹

Country (year)	Virus	Study type	Exposure/occupation	Comments	Reference
Turkey (2006)	H5N1	Case study	Contact with diseased or dead chickens	Of eight human H5N1 infections, all eight patients had a history of close contact with diseased or dead chickens	Oner <i>et al.</i> ²²

ILI, influenza-like illness; OR, odds ratio; PW, poultry worker.