

RESPIRATORY HEALTH EFFECTS IN POULTRY WORKERS

Dr Dorothy Ngajilo, MBChB, Occupation Medicine Registrar

Correspondence

Occupational Medicine Division, Centre for Occupational and Environmental Health Research, School of Public Health and Family Medicine, University of Cape Town, South Africa

Email: dorongajilo@yahoo.com

ABSTRACT

The South African poultry industry dominates the agricultural sector with more poultry products consumed annually than all other animal-protein sources combined. Individuals involved in animal production, particularly poultry workers, have been reported to have a greater prevalence of respiratory symptoms than other farmers or rural residents. This review focuses on respiratory diseases associated with poultry work published in the literature from 1980-2014. The review confirms that poultry workers are at increased risk of developing adverse respiratory health outcomes that may be attributed to exposure to dust and other airborne contaminants in poultry-house environments. Further research needs to focus on describing, in more detail, the various respiratory phenotypes and their prevalence in poultry workers. More studies need to explore the interaction between the complex environmental exposures and host risk factors in causing respiratory disease in this group of workers.

INTRODUCTION

The South African poultry industry dominates the agricultural sector with more poultry products consumed annually than all other animal-protein sources combined.¹ The poultry industry provides 65.5% of locally produced animal protein, and according to the South African Poultry Association, the poultry industry contributed 22.3% of agriculture income in 2012. Being an important contributor to job creation and formal employment opportunities, the poultry sector employs about 10% of all workers in agriculture.²

Agricultural production is associated with a variety of occupational illnesses.³ Individuals involved in animal production, particularly poultry workers, have been shown to have greater prevalence of respiratory symptoms than other farmers or other rural residents.⁴ This is because working in this industry is associated with a large spectrum of potentially hazardous airborne agents including chemical pollutants, dust particulate, allergens, endotoxins, micro-organisms and organic gases.⁵ Both acute and chronic work-related respiratory symptoms have been reported in poultry workers exposed to these pollutants.^{6,7}

This review focuses on respiratory diseases associated with poultry work as it continues to be the most commonly reported adverse health effect. To identify relevant articles, Google Scholar and MEDLINE searches were undertaken for studies on adverse respiratory outcomes in poultry workers from 1980-2014. Review articles identified in the

process were surveyed for additional and earlier citations. Key words that were used included: poultry, dust, asthma, allergy, occupational, work related, poultry, chicken, broiler, bioaerosols, bacteria, fungi, virus, endotoxin, (1-3) β -D glucan, allergens, and mites. Reports from credible international occupational health and safety institutions such as the Health and Safety Executive (UK) and the National Institute for Occupational Safety and Health (USA) were also included.

THE POULTRY WORKING POPULATION AND WORK PRACTICES

Although exposure patterns related to development of respiratory symptoms in the poultry industry are not clearly understood, the literature suggests that the type of production, housing systems, and tasks performed, have significant influence on the level of exposure to environmental contaminants in workers, which has an impact on their respiratory health.⁸

Poultry facilities may operate by either housing birds in cages or on litter on the floor. These two types of production processes may influence the levels of various environmental contaminants from poultry dust.⁹ In the cage-based system, birds are kept in cages mainly for egg production, while in the floor-based system, birds are housed on the floor mainly for meat production.^{10,11}

The two poultry operations differ in a number of ways including the time spent by workers in bird houses, the

allergies in the workplace

age of birds, the time spent by birds in the houses and the housing management practices.¹⁰ Workers in cage-based systems usually spend less time in poultry houses, which is associated with a reduced duration of exposure and possibly reducing the risk of adverse health effects.¹²

Table 1 summarises important tasks that are sources of potential airborne exposure to poultry dust in poultry workers.

Particles in poultry dust vary in size from 0.5 to 50 microns. This range includes respirable particles (<5 microns), which are capable of penetrating in the gas exchange region of the lung.⁷

Constituents of poultry dust have been reported to vary depending on the type of birds, the point in the growing cycle and the work activity in the poultry farm.^{7,17}

Table 1. Tasks associated with sources of potential airborne exposure to poultry dust in poultry workers

Task	Description of duties	Source of exposure
Laying down litter/bedding	Spreading litter/bedding in poultry houses	Nature of material. Some contamination with fungal spores and inhalable dust.
Catching	Repopulating and depopulating chicks/chickens	Proteins from feather debris or dander, mites (dust mites, storage mites), faecal residues, dust particulate, airborne bacteria, endotoxin.
Litter/manure removal	Removing soiled litter	Inhalable dust, organic compounds released during degradation of litter and feed.
Cleaning	Routine cleaning	Exposure to feathers, mites, feed particulate.
Routine housework/flock management	• Adding fresh litter/bedding and feed • Routine checks (inspections, weighing, vaccinations)	Microbial degradation of material. Bedding contaminated with organic material from feed, faeces, feathers, dander, mites, micro-organisms and their constituents.
Forklift drivers	Load boxes/cages of chicken into trucks for transportation to slaughter-houses	Inhalable poultry dust.

Modified and adapted from Singh and Matuka, 2010³⁵

CONSTITUENTS OF POULTRY DUST

'Poultry dust' is used to describe dust, including biological agents, that is produced from work activities in poultry farms.⁷ The constituents of poultry dust may range from pure wood dust to a complex mixture of organic and inorganic materials containing poultry faeces, feathers, dander, bacteria, endotoxin, fungi, fungal spores and mites.¹³ In addition to particulates, the decomposition of biological materials may produce gases such as ammonia, hydrogen sulphide and carbon dioxide that may also cause respiratory health problems.¹⁴⁻¹⁶

EXPOSURE LEVELS OF DUST AND BIO-AEROSOLS IN POULTRY HOUSES

Various studies have been conducted to evaluate different airborne contaminants that poultry workers may be exposed to when working in poultry houses.

a) POULTRY DUST

The reported mean concentration of total dust from poultry operations range between 0.12 mg/m³ to 26 mg/m³.^{3,18,19} The inhalable dust concentration has been shown to range from 0.02 to 81.33 mg/m³ and that

allergies in the workplace

of respirable dust from 0.01 to 6.5mg/m³.^{20,21} Higher dust concentrations have been reported in floor-based operations than in cage-based operations.¹⁹⁻²³

b) MICROBES

Bacteria

Bacteria in poultry dust may be derived from soil, bird's faeces, skin micro flora and zoonotic agents, as well as feed and bedding.⁷

The average concentration of viable bacteria from different studies ranged between 3.86x10⁵ to 4.66x10⁵ CFU/m³.^{18,24,25} Using epifluorescence microscopy, the median total bacteria (viable and non-viable) was 4.7x10⁹ cells/m³ with a range between 2.7x10⁷ and 4.2x10⁹ cells/m³.²⁶

The concentration and kind of bacteria in poultry houses depend on factors such as the type of the housing system, tasks performed, number of birds, type of ventilation systems, dust concentration and microclimatic conditions (humidity, temperature), concentration of gases and lighting.^{27,28}



Poultry House

Fungi

As with bacteria, fungi in poultry dust may be derived from soil, dust, feed and bedding and to a lesser extent from the birds themselves. Fungi present in bedding materials usually grow and multiply in moist conditions.⁷

Published data on poultry workers' exposure to fungi reports the concentration of airborne fungi ranging from 1800 CFU/m³ to levels reaching 110 million CFU/m³ air.^{26,29-31} A study that measured fungal levels with respect to specific tasks done in poultry houses reported a range from 1120 CFU/m³ during depopulating (catching) task to 4 million CFU/m³ during laying of bedding or litter. Using epifluorescence microscopy, the median fungal

concentration was 2.0x10⁷ cells/m³, ranging from below detection limit to 1.1x10⁹ cells/m³.²⁶

c) TOXINS: ENDOTOXIN AND MYCOTOXINS (GLUCANS)

Endotoxins

Endotoxins are common air contaminants in agricultural setting including poultry operations.¹⁰ They are structural components of the outer lipopolysaccharide containing membrane of gram negative bacteria.²³ When compared to the swine, grain, and animal feed industries, the poultry industry has been reported to have the highest endotoxin concentrations.³² These agents have been shown to be present in samples of poultry dust collected in all stages of the production cycle.⁷

Studies of exposure in poultry farms have reported concentrations ranging from below detection limit to 83640 EU/m³ for total endotoxin, 7.1 to 704 EU/m³ for airborne respirable endotoxin and 1000 to 8600 EU/m³ for non respirable endotoxin.^{23,29,33,34} Similar to dust particulate, personal endotoxin exposure concentrations may be influenced by the type of poultry housing, age and number of birds, type of litter and feed, ventilation, amount of worker time spent in contact with birds, manure management system and general housekeeping practices.¹⁰ These levels have been shown to be similar or higher in cage based as compared to floor based operations.^{9,12,15}

(1-3) β-D-glucan

(1-3) β-D-glucans are non-allergenic cell wall components of most fungi, some bacteria and plants and can be found in organic dust. They are usually used as surrogate markers of fungal exposure.^{35,36} A study that measured the levels of (1-3) β-D-glucan reported values of 20 (0.01-70) ng/m³ for water soluble and 270 (4-870) ng/m³ for non-water soluble (1-3) β-D-glucan.³⁷ Another study reported values ranging from 0.8 to 6886 ng/m³.²⁹

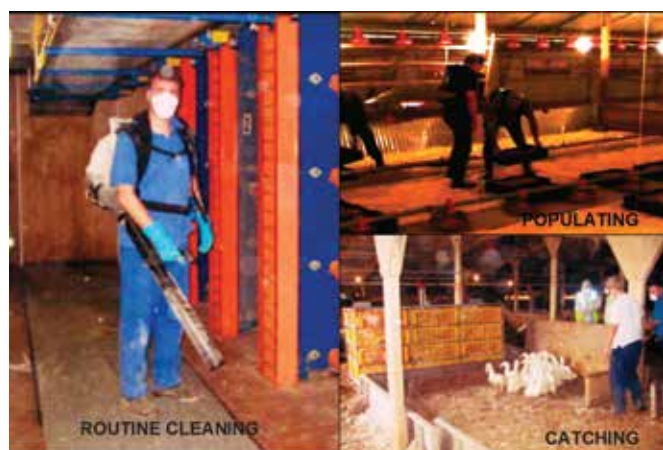
d) ALLERGENS

Allergen exposure in poultry industry may occur from contact with mites, poultry dust containing grain or animal feed protein allergens (wheat allergens), and allergenic fungi (mostly from *Aspergillus spp.*).^{7,38} Other sources include bird feathers, dander, serum, droppings which poultry workers may be exposed to during close handling of birds.⁷

A study evaluating exposure to moulds and house dust mite *Dermatophagoides pteronyssinus* allergen in poultry farms reported levels ranging from <0.1 to 3.3 µg/g.³⁹ Another study of indoor dust samples from poultry farms for quantifying Asp f 1 the major allergen of *Asperillus fumigatus*, reported levels of 17.9 (3.8-72.4) ng/g dust.³⁸

Chemical pollutant gases

Livestock buildings have been reported to be one of the major anthropogenic sources of atmospheric pollutants, such as ammonia, methane, nitrous oxide and carbon dioxide.¹⁵ Among the studies that measured environmental levels of different gases in poultry houses, ammonia levels have been the most commonly reported ranging from below detection limits in active areas²⁶ to 170ppm in unused areas of poultry houses.³³ Carbon dioxide levels have been reported in the range of 600 to 4100 ppm²⁶ while methane and nitric oxide levels reported as being similar to general ambient levels.¹⁵



Tasks associated with significant exposure to poultry dust.

UPPER AND LOWER AIRWAY RESPIRATORY OUTCOMES ASSOCIATED WITH POULTRY DUST EXPOSURE

Exposure to poultry dust is associated with increased incidence of upper and lower airway respiratory symptoms and deficits in lung function.^{9,39} The severity of symptoms may be influenced by the airborne levels of the dust as well as the composition of the dust.⁵ The extent to which these components cause disease will depend on the dose, the duration of exposure, and possible worker's susceptibility.³⁵

RHINITIS

The prevalence of rhinitis among poultry workers from various studies has been in the range of 19% to 39%.^{22,26,39-42}

Rimac *et al* reported a fourfold higher prevalence of rhinitis among poultry workers when compared to controls.³⁹ Symptoms of rhinitis were reported in all workers with a job-duration greater than 11 years in a poultry farm, and the incidence of rhinitis was shown to have bearing on the incidence of both cough and breathlessness.⁴² A higher prevalence was reported among workers in floor-based operations when compared to cage-based operations in a study comparing the two housing systems.²²

ASTHMA

Studies conducted among poultry workers have documented the prevalence of asthma varying between 1% and 43% for self-reported asthma and 6% to 14% for asthma diagnosed using spirometry.^{4,6,39,43-46}

The prevalence reported in most studies has been that of general adult asthma, which is generally higher in poultry workers than other occupations including other farm workers.^{40,41} Additionally, studies have reported a higher prevalence of work-related symptoms that were consistent with asthma in poultry workers compared to non-poultry workers. Fourteen out of 16 poultry workers were reported to have work-related asthma like symptoms, one of whom tested positive to northern fowl mites.⁴⁷ Asthma had been diagnosed in 4%, 13% and 11% in poultry workers with low, medium and high exposure to poultry dust respectively, compared to 3% in controls in a South African study.⁶ 10.7% of Victoria broiler growers had asthma compared to a prevalence of 5.7% among adults in South Australia.⁴⁸ Symptoms of occupational asthma were reported in 5.3% of poultry feed workers⁴⁹ whereas no significant difference in asthma symptoms between poultry workers and controls have been reported in other studies.^{45,50}

CHRONIC BRONCHITIS

The prevalence of chronic bronchitis in various studies among poultry workers varied between 4.4% to 21%.^{6,32,45,51,52} This prevalence had been reported to be higher when compared to unexposed controls. A study done to assess the respiratory symptoms and lung function of Norwegian farmers reported a two fold increase in odds of chronic bronchitis among poultry farmers compared to crop farmers (OR 2.2, CI 1.3-4.0).⁵¹ Similarly, a significantly increased risk of chronic bronchitis was reported in South African poultry workers with medium (OR=2.88, CI: 1.14-7.28) and high dust exposure (OR=2.86, CI: 1.04-7.90). The prevalence of work related chronic bronchitis was higher in poultry handlers (15.5%) as compared to other workers exposed to organic dusts in a UK study.³²

OTHER SYMPTOMS

Other acute and chronic work-related symptoms common in poultry workers include, sneezing, cough, wheezing, shortness of breath, eye irritation, phlegm, flu like illness, chest tightness, dry throat, dry nose, nose bleeding, headache, and fever.^{8,9,26,45} These symptoms are usually non-specific and may disappear during periods away from work.⁷ This wide range of symptoms emphasises the complexity of pathophysiological mechanisms by which poultry dust may cause respiratory disease.

ENVIRONMENTAL RISK FACTORS AND EXPOSURE-RESPONSE RELATIONSHIPS FOR POULTRY DUST AND RESPIRATORY DISEASES

Environmental risk factors for development of respiratory disease among poultry workers depends on the level of exposure to the agent, concomitant exposure to other agents in the workplaces, and the design and operation of the poultry facilities.

LEVEL OF EXPOSURE

An association between the levels of exposure to poultry dust and respiratory illnesses among poultry workers has been reported. The odds of having cough, wheeze, dyspnoea, chronic bronchitis and asthma was shown to increase among poultry workers from low medium to high exposure groups.⁶

A dose response relationship between the number of poultry on the farm and wheeze has been documented.⁴ A 2.4mg/m³ concentration of total dust, 0.16 mg/m³ respirable dust, 614 EU/m³ endotoxin, and 12 ppm ammonia have been shown to have significant pulmonary function decrements.⁵³

Poultry workers with more than ten years of exposure have a higher prevalence of symptoms and/or decreased lung function compared to those with fewer years of exposure.^{7,45,47} Workers spending more than five hours at a time in confinement areas have been shown to be at increased risk of having rhinitis.⁵⁴

CONCOMITANT EXPOSURES TO CHEMICAL POLLUTANTS IN THE WORKPLACE

The risk of respiratory illnesses has been shown to increase with poultry workers exposed to combination of bioaerosols, particulates, and gases.^{55,56} Synergistic effects between ammonia levels and airborne dust have been reported to explain up to 43% and 63% of the decline in FEV₁ and FEF₂₅₋₇₅ respectively.¹⁶

These findings emphasise the importance of considering the combined effects of air contaminants in causation of health problems, and the need to redefine occupational exposure limits of airborne contaminants when workers are exposed to more than one agent known to have synergistic effects.

DESIGN AND OPERATION OF FACILITIES

Ventilation of the poultry facility has a major impact on the risk of respiratory disease.²⁶ The use of wood shavings for bedding, disinfectants, dry feeds and non-slatted floors has been shown to increase the risk of flu like illness (ODTS).⁵⁷ A greater preponderance of workers from cage-housed operations reporting cough and wheeze and decreased lung function compared to workers from floor-housed facilities has been reported.⁹ A 3-hr exposure in confined buildings for egg production was shown to induce an acute inflammatory reaction in the upper airways and increased bronchial responsiveness in workers exposed to facilities with loose housing for laying hens compared to those using the cage system.¹²

HOST-ASSOCIATED RISK FACTORS FOR RESPIRATORY DISEASES ASSOCIATED WITH POULTRY DUST

GENETICS

The role of genetics in the development of asthma and other work related respiratory illnesses among poultry farmers has not been well documented. A study done on Indian farmers did not demonstrate any hereditary factors to influence the incidence of respiratory symptoms in examined poultry and other farm workers (except farm workers working in granaries).⁴² It would appear that the environment and other host related factors are more important.⁵⁸

ATOPY

Atopy has been shown to have independent and additive effects on the occurrence of chronic bronchitis in dusty farm work.⁵⁹ The odds of wheeze in poultry production have been reported to be greater among atopic than non-atopic individuals.⁴ A South African study reported tentative evidence that atopic workers may have been selected out of the poultry workforce, because the prevalence of workers with atopy declined with increasing years of service.⁶

AGE

Advancing age has been shown to increase the risk of occupational asthma among farmers.⁶⁰ An epidemiological survey of respiratory diseases among agricultural industry

workers reported a high incidence (31.6%) of breathlessness in poultry workers in the age group of 30–44 years when compared to only 13.6% incidence in workers under 29 years.⁴²

GENDER

Relatively few studies have compared the effect of poultry work on respiratory function by gender. A Brazilian study reported no association between gender and respiratory test results.⁶¹ The study by Zuskin *et al*, demonstrated that the prevalence of chronic cough, chronic phlegm, chronic bronchitis were higher in males than in females with similar asthma prevalence in males and females.⁴⁵

SMOKING

Smoking has been reported to increase the risk of many respiratory illnesses including chronic bronchitis among farmers.⁵⁹ Male poultry workers who were smokers have been reported to have a higher prevalence of chronic cough, chronic phlegm, and chronic bronchitis than male poultry workers who were non-smokers.⁴⁵ The odds of wheeze associated with egg production was highest in past smokers (OR=2.88) followed by never smokers (OR=1.46) and then current smokers (OR=0.80) in the Agricultural Health Study.⁴ Smoking habit has also been shown to influence the incidence of cough but had no direct effect on breathlessness and rhinitis.⁴²

CONCLUSION

This review has demonstrated that poultry farm workers are at increased risk of developing adverse respiratory health outcomes that may be attributed to exposure to dust and other airborne contaminants in poultry house environments. Intervention programs aimed at reducing exposure to dust is likely to have a positive impact on the respiratory health of workers.

While most studies report on the prevalence of asthma based on symptoms and occasionally using spirometry, further research needs to focus on describing the various asthma phenotypes and their prevalence in poultry workers. Furthermore, very few studies have documented the extent to which occupational exposure to various allergens constitute a risk to health of poultry workers. Future research may be needed to explore the complex interaction between environmental exposures and host risk factors in causing respiratory disease. This will enable the development of improved preventive strategies in reducing the adverse respiratory health impacts associated with poultry work.

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