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Short communication

Interaction of the role of Concentrated Animal Feeding Operations (CAFOs) in Emerging Infectious Diseases (EIDS)

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ABSTRACT

Most significant change in the evolution of the influenza virus is the rapid growth of the Concentrated Animal Feeding Operations (CAFOs) on a global scale. These industrial agricultural operations have the potential of housing thousands of animals in a relatively small area. Emerging Infectious Diseases (EIDs) event can be considered as a shift in the pathogen–host–environment interplay characteristics described by Engering et al. (2013). These changes in the host–environment and the disease ecology are key to creating novel transmission patterns and selection of novel pathogens with a modification of genetic traits. With the development of CAFOs throughout the world, the need for training of animal caretakers to observe, identify, treat, vaccinate and cull if necessary is important to safeguard public health. The best defense against another pandemic of Emerging Infectious Diseases (EIDs) is the constant monitoring of the livestock and handlers of CAFOs and the live animal markets. These are the most likely epicenter of the next pandemic.

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1. The rise of industrial agriculture and its role in Emerging Infectious Diseases (EIDs)

The most significant change in the emergence of EIDs is the rapid growth of Concentrated Animal Feeding Operations (CAFOs) in industrial and emerging industrial nations. These industrial agricultural operations can house hundreds of thousands of animals in relatively small areas near human population centers. World pork consumption has increased by 27% from 1997 to 2005, with total global pork consumption for 2005 at over 93 million metric tons (MT) (Orr and Shen, 2006). The majority of CAFOs for swine production is in the upper mid-west and southeastern United States, Canada and northern Europe, primarily to accommodate for harsh weather conditions. According to O'Connor et al. (2010), a typical CAFO can house over 1000 swine in multiple barns at a single site. Feedlots can house up to 50,000 head of cattle, 50,000 chickens, ducks or turkeys. Many of these industrial farms are near human population centers. The People's Republic of China is the world leader in the production of pigs, ducks and geese, all known reservoirs for the influenza virus (McMichael, 2004; Gregor, 2005).

Research on CAFOs has been confined to water quality issues and odor abatement, with only few studies on airborne pathogens. CAFO production first developed in the United States in the 1950s and spread globally in the 1990s, resulting in the “livestock revolution” with the production of millions of animals, much akin to the “green revolution” of the 1960s with grain production (Gregor, 2005). This livestock revolution was a transition from low-efficiency higher cost family operations to high-efficiency lower-operational-cost CAFO organizations. Not until the 1970s were the first studies initiated concerning the health and safety of CAFOs and since that time only 30 studies have been published, most of them about water quality, and odor abatement (Orr and Shen, 2006).

The concern about CAFOs is the harboring and providing a rich environment for the evolution of new strains of diseases. CAFOs hold large populations of animals; they can facilitate the rapid spread of a pathogenic agent to population centers as was in the case in the 2009 pandemic influenza A (H1N1) outbreak. More than 150 known enteric pathogens may be present in the untreated wastes, and one new enteric pathogen has been discovered every year over the past decade. Training in the surveillance, and vaccination against disease, especially airborne pathogens should be a priority (Gerba and Smith, 2005). These facilities provide an unnaturally high concentration of animals with limited air space, and waste removal, which allows for the rapid selection of, amplification, and with the rapid transportation of animals from one site to another, and results in never before spread of zoonotic pathogens on such a large scale (Orr and Shen, 2006, Gregor, 2005; Gerba and Smith, 2005). These are unique circumstances to animal husbandry.

2. Emerging Infectious Diseases (EIDs)

An emerging infectious disease (EID) can be defined as “an infectious disease whose incidence is increasing following its first introduction into a new host population or whose incidence is increasing in an existing host population as a result of long-term changes in its underlying epidemiology” (Engering et al., 2013). EID events may also be caused by a pathogen

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expanding into an area in which it has not previously been reported, or which has significantly changed its pathological or clinical presentation (Engering et al., 2013; Salman et al., 2008). Usually an infectious disease emergence in humans is caused by pathogens of animal origin, so-called zoonoses (McMichael, 2004; Gregor, 2005; Engering et al., 2013). Likewise, cross-over events may occur between non-human species including between domestic animals and wildlife, and such events also involve transmission from a reservoir population into a novel host population (spill-over) (Engering et al., 2013; Jones et al., 2008). Emergence in a novel host, which includes spill-over/zoonoses, has been extensively studied. These have included disease with varied success i.e.: influenza, and HIV-1 pandemics with far reaching results; and potential pandemics that were never successful, e.g. severe acute respiratory syndrome (SARS) because of quick action; and other pathogens that never reached the spill-over threshold to be transmission by simple methodology e.g.: Ebola HEV and monkey pox (Engering et al., 2013).

3. New research on EIDs

An EID event can be considered as a shift in the pathogen–host–environment interplay characteristics. Changes in the host–environment and the disease ecology are key to creating novel transmission patterns and selection of novel pathogens with fitter genetic traits. This process will finally result in a novel steady state pathogen–host–environment interplay. Yet, it is difficult to tell what this new pattern will look like until it materializes. The most commonly studied scenario for the pathogen-host-environment shift is the influenza virus.

Normally, human influenza viruses do not replicate efficiently in ducks and other waterfowl, and neither duck influenza viruses in humans (Gregor, 2005; Jones et al., 2008; Taylor et al., 2001). Influenza viruses found in their natural hosts do not seem to pose a threat, however, once disturbed or have migrated to another host there are two means in which they can enter the human species: assortment or adaptation in an intermediated host (Gregor, 2005). The increase of CAFOs incorporating rice-duck farming (Gregor, 2005; Clauss and Osterhaus, 1998), pig-waterfowl-fish aquaculture (Gregor, 2005; Taubenberger and Morens, 2006); and live poultry markets (Gregor, 2005; Shortridge, 1999) are all implicated in the emergence of an influenza virus with pandemic potential. With the expansion of the intensive poultry CAFOs to 10-million-bird- mega-farms could account for the dramatic genetic shift resulting from the change in the ecology and epidemiology of avian influenza and other EIDs. In China alone, there are now over 10 billion potential reservoirs EIDs to exist and change (Woo et al., 2006). This translates into the greater risk of genetic drift and a greater degree of reassortment by just simple probability to a novel strain. This model alone can offer with evidence that Galliform species (i.e., terrestrial birds such as chickens, turkeys and quail) may serve as a suitable intermediate hosts to influenza to convert to more virulent strains. The drivers of pathogen emergence change the overall pattern of the pathogen–host–environment interactions leading to either (i) a pathogen showing up in a novel host; (ii) a mutant pathogen with novel traits causing more frequent or more severe disease while remaining in the same host; or (iii) an invasion process involving a novel geographic area (Engering et al., 2013). The disease emergence starts with an existing disease complex or pathogen–host–environment complex. While the three emergence categories are broadly speaking distinct, there are also gray areas, between existing and emerging disease events and at the interface of the three disease emergence categories, creating ambiguity in where the disease will emerge and it what way.

4. Regulation of CAFOs and protection of human health

The challenge of the future is recognizing the potential which the health effects of CAFOs may have on human health centers. One probable cause of the 1918 influenza pandemic has been traced back to a single soldier near present day Ft. Riley, Kansas, cleaning the pig pens one spring day. Since that day, we have recorded a number of pandemics (Table 1) linked to swine and birds. With the expansion of CAFOs as shown on Table 1, the threat continues. The water run-off and odors have been exhaustively studied, yet the potential viral load in airborne particulates has been ignored. The massive populations of animals should force researchers to move beyond odor based studies to that of one encompassing research of composition and potential health risks to humans (Orr and Shen, 2006; Beaudoin et al., 2011). Recent research and shared results indicate that neighbors of CAFOs do experience health problems at a significantly higher rate than the control populations (Ludwig et al.,1995; Corzo et al., 2013; Gilchrist et al., 2007. Dust from feedlots and animal housing units contain biologically active organisms such as bacteria, mold, and fungi from feces, and feed; this dust poses a greater health hazard than does general “nuisance” dust (Donham, 1991; Ludwig et al., 1995; Daszak et al., 2000; Arnold, 2013). In a recent study of swine confinements in Texas, 20% of workers suffered from Organic Dust Toxic Syndrome (ODTS). ODTS is an acute influenza-like illness that follows four-six hours of intense exposure to agricultural dusts (Gilchrist et al., 2007; O'Connor et al., 2010; Beaudoin et al., 2011). The emissions from CAFOs alone create problems as aerosols and act as vectors for airborne viruses. With so many swine and poultry CAFOs in close proximity, the acceleration of the “mixing” and assortment of influenza viruses is unfathomable (Donham, 1998; Daszak et al., 2000; Woolhouse and Gowtage-Sequeria, 2005; Corzo et al., 2013; Gilchrist et al., 2007; Arnold, 2013).

The evidence is growing for interspecies spread of human, swine and avian viruses (Daszak et al., 2000; Woolhouse and Gowtage-Sequeria, 2005). The need for global integration and rapid sharing of data and resources to fight IAV in swine and other animal species is apparent, but this effort requires grassroots support from governments, practicing veterinarians and the swine industry and, ultimately, requires significant increases in funding and infrastructure (Liverani et al., 2013; Vincent et al., 2014). In addition to the call for sharing resources, the need for training of animal caretakers to observe, identify, treat, vaccinate and cull if necessary is vital. These workers will be the next patient zero in the next pandemic (Beaudoin et al., 2010, 2011). Our best defense against the next pandemic is to monitor the CAFOs and their workers.

Table 1
Major historical pandemics since 1900.

Year	Name of pandemic	Origin	Deaths recorded
1918–1919	Spanish flu	First thought Kansas, now China and simultaneous outbreaks in Detroit, South Carolina and San Quentin Prison.	40 ± 50 million global estimate.
1957–1958	Asian flu	Yunan Province, China	1 million estimate
1968–1969	Hong Kong flu	China	0.75–1 million
1977–1978	Russian flu	Russia or northern China	No accurate estimate
2009–2010	2009 flu pandemic	Mexico	18,000

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