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Scientific Literature Review: Available Research on Potential Human Health Impacts of Air Emissions from High-Density Poultry Farming July 2022

I. Overview and Summary of Studies

In response to a request from an Oregon resident, the Oregon Health Authority (OHA) conducted a high-level review of available research on potential human health concerns related to air emissions from high-density poultry farming. The following review summarizes the current literature OHA's Environmental Public Health Section found regarding community health, as well as background information about chemical emissions associated with such operations. This review responds to a request for information about health effects of air emissions from these facilities, and so does not cover health impacts from water and soil contamination. In addition, OHA's focus is on community health, and so this review does not include literature focused on occupational health, which is in the purview of Oregon Occupational Safety and Health. In general, OHA found a limited number of relevant studies, and as noted below certain studies had identified data gaps.

- Air emissions from high-density poultry farming include particulate matter, ammonia, hydrogen sulfide, greenhouse gases, as well as other hazardous materials (e.g., bioaerosols).
- Studies have found microorganisms, including low-pathogenic avian influenza virus (i.e., avian influenza virus with a low potential to kill chickens), downwind of high-density poultry buildings. One study found that microorganisms could be dispersed up to 3000 meters from poultry buildings.
- Six-peer reviewed studies analyzed human health effects near poultry farms, and key details about each study can be found in this document.

All six studies state that additional research is needed to either confirm key results or more fully characterize the range of potential health effects to neighbors of high-density poultry farming.

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The six studies and their focal areas are:

- Respiratory Health Effects (4 studies)
 - Three studies reported that air emissions from high-density poultry farms were associated with adverse respiratory health effects (1 in Pennsylvania and 2 in the Netherlands). One of the studies focused on livestock farms, some of which were poultry farms.
 - One study in the Netherlands found a lower prevalence (i.e., proportion of a population) with respiratory health issues near livestock farms. This study included poultry farms as well as other types of farms.
- Gastrointestinal Health Effects (1 study)
 - One study in Pennsylvania suggests that high-density poultry operations may be associated with campylobacteriosis and infectious diarrhea in nearby communities.
- Noncancer Health Risk Calculation (1 study)
 - One study in Poland calculated potential noncancer health risks to nearby neighbors using a screening tool (hazard indices) and found a low potential for adverse health effects.

High-density poultry farming reports and studies describe additional factors that can contribute to adverse human health effects (e.g., odor, insect, social and mental health issues). For example, a report from the Food and Agriculture Organization of the United Nations stated that odor issues are frequently reported by neighbors as the most disturbing environmental factor. Two journal articles assessing the state of the science regarding confined animal feeding operations recommended more research on how poultry farming affects the health of neighboring residents, especially in regards to vulnerable populations.

II. Background on Air Emissions

There is a wide range of air emissions from high-density poultry farming, including ammonia, particulate matter and bioaerosols, as documented in several studies:

- Air contaminants from poultry production include ammonia, hydrogen sulfide, other odor-causing compounds, and particulate matter (Gerber et al., 2007).
- Greenhouse gases (e.g., carbon dioxide and nitrous oxide) are emitted (Dunkley & Dunkley, 2013; Gerber et al., 2007).
- Volatilized ammonia can be re-deposited in nearby water and land and contribute to eutrophication, acidification and damage to vegetation and sensitive ecosystems (Gerber et al., 2007). Ammonia is a chemical made up of nitrogen and hydrogen. In the environment it breaks down into its component parts.

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- A study that included microorganism samples in air near industrial poultry buildings found that microorganisms can be dispersed by air flow over long distances from production buildings. Authors conclude that the microorganisms could be dispersed by air flow for up to 3000 meters from the production buildings (Baykov & Stoyanov, 1999).
- Researchers collected samples of suspended particulate matter inside and near buildings holding poultry infected with low-pathogenic avian influenza virus. [OHA Note: low-pathogenic avian influenza-infected poultry flocks show milder or even non observable symptoms compared to high-pathogenic avian influenza infected flocks]. The researchers tested particulate matter for the presence of influenza virus. The data suggest that humans living downwind of farms associated with avian influenza virus were possibly exposed to these viruses in airborne particulate matter (Jonges et al., 2015), and additional research is needed to understand public health implications.

Note that "low-pathogenic" refers to the ability to cause disease in chickens; it does not refer to how infectious the avian influenza-A virus may be to humans. According to the US Centers for Disease Control and Prevention (CDC), human infections with avian influenza-A viruses are uncommon (<u>CDC website</u>; accessed May 25, 2022).

III. Details from Peer-Reviewed Health Studies

Four studies focused on human health effects near high-density poultry farms and two studies focused on health effects from livestock farms which included poultry farms. Key details about each study's objectives, methods, and conclusions are listed below. All these studies state that additional research is needed to either confirm key results or more fully characterize the range of potential health effects to neighbors of high-density poultry farming.

A. Respiratory Effects Observed – Three Studies

Study Title: High-density poultry operations and community-acquired pneumonia in Pennsylvania (Poulsen, Pollak, Sills, Casey, Nachman, et al., 2018)

• Objective: Researchers evaluated the association between distance to high-density poultry operations and diagnosis with community-acquired pneumonia (CAP). • Methods: Researchers conducted a nested case—control study among patients of a large health system in Pennsylvania. They used electronic health records from 2004 to 2015 to identify 11,910 child and adult cases of CAP and 59,550 frequency-matched outpatient controls. They estimated exposure to poultry operations using data from nutrient management plans and residential addresses that incorporated number, size, and location of operations. Poultry types included broilers, layers, pullets, turkeys, and ducks.

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- Living in the highest quartile of the poultry operation metric (i.e., living closer to a larger number and size of poultry operations) was associated with 66% increased odds of CAP diagnosis.
- Key Limitations: Authors propose that farm-related air pollutants may alter oropharyngeal microbiota (i.e., microorganisms in the mouth and throat area), leading to increased susceptibility to respiratory infections; however, this study did not include samples from nearby air, water, soil, or people's microbiota to assess this hypothesis. Authors also note that this study does not account for all dimensions of socioeconomic status; for example, they only had information on participant's Medical Assistance history and were not able to account for income or education levels.
- This study provides initial evidence that residential proximity to a larger number and size of poultry operations may increase risk for CAP, but the authors state that additional research is needed to confirm these findings and elucidate the environmental and biological pathways.

Study Title: Increased risk of pneumonia in residents living near poultry farms: does the upper respiratory tract microbiota play a role? (Smit et al., 2017)

- Background: Authors aimed to confirm the increased risk of community-acquired pneumonia (CAP) near poultry farms, and hypothesized that the oropharyngeal microbiota composition in CAP patients may be associated with residential proximity to poultry farms.
- Methods: A spatial kernel model was used to analyze the association between proximity to poultry farms and CAP diagnosis, obtained from electronic medical records of 92,548 patients in a region of the Netherlands with a high density of intensive livestock farms.
- Analysis confirmed a significantly increased risk of CAP when living near poultry farms, suggesting an excess risk up to 1.15 km [0.71 miles], with little to no excess risk past 1.15 km.
- Living near poultry farms was associated with an 11% increased risk of CAP, possibly resulting from changes in the upper respiratory tract microbiota composition in susceptible individuals.
- Results suggested higher abundance of *S. pneumoniae* in patients living near poultry farms.
- Key Limitations: This study did not include healthy controls from the same study area. Risk factors for pneumonia such as household size and contact with children were not evaluated. The statistical analysis could be impacted by the sample size and multiple comparisons, which could lead to incorrect conclusions.

• The authors state that this was a "hypothesis-generating study [i.e., study that explores data for patterns in order to generate proposals to test in future research], and results OREGON HEALTH AUTHORITY

need to be confirmed in larger, preferably longitudinal, studies". Longitudinal studies involve repeatedly monitoring participants health over time.

Study Title: Air Pollution from Livestock Farms Is Associated with Airway Obstruction in Neighboring Residents (Borlée et al., 2017)

- Background: The following study did not exclusively look at air pollution from poultry farming, but it did look at health effects to neighbors from a wide range of farms in the Netherlands (i.e., pig, poultry, cattle, goat, and mink farms).
- OHA Observation: The paper lacked details about the size of the farms included in the study.
- Methods: This was a cross-sectional study in 2,308 adults (age, 20–72 years) in the Netherlands. A pulmonary function test was performed. Spatial exposure was assessed as (1) number of farms within 500 meters and 1,000 meters of the home, (2) distance to the nearest farm, and (3) modeled annual average fine dust emissions from farms. Temporal exposure was assessed as weekly average ambient particulate matter and ammonia concentrations.
- Ammonia emissions from livestock farms were associated with reduced lung function level in nonfarming residents of a rural area in the Netherlands.
- Key Limitations: This study does not include wind direction or speed on exposure. In addition, exposure was based on participants' home addresses, but this could lead to some incorrect exposure assumptions for people that do not spend a lot of time at home.
- The authors stated that further research into the impact of emissions from livestock farms, especially on respiratory health of susceptible subgroups is needed to confirm the study's findings.

B. No Adverse Respiratory Effects Observed – One Study

Study Title: Air pollution from livestock farms, and asthma, allergic rhinitis and COPD among neighbouring residents (Smit et al., 2014)

- Background: The following study did not exclusively look at air pollution from poultry farming, but it did look at health effects to neighbors from a wide range of farms in the Netherlands (i.e., pig, chicken and other poultry, cow, goat, sheep, and mink farms).
- Methods: This study included electronic medical records of 92,548 patients from 27 general practices in a rural area of the Netherlands with a high density of animal farms. Distance between livestock farms and home address, presence of livestock within 500 meters, and particulate matter emissions from farms within 500 meters were computed as proxies for farm exposure.

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- Researchers did not find a higher number of respiratory issues near livestock farms. Indicators of air pollution from livestock farms were associated with a lower prevalence of asthma, allergic rhinitis, and COPD.
- Key Limitations: Smoking habits and occupation can impact respiratory health and this
 information for study participants was not available. This study also used medical
 records; this only includes patients who sought medical treatment for their symptoms,
 which could miss health effects that are not captured by medical records. Due to the
 study design, authors could not make definitive conclusions on the cause of the
 respiratory health trends observed. Authors also only had current residential addresses
 and could not track if less healthy resident had moved farther away.
- Authors state that more research needs to be conducted before firm conclusions can be made, especially more research on health effects of vulnerable populations. Authors hypothesize that farm exposures may provide a protective effect on health, possibly due to higher and more diverse microbial exposures.

C. Gastrointestinal Effects Observed

Study Title: Residential proximity to high-density poultry operations associated with

campylobacteriosis and infectious diarrhea (Poulsen, Pollak, Sills, Casey, Rasmussen, et al., 2018)

- Objective and Methods: To evaluate associations between residential proximity to high density poultry operations and individual-level diarrheal illnesses, authors conducted a nested case-control study among 514,488 patients in Pennsylvania (2006–2015). Using electronic health records, they identified cases of five gastrointestinal outcomes and estimated an inverse-distance squared activity metric for poultry operations based on farm and patient addresses.
- The poultry operation activity metric was largely unassociated with E. coli, Salmonella, and non-specific diarrhea.
- Findings suggest high-density poultry operations may be associated with campylobacteriosis and infectious diarrhea in nearby communities.
- Authors state that additional research is needed in the future to characterize the source of the camplylobacteriosis and infectious diarrhea.
- Key Limitations: In this present study, it is unclear what the exact source of exposure was that led to infection patterns observed. Infection patterns could be due to aerosolized particles or dust emitted through ventilation fans, or through pests such as flies. It could also be due to water or soil contamination. The study was silent about whether the health effects could be unrelated to poultry operations.

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D. No Overall Noncancer Health Effects Calculated from Screening Tool

Study Title: Modeling emissions from CAFO poultry farms in Poland and evaluating potential risk to surrounding populations (Pohl et al., 2017)

- Objective and Methods: A 2017 study estimated the exposure of various airborne pollutants for populations residing in close proximity to 10 high-density poultry farms located in Central Poland using a dispersion model and calculated hazard indices. Ammonia, carbon dioxide, carbon monoxide, hydrogen sulfide, methane, nitrogen dioxide, nitrous oxide, sulfur dioxide, and organic dust were the pollutants of interest for this study.
- Results indicated that levels of certain pollutants are expected to exceed background levels commonly found in the environment. Calculated hazard indices were all below one, which suggests a low potential for adverse health effects for the surrounding community for this mixture of chemicals. Hazard indices are a screening tool to assess potential health risks.
- OHA Observation: It is not clear how emissions from poultry farms in Poland compare to the United States.
- Key Limitations: In this study, potential risk from organic dust could not be calculated due to a lack of data. Authors indicate that future research should focus on organic dust exposure and associated risk. Authors state that the calculation of potential health risks could be improved upon in the future. For example, more accurate emission factors, site specific meteorological data, consideration of manure management, and a better understanding of chemical mixture interactions could lead to more accurate risk evaluation.

IV. Additional Factors of High-Density Poultry Farming that May Contribute to Adverse Health Effects

OHA found limited studies addressing potential health impacts of high-density poultry farming related to odor, insects, and poultry transport, as well as mental health impacts to community members living in proximity to such facilities. All the references below noted the need for additional research for each topic.

A. Odors

OHA found a report authored by staff of the United Nations' Food and Agricultural Organization which describes odor issues related to high-density poultry farming:

• Odor issues are generally concentrated within 500 meters of the farm and are frequently reported by farms' neighbors as the most disturbing environmental impact (Gerber et al., 2007).

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• Odor emissions depends on the frequency of animal-house cleaning, on the temperature and humidity of the manure, on the type of manure storage, and on air movements (Gerber et al., 2007).

Everyone responds to environmental odors differently. Environmental odors do not necessarily mean someone is being exposed to toxic amounts of chemicals. However, odors can worsen quality of life and result in health symptoms (e.g., headache, nausea, or mood changes). OHA has a general <u>fact sheet</u> on environmental odors.

B. Insects

OHA found two studies and one report authored by staff of the United Nations' Food and Agricultural Organization that describe insect-related issues near high-density poultry farming:

- Research conducted by the Ohio Department of Health indicated that residences that were located in close proximity to poultry facilities (within half a mile) had 83 times the average number of flies (Gerber et al., 2007).
- In addition to the nuisance they cause, flies and mosquitoes can transmit diseases (Gerber et al., 2007).
- Graham et al. isolated drug resistant enterococci and staphylococci from flies caught near confined poultry feeding operations. The authors conclude that flies near poultry operations may be involved in the spread of drug resistant bacteria from these operations and may increase the potential for human exposure to drug resistant bacteria (Graham et al., 2009).
- Sawabe et al. detected influenza A virus genes from flies collected within 2.3 kilometers of a high-density poultry farm during an outbreak of highly pathogenic avian influenza in Kyoto, Japan. According to the authors, the results suggest that flies could transmit avian influenza A virus and additional studies are required to understand how long viruses can survive in the organs of flies and if there is enough virus present to lead to human infections (Sawabe et al., 2006).

C. Poultry Transport

OHA found one study on bacterial emissions from poultry transport vehicles:

 Researchers took air and surface samples from cars driving behind poultry trucks for 17 miles (Rule et al., 2008). Results indicate an increase in the number of total oxygen dependent bacteria (including drug-resistant enterococci bacteria) isolated from air and surface samples. The results indicate the poultry transport vehicles may be a route of exposure of harmful microorganisms to people near the trucks. Researchers note that this is a small exploratory study and does not evaluate if these bacterial exposures led to OREGON HEALTH AUTHORITY

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any human health issues. Researchers state that additional research is needed to further understand emissions from poultry trucks.

D. Social and Mental Health

There is a lack of research on how high-density poultry farming specifically impacts the social and mental health of neighbors.

 A 2017 journal article that reviewed and commented on issues surrounding concentrated animal feeding operations (CAFOs) highlights that living in proximity to large-scale CAFOs has been linked to symptoms of impaired mental health (Donham et al., 2007). For example, the authors compiled research articles that indicate that concentrated animal feeding operations in the community can disrupt social gatherings, community relationships, and quality of life as well as reduce property values (Donham et al., 2007).

V. Published Commentary on Health Data Gaps

OHA found two journal articles assessing the state of the science regarding health impacts of large-scale confined animal feeding operations. These articles underscore the need for more research to arrive at conclusions about how such facilities impact neighbors' health:

- A 2017 commentary from researchers in the Netherlands state that "large-scale livestock farms have expanded rapidly in the last few decades, but their potential impact on neighboring residents' health has hardly been accompanied by any research" (Smit & Heederik, 2017). Authors present other key arguments to advocate for further research:
 - The authors argue, "The current situation in densely populated livestock farming areas could be regarded as a 'natural experiment,' with residents being exposed to potentially harmful bacteria, viruses, and air pollutants" (Smit & Heederik, 2017).
 - According to the authors, "there is a clear need to firmly embed public health perspectives in the decision-making process in environmental planning and agricultural development", and that research on a broad range of potential health risks from agriculture air pollution is needed (Smit & Heederik, 2017).
- A 2007 Environmental Health Perspectives article recommends further scientific research on the impact of concentrated animal feeding operations on human health (Donham et al., 2007). Specifically, the authors recommend more research on the psychophysiologic impacts of malodor; impacts of malodor on mental health and quality of life; and respiratory impacts of bioaerosol mixtures, especially among asthmatics, children, and the elderly (Donham et al., 2007).

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