Measurement and Protection of Lung Health in Poultry Farmers of Southwestern Ontario

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Abstract

Chronic obstructive lung disease (COPD), develops gradually, and tends to be noticed by farmers only after there has been a significant loss of lung function. People with symptoms of COPD often present for health care in later stages of disease, because they accept cough or breathlessness as “normal”. Measurement of lung health for those at risk of developing COPD provides an opportunity for early detection of lung disease, and deter the progression toward irreversible damage to the lungs. COPD is, however, under-diagnosed.

The importance of bringing primary care providers and farmers together, and acknowledging the high-risk nature of occupational exposures, is essential in being able to influence change in early detection and protection of lung health. Standardized methods and measurement of lung health are needed to ensure the earliest diagnosis of COPD.

The purpose of this dissertation is to determine if early signs of lung disease are present in poultry farmers of Huron county in southwestern Ontario, and determine how often farmers use respiratory protection during poultry farming operations. A cross-Canada survey of lung health symptoms and respirator use will be reported, in comparison to the Huron county findings.

A cross-sectional observational study, with a convenience sample, based on the available 2-day lung health clinic appointments, provided fourteen (n=14) interpretable pre/post spirometry results. All FEV1/FVC ratios were above the cutoff of < 0.70%, however four of the results were between 70 and 75%, with three approaching COPD diagnostic criteria. The independent collection of symptoms from the standardized lung health questionnaire of MD-confirmed chronic bronchitis matched spirometry results and reduction in post FEF 25-75%. Report of respirator use within Huron county, and across Canada, demonstrated low use of respirators all of the time, in both samples, 6.25% and 2% respectively. All poultry producers in the Huron county and cross-Canada lung health survey reported having a family physician. MD-confirmed bronchitis were reported as 18.75% in Huron county and 28.0% in the cross-Canada survey reported results.
The dissertation is the result of concerns raised by poultry farmers about their lung health. These findings point to the urgent need for lung health clinics for poultry farmers, to provide early detection and prevention of COPD.

Keywords

Occupational health, pre/post spirometry, lung function, N95 respirators, small airway disease, bioactive dust
Co-Authorship Statement

This dissertation document includes an introductory chapter which offers background information to the project, including a description of the instruments of measurement, the pre/post spirometry and the Lung Health Questionnaire; three integrated manuscripts, of which two have been published, (Doyon Dolinar, Devereaux and Johnson, 2017; Dolinar, 2018); with a third manuscript, accepted for publication, Fall of 2018 (Doyon Dolinar, 2018). Chapter 5 presents the cross-Canada survey results. A concluding chapter, Chapter 6, summarizes the dissertation. I, Rose-Marie Doyon Dolinar, am responsible for the conception and design of this body of work and the analyses and interpretation of the data. I am the primary author of all the manuscripts including this document. I, Rose-Marie Doyon Dolinar, am responsible for the writing and content of Chapters 1, 2, 3, 4, 5 and 6. Dr. Andrew M. Johnson was consulted on the project methodology and statistical analyses for the manuscript, and reviewed and submitted the ethics application and received approval, however, I was responsible for its preparation. Dr. Andrew M. Johnson reviewed and gave final approval to the questionnaires used in Chapter 2 and Chapter 5. I, Rose-Marie Doyon Dolinar, was the sole author of Chapter 2 with consultation with Dr. Tony D’Urzo for spirometry interpretation. I, Rose-Marie Doyon Dolinar, was the sole author for Chapter 4 with contributions from Gwendolyn Devereaux, Gateway Centre of Excellence in Rural Health to the section on community partnerships and collaboration between farmers and researchers, and Dr. Andrew M. Johnson reviewed and provided recommendations on the manuscript. My PhD Advisory committee members, Dr. Andrew M. Johnson, Dr. Christopher Lee and Dr. Alan Salmoni provided feedback and recommendations throughout the research study.
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Thank you to Dr. Andrew M. Johnson, my PhD Supervisor, for his unfailing support and guidance throughout my PhD studies. Thank you Dr. Johnson for believing in my research topic, and how this has grown from a question from a group of poultry farmers from southwestern Ontario to a Canada-wide survey. Thank you Dr. Johnson for your support of my dedication to rural research.

Thank you to my PhD Advisory Committee, Dr. Andrew M Johnson, Dr. Christopher Lee and Dr. Alan Salmoni. You have been the best and most supportive Advisory Committee a student could ever have! I have benefitted so much as a student, from all three of you, and I will cherish always your wisdom, and patience, and reflections, which contributed greatly to my learning.

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Special thank you to the poultry farmers of Huron County.

Thank you to my fellow graduate students and to the University of Western Ontario Health & Rehabilitation office staff, professors and tutors, and for my dear friends, for all of your support and encouragement.

Dedication

Je voudrais dédier ce travail à mes parents Loretta (née Ferguson) et Paul Doyon, pour l’amour continu el qu’ils m’ont donnés. Leur détermination et goût du travail me guideront toujours. Que je puisse partager l’amour à l’exemple de ma mère et poursuivre la veine d’or comme mon père. To my son Paul and my daughter Anne-Marie, I love you both with all my heart and soul, I dedicate this work to both of you.
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Preface

This work is the result of a conversation between poultry farmers and a lung health researcher. The result was the launch of a lung health pilot study, growing to a cross-Canada survey. The research was to answer questions regarding lung health concerns of the farmers, individuals who keep working, 7 days a week, despite symptoms of illness. The goals of this research were to provide standardized measurement of lung function, improve access to occupational health services, ensure respiratory protection is optimal for the lung health risks, and share the results through publications, to influence changes in practice for the farmer, as well as influence changes in practice for the health care provider, in acknowledging this population at high risk of developing COPD.
Chapter 1

Lung health and agriculture

1.1 Introduction

Agriculture in Canada has changed dramatically within the past 100 years, from single family farms to large industrial operations, matching the shift of the Canadian population, from 80 percent rural to 80 percent urban over this same time period (Statistics Canada, 2017). Consumer demands for farm produce have shifted small farms to large industrial-sized operations. With this change, there has been an increase in concerns related to the air quality in the barns. The present study is the result of poultry farmers concerned about their lung health, due to increased exposure to dust within the poultry barns.

Agricultural activities produce dust both outside (from work in the fields) and inside (within the barn environment). Thus, appropriate research control requires adequate measurement and control of all dust exposures. Mineral dust from the fields is different from the bioactive dust which includes bioactive dust, mold spores, bacteria, viruses, feather particles, endotoxins, and ammonia, sulfur dioxide and carbon monoxide gases, found in confined animal housing (Arogo, Westerman, & Heber, 2003; Basinas et al., 2012; Rimac et al., 2010; Viegas et al., 2013).

Lung health risks in farming can be divided into three main categories:

a) Particulates, including bioactive dust, including bacteria, moulds and viruses, from animal confinement barns,

b) Gases, such as carbon dioxide, ammonia and sulfur dioxide, and
c) Oxygen-deficient work environments, such as sealed silos, and controlled atmospheres such as storage buildings for fruit and vegetables (Pickrell, 1991).

1.2 Lung disease in agriculture

Occupational exposures in agricultural operations are associated with lung disease, including chronic obstructive pulmonary disease, asthma, hypersensitivity pneumonitis, lung cancer and interstitial lung diseases (Nordgren & Bailey, 2016). Efforts are ongoing to ascertain contributing factors to these negative respiratory outcomes and improve monitoring of environmental factors that lead to disease.

In 1997, COPD was predicted to become the third leading cause of global death by 2020, but a subsequent analysis found that COPD had become the third leading cause of global death by 2010 (Lozano et al., 2012).

The development of lung disease such as COPD is very gradual, and tends to be noticed by farm workers only after there has been a significant loss of lung function, often up to 50-60% [Global Initiative for Chronic Obstructive Lung Disease, (GOLD) 2017]. People with COPD often present for health care far too late, because they accept cough or mild breathlessness as “normal” (GOLD, 2017).

Farmers and agriculture workers are at an increased risk of respiratory morbidity and mortality from obstructive lung diseases such as chronic bronchitis and COPD (May, Romberger, & Poole, 2012). This is due to the years of exposure to dust being produced during agricultural work. Exposures to inorganic (mineral) dusts in field work during plowing and tilling, as well as during harvest times, perturbs the soil, resulting in respirable dust composed of inorganic dust. Depending on the geographic region of the farming activities, the inorganic dust may contain up to 20% crystalline silica and up to
80% silicates (Schenker, 2000). Inorganic dust exposure can contribute to chronic bronchitis, however, attributing the lung disease to field work alone is problematic, since many farmers are exposed to both mixed organic and inorganic dusts (Schenker, 2000).

Organic dust within the poultry barn environment contains poultry feces residues, molds, and feathers and is called bioactive dust, since the dust contains microorganisms such as bacteria, fungi, molds and viruses (Viegas et al., 2013). Bioactive dust exposure is increased in large scale poultry barns, and studies have shown that livestock farmers have an increased risk of chronic bronchitis and COPD (Szczyrek et al., 2011). Organic dust is not a recognized hazardous substance within the Occupational Health & Safety Act of Ontario, within the regulations applied to farming, including poultry farming (see Appendix A). However the Act includes the regulation applied to health and safety awareness and training.

Because poultry farmers are at high risk of lung disease associated with their work as poultry producers, early detection of lung disease is an important strategy in detecting and hopefully slowing down disease progression. Understanding the structure and function of different areas of the lung, helps to differentiate between normal and abnormal lung symptoms and signs of disease.

1.3 Anatomy and physiology of the lungs

The structure of the lungs is similar to an inverted tree. The first divisions of the lungs are the bronchial tree, the large conducting airway. See Figure 1.1 for a graphical representation of the conducting airways and alveolar units of the lung.

The first 15 division of the lungs are still part of the conducting airways, and their function is to transport gases, in and out of the lungs. There is no gas exchange occurring in these regions. The conduction airway has an important function, and that is to reduce
flow if a lung irritant presents itself to the lung, and the protective mechanism is bronchoconstriction.

**Figure 1.1:** Conducting airways and alveolar units of the lung


Beyond the 15th division region, the respiratory function begins to take place, continuing with further sub-divisions toward the respiratory bronchioles, until the acinar area of the lungs are reached, where the alveolar ducts connect to the alveolar sacs, each containing hundreds of millions of alveoli. Each alveoli are small pouches made of epithelial cells, where direct molecular gas exchange occurs. The surface area of the lungs available for gas exchange can reach an expanse between 70 to 80 m².
Small airways are defined as airways of less than 2 to 3 mm internal diameter, and include both the terminal bronchioles of the conducting airway, as well as the respiratory bronchioles.

Increased awareness of the importance of the dual function of the small airways (conduction and respiration) is the first step in recognizing the potential for permanent versus reversible damage to the lungs.

1.4 Spirometry

Spirometry is defined as the measurement of breath (spiro). The measurement of breath, which includes inspiration and exhalation, can be measured through lung function studies of spirometry. The way the lungs inhale and exhale can determine if an individual has an obstructive or restrictive lung disease.

Obstructive lung diseases includes conditions that affect a person’s ability to exhale with ease, such as asthma and COPD. The inspiration is usually normal. Restrictive lung disease is a problem with full inspiration, caused by stiffness of the lungs, weak muscles or damaged nerves may cause restriction in lung expansion.

Forced vital capacity (FVC) is the maximum amount of air you can forcibly exhale from your lungs after fully inhaling. It is about 80 percent of total capacity, for both men and women, because some air remains in your lungs after you exhale. Forced vital capacity can decrease by about 0.2 liters per decade, even for healthy people who have never smoked.

Forced expiratory volume (FEV1) is the amount of air you can exhale with force in 1 second. FEV1 declines 1 to 2 percent per year after about the age of 25, which may not sound like much but adds up over the course of a lifetime.
The flow volume loop (graphically depicted in Figure 1.2) demonstrates the inhalation and expiration phases of the spirometry reading. Flow is measured in litres per second, and the volume is measured in litres.

Figure 1.2: Flow volume loop

CJmarchin (2012). Creative Commons Attribution-Share Alike 3.0 Wikimedia Commons.

1.5 COPD

Chronic Obstructive Pulmonary Disease (COPD) is a lung disease that includes chronic bronchitis and emphysema (O'Donnell et al., 2008). In 80-90% of cases, COPD is caused by smoking, and directly related to individuals with greater than 10 years of smoking, or 10 pack years, the equivalent of smoking 20 cigarettes per day for 10 years.
Besides a history of smoking cigarettes, other factors which can cause COPD include occupational exposures to dusts, fumes and gases, as well as air pollution in large cities with heavy smog and traffic, as well as smoke from burning of biomass fuels used for cooking and heating in poorly ventilated homes. The onset of COPD is usually between 35 and 40 years of age, and the progress of the disease is slow and cumulative. When the disease progresses to an advanced stage, COPD is associated with exacerbations causing frequent and lengthy hospitalizations.

The severity levels of COPD have been classified by the Global Initiative for COPD Staging (GOLD, 2017). The COPD stages range from mild to severe, with Stage 1 being classified as mild COPD with an FEV1 of 80 percent or more of normal; Stage 2 being classified as moderate COPD, with an FEV1 between 50 and 80 percent of normal; and Stage 3 being classified as severe emphysema with an FEV1 between 30 and 50 percent of normal (GOLD, 2017).

COPD is an obstructive lung disease which include symptoms of cough, mucous production, wheezing, and breathlessness (Akinbami, Liu, & American Lung Association, 2013).

In a study using a multi-detector CT scan, comparing patients with COPD with control samples, the number of airways measuring 2.0 to 2.5 mm in diameter was reduced in patients with GOLD stage 1 disease ($p = 0.001$), GOLD stage 2 disease ($p = 0.02$), and GOLD stage 3 or 4 disease ($p < 0.001$). Micro CT of isolated samples of lungs removed from patients with GOLD stage 4 disease showed a reduction of 81 to 99.7% in the total cross-sectional area of terminal bronchioles and a reduction of 72 to 89% in the number of terminal bronchioles ($p < 0.001$; McDonough et al., 2011).
A comparison of the number of terminal bronchioles and dimensions at different levels of emphysematous destruction, showed that the narrowing and loss of terminal bronchioles preceded emphysematous destruction in COPD ($p < 0.001$). These results show that narrowing and disappearance of small conducting airways occurs before the onset of emphysematous destruction (McDonough et al., 2011).

What is significant about this CT study, is the loss of terminal bronchioles precedes emphysema. This points to a possible opportunity for the prevention of irreversible damage to the lungs.

1.5.1 Chronic bronchitis

Chronic bronchitis occurs as a result of chronic exposure to lung irritants. Mucous production is a normal reaction of the lungs, since mucous traps the irritants, and then the small villi, which have a wave motion upward in the bronchial tree, move the mucous upward into the large airways, and coughing and breathing deeply during a cough, brings the phlegm or mucous up to the throat to be swallowed or spit out. Mucous is produced by goblet cells, and with daily and weekly exposure to lung irritants such as cigarette smoke or mineral dust from the fields and bioactive dust from the barns, mucous production increases, causing chronic bronchitis. This natural and normal inflammatory and trapping response of the lungs, derives from the lungs attempting to remove the lung irritants. A histological study have observed that goblet cell hyperplasia reverses following smoking cessation (Lapperre et al., 2007). Individuals at risk for developing chronic bronchitis include daily cigarette smokers or those who are exposed on a daily basis to lung irritants at work.

In chronic bronchitis, airways become swollen and can be filled with mucous, which can make it hard for you to breathe. In emphysema, the damage is deeper, in the
alveolar sacs, where oxygen exchange occurs. When the alveoli are damaged, breathlessness is the key symptom. In chronic bronchitis, cough and phlegm are the key symptoms, due to the accumulation of mucous in the large and small airways. In severe COPD, both chronic bronchitis and emphysema are present, with cough, phlegm, and breathlessness present. Each individual will have varying presentations of lung impairment.

1.5.2 Asthma in comparison to COPD

Diagnosis of asthma is generally based on clinical evaluation of symptoms, as well as “objective measurements” such as spirometry. Symptoms include wheezing, chest tightness, shortness of breath (dyspnea), and cough. These symptoms are variable, and can be provoked by cold air, viral infections, lung irritants and allergens.

As discussed earlier, pre-and post-bronchodilator spirometry can help differentiate asthma from COPD. Asthma will show a reversible component of airflow obstruction, with an increase of ≥ 12% of baseline and ≥ 200 ml change from pre-bronchodilator FEV\textsubscript{1} to post-bronchodilator FEV\textsubscript{1}. COPD will not show this reversibility in the pre/post spirometry results due to differences shown in Table 1.1.

**Table 1.1. Comparison of asthma and COPD**

<table>
<thead>
<tr>
<th></th>
<th>Asthma</th>
<th>COPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at onset</td>
<td>Any age, usually childhood and &lt; 40 years</td>
<td>Adulthood, usually 40 years and older</td>
</tr>
<tr>
<td>Role of smoking</td>
<td>Not directly related</td>
<td>Directly related</td>
</tr>
</tbody>
</table>
1.5.3 Emphysema

Emphysema is a progressive obstructive lung disease and results from damage to the fragile connections between the alveoli. As emphysema progresses, more and more alveolar sacs are destroyed, and the walls of the air sacs break down. Alveoli are small, thin-walled, very fragile air sacs located in clusters at the end of the bronchial tree. There are about 300 million alveoli in normal healthy lungs, however when the inner walls of the air sacs are damaged, they weaken and rupture, creating larger air sacs, instead of many small alveoli. As more and more alveoli are destroyed, this affects the amount of oxygen that reaches the bloodstream. Emphysema affects the lung parenchyma, the portion of the lung involved in gas transfer - the alveoli, alveolar ducts and respiratory bronchioles (Vogelmeier et al., 2017). The defining symptom of emphysema is breathlessness, due to damage to the respiratory sections of the lung, as depicted in Figure 1.1.

Determining if an individual has any breathlessness requires a standardized lung health questionnaire. The next section will discuss the available instruments which would be able to discern the symptom of breathlessness.

1.6 Self-report Measurement of Lung Health

The first widely used questionnaire in respiratory epidemiology was a questionnaire developed by the Medical Research Council (MRC) in 1960. In this first version, there
were questions related to wheezing, but in later editions, more questions about asthma and asthma-like symptoms were added. The MRC questionnaire initiated the development of other questionnaires such as the European Community for Coal and Steel (ECSC) questionnaire of respiratory symptoms and the questionnaire from the American Thoracic Society and the Division of Lung Diseases (ATS-DLD-78).

The original American Thoracic Society-Division of Lung Disease questionnaire (ATS-DLD-78) of the National Heart, Lung, and Blood Institute, was first released in 1978 by Ferris (1978), to record the presence of respiratory symptoms in large US studies of respiratory and occupational health. In a study of three lung health questionnaires self-administered by mail, the ATS-DLD-78 showed the lowest percentage of misunderstood questions, when compared to two other lung health symptom questionnaires (Helsing et al., 1979).

As will be discussed in subsequent sections of this dissertation, the present study employs the ATS-DLD-78 for measurement of self-report lung function. This choice was based on the clarity of questions, and the standardization of the instrument that has been documented over decades of epidemiological studies that have screened for lung disease (Ferris, 1978; Stenton et al., 2008).

1.6.1 The MRC Breathlessness Scale

The MRC Breathlessness Scale (Fletcher, 1952) is included in the ATS-DLD-78 as a measure of level of exercise capacity (Stenton et al., 2008), and is an important symptom to measure severity of alveolar impairment (i.e., breathlessness). The MRC breathlessness scale has been used since the 1950s, starting with coal miners in the UK, and is typically used to determine the degree of disability. The instrument has been described as a simple and valid method of evaluating patients with COPD in terms of
their physical activity limitations, that could be used to complement FEV1 in the classification of COPD severity (Bestall et al., 1999).

The MRC Breathlessness Scale (Table 1.2) consists of five questions that assess the extent to which an individual is affected by breathlessness when doing physical activity. These five statements describe a range of functional impairments that range from expected breathlessness related to activity (Grade 1 and Grade 2), to severe physical limitations due to breathlessness (Grade 5).

### Table 1.2 MRC Breathlessness scale

<table>
<thead>
<tr>
<th>Grade</th>
<th>Degree of breathlessness related to activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Not troubled by breathlessness except on strenuous exercise</td>
</tr>
<tr>
<td>2</td>
<td>Are you troubled by shortness of breath when hurrying on the level or walking up a slight hill?</td>
</tr>
<tr>
<td>3a</td>
<td>Do you have to walk slower than people of your age on the level because of breathlessness?</td>
</tr>
<tr>
<td>3b</td>
<td>Do you ever have to stop for breath when walking at your own pace on the level?</td>
</tr>
<tr>
<td>4</td>
<td>Do you ever have to stop for breath after walking approximately 100 metres or after a few minutes on the level?</td>
</tr>
<tr>
<td>5</td>
<td>Are you too breathless to leave the house or breathless on dressing or undressing?</td>
</tr>
</tbody>
</table>

### 1.6.2 Measurement of Lung Health in Poultry Farmers

The ATS-DLD-78 has been used for epidemiological surveys of both the general population and occupational health settings. There are risk factors, protection factors, and
symptoms that should be included in order to make the instrument more useful in screening for lung disease and symptoms among individuals engaged in poultry farming. Thus, the development of a farm-specific measurement instrument must include demographic variables that speak to these important descriptors (e.g., type of farming, size of operation) that are critical to describing one’s population – and there are farm-specific occupational questions (e.g., respirator usage) that need to be added to the questionnaire, in order to improve the applicability of the measure to poultry farmers.

Radon gas monitoring of the home was included within the questionnaire, as exposure to indoor radon gas has been determined to be the second leading cause of lung cancer after tobacco smoking (Chen, Moir, & Whyte, 2012), with estimates showing that 16% of lung cancer deaths among Canadians are attributable to indoor radon exposure.

Questions concerning influenza vaccination are also particularly topical, given that on May 2015, the first case of Avian flu (H5N2) was detected in a turkey farm in Oxford County, in southwestern Ontario. This was the first time H5N2 was present in Ontario, and it has affected all poultry farms in Ontario, since biohazard precautions are now the new standard of operation. The recommendations from Public Health Ontario in 2015 recommended all poultry workers to receive influenza vaccination, because of the danger of the H1N1 and H5N2 being present at the same time (Public Health Ontario, 2015).

Since the Avian flu outbreak in 2015, all poultry producers have been advised to wear N95 respirators. Respirator use among poultry producers is, however, unknown, and so it is important to develop a method for documenting uptake of this critical health recommendation, among poultry farmers. As suggested earlier, it is also critical to include questions about dust exposure types (and duration of exposure), the types of farming activities in which the individual engages, and the frequency (and duration) with which farmers wear their respirator.
1.6.2.1 The Poultry Producers Lung Health Questionnaire

The Poultry Producers Lung Health Questionnaire (PPLHQ) was designed to measure the lung health of the poultry farmers since lung health questionnaires, specific to farming are sparse in the literature. The PPLHQ was formulated to include the standardized ATS-DLD-78, including the poultry farm-specific questions, and the complete PPLHQ is found in Appendix B.

When reviewing the groupings of questions of the PPLHQ, questions 1 to 14 include demographic items of age, gender, as well as non-occupational lung risks (radon, smoking history, influenza).

Questions 15 to 70 are the complete set of questions from the standardized and validated American Thoracic Society-Department of Lung Disease (ATS-DLD-78) from Ferris (1978).

Questions 71, 72, 73 and 74 are the occupational lung health risk assessment items, including years of dust exposure, identification of lung health risks, and what frequency the farmer uses respiratory protection.

Q71 Have you worked in a dusty job (including poultry barns): yes no

Q72 Total years worked in dusty jobs: Years _________

Q73 What type(s) of lung health hazards may be present during your farming work (choose as many as apply): ammonia gas, nitrogen gas, methane gas, carbon dioxide, carbon monoxide, organic dust (poultry barn dust including bacteria, fungi, mold, feathers, liter, etc.), chemical dust (pesticides), fumes (welding), other ____
Q74 Do you wear a respirator when working in jobs when exposed to dust, gas and/or chemicals: never, some of the time, most of the time, all of the time.

Question 75 to question 82 are items specific to smoking.

Question 83 is the final question of the PPLHQ which asks the farmers what information would be useful to help protect their lungs.

Part of the challenge in assessing the lung health of farmers lies in the administration of a questionnaire across large geographic areas. There is no tool available that includes both non-occupational and occupational lung health risks, and also assesses respirator use.

1.7 Self-report Measurement of Lung Health

The program of research described in this document includes objectives which address the concerns of the poultry farmers of southwestern Ontario by determining if lung health problems exists, as well as review the measures of respiratory protection against the lung health hazards of the job, and ultimately determine if the lung health concerns are localized or occur across Canada.

The first objective is to identify a testing protocol for the measurement of lung health of Canadian poultry farmers. Self-report and objective procedures (i.e., spirometry) are described, as methods for screening for early detection of COPD.

A second objective is to identify the best methods to protect the lungs against the development of COPD, by providing a barrier to respirable bioactive dust. The provision of N95 respirators fit-testing as standard protocol for all poultry farmers will be explored.
A third objective is to present the components of rural outreach lung health clinics, that combine both the measurement and protection aspects of promoting lung health of poultry farmers, with the goal of early detection and prevention of COPD.

To this end, this thesis presents three manuscripts that address measurement and protection of lung health of poultry farmers, as well as a cross-Canada survey comparing regional findings to determine if similarities exist between poultry farmers across the country.

1) Chapter 2 presents a study in which we administered the PPLHQ to a sample of poultry farmers, as part of a comprehensive lung health clinic visit. We compared the symptom findings to results of the pre/post-bronchodilator spirometry assessment, in an effort to identifying chronic lung disease within this population.

2) Chapter 3 presents a paper regarding the importance of lung health protection, specifically by providing N95 respirator fit-testing as a requirement for maximal protection to bioactive dust encountered during poultry production farming.

3) Chapter 4 presents a paper on the planning and delivery of a comprehensive lung health clinic for poultry farmers, including pre/post bronchodilator spirometric measurement and N95 respirator fit-testing protocol.

4) Chapter 5 presents the findings of the cross-Canada online survey, to determine if similar patterns of lung health findings are present, and to determine if lung health clinics would be needed.
1.8 References


Chapter 2

Measurement of lung health

2.1 Introduction

Chronic Obstructive Pulmonary Disease (COPD) is preventable and treatable. The Global Initiative for Chronic Obstructive Lung Disease (GOLD, 2017) states that COPD is “characterized by persistent respiratory symptoms and airflow limitation that is due to airway and/or alveolar abnormalities usually caused by significant exposure to noxious particles or gases” (GOLD, 2017). GOLD further explains the variable nature of COPD, as a mixture of small airway disease (i.e. chronic bronchitis) and parenchymal destruction (i.e. emphysema), and that both conditions vary from person to person (GOLD, 2017).

Vogelmeir et al. (2017) summarized the changes in the 2017 GOLD diagnostic and treatment recommendations, which now include both spirometry and symptom evaluation through standardized lung health questionnaire. Spirometry is the gold standard for the diagnosis for COPD, however, before irreversible damage to the lungs have occurred, symptoms such as chronic cough and phlegm production are present.

The range of undetected COPD is between 25 and 50% of patients with COPD symptoms and risk factors, according to (Hill et al., 2010). As many as one in five adults with known risk factors for COPD and who meet spirometry criteria for COPD, were not diagnosed for COPD (Hill et al., 2010). Under-diagnosis of COPD suggests a need for screening of at-risk individuals.
2.2 Persons at risk for COPD

Persons at highest risk for developing COPD are those who smoke cigarettes, with a 25% prevalence of moderate to severe COPD for both men and women equally (Lokke, Lange, Scharling, Fabricius, & Vestbo, 2006). Although cigarette smoking is a major risk factor, occupational health studies indicate that over 15% of all cases of COPD are work-related (Boschetto et al., 2006).

2.3 Poultry farmers lung health study

The present study is the result of a meeting held in January 2015, between poultry farmers and a lung health researcher, to discuss concerns of the poultry farmers regarding lung health in the workplace. This was the launch of the Poultry Producers Lung Health Study, after approval was obtained from the Health Sciences Research Ethics Board at the University of Western Ontario (protocol #107685).

The study’s aim was promote and protect lung health of poultry farmers and the N95 respirator results have been published in the 2018 Winter edition of Update. The present article will report for the first time, the measurement of lung health of poultry farmers, which include the spirometry and lung health symptoms and MD-confirmed diagnostic findings.

This study is a pilot study, with a convenience sample, based on the available 2-day lung health clinic appointments. These were the only two clinic days available for the pilot study, due to health centre booking and resource availability, as well as timing of harvest times for the farmers. The farmers stated that the best time for the lung health clinic appointments would be between the wheat harvest and the corn harvest, which would be at the beginning of August, and dependent on weather and best harvest.
conditions. The researcher had to keep in close contact throughout the summer, to ensure with the farmers, that the dates would work.

The total number of farm operations in Huron County of southwestern Ontario include 107 poultry farm operations, including chicken, egg and turkey farms (County of Huron Economic Development Services, 2013), so the turnout would be a sample from this group of farmers. The recruitment of the farmers was done on the Gateway Centre of Excellence in Rural Health website, and this was posted for the months of June and July 2016 on the Gateway Centre of Excellence in Rural Health website.

Participants of this pilot study were required to meet the following inclusion criteria: engaged in poultry farming; 40 years of age and over; fluent in English; and having a family physician or health care provider for ongoing medical care. Those who did not have a doctor were excluded from the study for ethical reasons, as spirometry reports were sent to each participant’s health care provider for follow-up care.

2.4 Method

2.4.1 Measuring lung symptoms

The first widely used questionnaire in respiratory epidemiology was the questionnaire from the Medical Research Council (MRC) in 1960. In this first version, there were questions related to wheezing, but in later editions, more questions about asthma and asthma-like symptoms were added. The MRC questionnaire initiated the development of other questionnaires such as the European Community for Coal and Steel (ECSC) questionnaire of respiratory symptoms and the questionnaire from the American Thoracic Society and the Division of Lung Diseases (ATS-DLD-78).
The original American Thoracic Society- Division of Lung Disease questionnaire (ATS-DLD-78) was first released in 1978 to record the presence of respiratory symptom for coal miners. However, the ATS-DLD-78 has been used to detect lung disease associated with work-related respiratory exposures around the world, for miners exposed to asbestos (Brodkin et al., 1993), for cotton textile workers (Mansouri, Pili, Abbasi, Soltani, & Izadi, 2016), and traffic police workers (Karita, Yano, Jinsart, Boudoung, & Tamura, 2001). This questionnaire has, therefore, been extensively validated within numerous populations, and was not further evaluated for its psychometric properties within the present study.

In the current study, the standardized American Thoracic Society (ATS) Lung Health Questionnaire (LHQ), from the Division of Lung Diseases (DLD) of the National Heart, Lung, and Blood Institute, ATS-DLD-78 was administered to determine if symptoms were present during poultry production work. The symptoms of cough, phlegm and wheeze, as well as breathlessness were collected. The MRC Breathlessness Scale which grades breathlessness related to exercise and activity, is included in the ATS-DLD-78, with the following grading scale (Stenton et al., 2008):

- Grade 1  Not troubled by breathlessness except on strenuous exercise
- Grade 2  Short of breath when hurrying on the level or walking up a slight hill
- Grade 3  Walks slower than most people on the level, stops after a mile or so, or stops after 15 minutes walking at own pace
- Grade 4  Stops for breath after walking about 100 yds or after a few minutes on level ground
- Grade 5  Too breathless to leave the house, or breathless when undressing.
2.4.2 Measuring lung function

Pre/post bronchodilator spirometry was performed, using the National Health and Nutrition Examination Survey (NHANES III) standard reference prediction equations (Hankinson, Odencrantz, & Fedan, 1999). Employing the pre/post bronchodilator spirometry was critical to the assessment of lung function within this study, to determine the presence or absence of reversibility of airflow obstruction, as well as measuring the health of the small airways of the lungs. A certified Registered Respiratory Therapist (RRT) performed all the pre/post spirometries, according to Canadian Thoracic Society guidelines (Coates et al., 2013).

Interpretation of the pre/post spirometry results were based on GOLD (2017) and D’Urzo (2011) spirometry interpretation logarithms for the identification of COPD and asthma, with COPD diagnostic criteria as the post-bronchodilator forced expiratory volume in 1 second (FEV1) and the forced vital capacity (FVC) ratio, FEV1/FVC of less than 0.70 (<0.70), and asthma, defined as an improvement in FEV1 of 12% and over, and 200 mL after bronchodilator challenge.

2.4.3 Independent data collection

Spirometry lung function was performed independently of the Lung Health Questionnaire, and evaluation of these measurements was conducted in a blinded fashion (i.e., neither the respiratory therapist conducting the spirometry, nor the physician spirometry expert evaluating the findings, had access to the questionnaire data during their testing or analyses).
2.5 Results

Two rural lung health clinics were held in Seaforth, Ontario and Clinton, Ontario, on August 3 and August 4, 2016, respectively, to fit within harvest times for the farmers.

Eight participants per day attended 1-hour long appointments, for a total of 16 poultry farmers (N=16). The average age of participants was 56.8 years (SD 9.74), with 82% males, and 18% females.

Farm dust exposure in numbers of years was reported by all 16 participants, with an average of 38 years (SD 14.95). Smoking was reported as current smoker, within the last month, never smoked, or an ex-smoker for the past month (Table 2.1). Duration of smoking was calculated by the standard measure of 1 pack years equals 20 cigarettes per day for one year.

Table 2.1: Cigarette smoking

<table>
<thead>
<tr>
<th>Cigarette smoking</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current smokers</td>
<td>1/16 (6.25%)</td>
</tr>
<tr>
<td>Never smoked</td>
<td>8/16 (50%)</td>
</tr>
<tr>
<td>Ex-smokers</td>
<td>7/16 (43.75%)</td>
</tr>
<tr>
<td>Pack years (1 pack of 20 cigarettes per day for one year)</td>
<td>5.07 (SD 6.93)</td>
</tr>
</tbody>
</table>
Lung health symptoms associated with chronic lung disease include cough and phlegm for a duration of 3 weeks or more in a year, wheeze and breathlessness, as measured by the MRC breathlessness scale, within the ATS-DLD-78 lung health questionnaire (Table 2.2).

**Table 2.2: Reporting of lung symptoms**

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Result (n=16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cough and phlegm</td>
<td>3/16</td>
</tr>
<tr>
<td>Wheeze</td>
<td>8/16</td>
</tr>
<tr>
<td>Exercise limitations/breathlessness</td>
<td>0/16</td>
</tr>
<tr>
<td>(MRC* levels 3,4,5)</td>
<td></td>
</tr>
</tbody>
</table>

*Medical research council breathlessness scale

Reporting of MD-confirmed lung disease provided an independent evaluation from the participant’s family physician. There were no reports of MD-confirmed emphysema, however 3 participants reported that their physicians confirmed chronic bronchitis and 2 participants reported confirmation of asthma (Table 2.3).
<table>
<thead>
<tr>
<th>MD-confirmed lung condition</th>
<th>Result (n=16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic bronchitis</td>
<td>3/16</td>
</tr>
<tr>
<td>Emphysema</td>
<td>0/16</td>
</tr>
<tr>
<td>Asthma</td>
<td>2/16</td>
</tr>
</tbody>
</table>

2.5.1 Spirometry results

Sixteen pre/post spirometry tests were performed and interpreted. Upon reviewing the results of the de-identified pre/post bronchodilator spirometry data, two spirometry results were excluded, due to non-reproducible manoeuvres and surgical history. Fourteen spirometry results were included as interpretable within the grouped data.

All fourteen (14) pre-post bronchodilator spirometry results were within normal limits (i.e., FEV1/FVC ratios were above 70%), and there were no results that supported the FEV1 criteria for a spirometric diagnosis of asthma (i.e., an improvement in FEV1 of 12% and over, and 200 mL after bronchodilator).

Four of the post-bronchodilator results revealed FEV1/FVC ratios that were between 70 and 75%, with three approaching COPD criteria. These same results had post FEF 25-75% percent reduction from predicted between -12% and -20%, whereas all other spirometries had no reductions in the mid-range small airway region.
2.5.2 Comparison of symptoms, diagnoses and spirometry results

When comparing the lung health questionnaire results to the spirometry results, the participants with symptoms of cough and phlegm and MD-confirmed diagnosis of chronic bronchitis matched the reduced FEV1/FVC results between 70% and 75%. The small airway reductions of the FEF25-75% results also matched to the MD-confirmed diagnosis of chronic bronchitis. The negative results, or absence of symptoms, also matched the absence of MD-confirmed diagnoses and above 75% normal spirometry results.

Neither the pre-post spirometry, nor the lung health questionnaire, suggested that any participants had emphysema. This was also confirmed by questions within the MRC breathlessness scale. Age, spirometry results, smoking history, and frequency of lung health symptoms are summarized in Table 2.4. From the grouped data of the 14 pilot study participants, the average age was 55 years, and there were no indications of asthma from the post FEV1/FEV results. Symptoms were an important finding, with cough and phlegm at 36% of the grouped data results, and wheeze at 57%. There were no limitations to physical activity due to breathlessness, and MD-confirmed bronchitis was at 21%.
Table 2.4  Summary of descriptive information, concerning spirometry results, smoking history, and lung health symptoms (n = 14)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Mean = 55.36, SD = 9.484</td>
</tr>
<tr>
<td>Post FEV1 / FVC</td>
<td>Mean = 3.81, SD = 0.814</td>
</tr>
<tr>
<td>Post FEV1 ≥ 12% 200ml</td>
<td>0/14</td>
</tr>
<tr>
<td>Post FEF 25-75%</td>
<td>7/14</td>
</tr>
<tr>
<td>Smoking (pack years)</td>
<td>Mean = 5.07, SD = 6.933</td>
</tr>
<tr>
<td>Cough and Phlegm</td>
<td>5/14</td>
</tr>
<tr>
<td>Wheeze</td>
<td>8/14</td>
</tr>
<tr>
<td>Exercise limitations (MRC 3,4,5)</td>
<td>0/14</td>
</tr>
<tr>
<td>MD-confirmed bronchitis</td>
<td>3/14</td>
</tr>
</tbody>
</table>

The forced expiratory flow between 25% and 75% of vital capacity (FEF25-75) reflects the middle forced expiratory flow of the small airways. Fifty percent of the sample of 14 farmers demonstrated significant change from baseline, indicating small airway changes.
2.6 Discussion

The poultry producers lung health study of symptoms and spirometry highlight two different methods of early detection, and underscore the importance of small airway disease in identifying future impairment. Small airway disease is present in the early stages of COPD and becomes more widespread over time. The major sites of obstruction in chronic bronchitis are small airways (<2 mm in diameter) (McDonough et al., 2011).

The presence of phlegm and cough and MD-diagnosed chronic bronchitis, and absence of emphysema despite a low incidence of smoking, point to occupational exposure as the lung irritant in chronic phlegm production.

Asthma was not found in the pre/post spirometry results, however wheeze was a symptom which may need closer attention, whether this is from the work environment, or from poultry production gases.

The poultry farmers were physically fit for work, however early lung health changes for this high-risk populations indicates a need for ongoing monitoring of lung health, to reduce progression and hopefully improve lung function.

Occupational exposure to dusts, chemicals, and gases found in poultry farming are risk factors for developing COPD (Boschetto et al., 2006; Viegas et al., 2013). The implications of occupational lung exposures in contributing to COPD must be considered in research planning, in public policy decision-making, and in clinical practice.

Results of the pre/post spirometry confirmed a relationship between symptoms of chronic bronchitis and spirometry results which are near the cutoff score of 0.70 FEV1/FVC ratio criteria for COPD diagnosis. A pre-post bronchodilator spirometry,
which includes FEF 25-75 %, may be an important result to report for agricultural workers, for early detection small airway disease.

Results of the pre/post spirometry confirmed a relationship between symptoms of chronic bronchitis and the spirometry results approaching COPD diagnosis. A pre-post bronchodilator spirometry, which includes FEF 25-75 %, may be an important result to report for agricultural workers, for early detection small airway disease. The potential for reversal of diagnosis of COPD for those who are close to diagnostic threshold has been found to occur in large sample studies (Aaron et al., 2017).

These results may help to plan for ongoing lung health clinics including spirometry for farmers who are actively involved in poultry production and at high risk for developing COPD.

2.7 Conclusion

The poultry farmers pilot study used both symptom detection and pre/post spirometry which indicate early detection of small airway disease in this high-risk population. Physician-confirmed presence of bronchitis matched the presence of reduced post-FEV1/FVC spirometry and FEF 25-75% (n=14), indicating early detection of small airway disease

Respiratory care health professionals including RRTs, physicians and nurses providing lung health clinics for farmers are needed, to provide screening for early signs of lung disease and to prevent the onset of COPD.
2.8 References


Professionals Global Initiative for Chronic Obstructive Disease. *Global Initiative for Chronic Obstructive Lung Disease.* https://doi.org/10.1097/00008483-200207000-00004


Chapter 3 *

Protection of lung health

3.1 Introduction

Chronic obstructive pulmonary disease (COPD) is a leading cause of morbidity and mortality in Canada (O’Donnell et al., 2008). COPD develops slowly over time and Canadian farmers with COPD often present for health care in late stages of the disease, because they accept cough or breathlessness as “normal”, and because access to health clinics, and the timing of appointments may be limiting factors. COPD is preventable and is easily detected (Global Initiative for Chronic Obstructive Lung Disease (GOLD), 2017). Knowing lung health risks and protecting the airways by wearing the appropriate fit-tested respirator reduces exposure to harmful respiratory hazards.

3.2 Changes in agriculture affecting lung health

Agriculture in Canada has grown from single family farms, to large-scale farming operations, in response to the shift of populations to large urban centres. In 2011, over 80% of Canadians lived in urban centres (Statistics Canada, 2017) compared to over 80% being rural dwellers in Canada in the early 1900s.

Because of this population shift, farming operations such as poultry production have moved towards industrial large-scale confinement facilities. Dust particles in poultry barns can be comprised of bird feed, bedding material, bird feces, feathers, dander, and bioactive components of bacteria, fungi/molds, dust mites and endotoxins (cell wall components of gram-negative bacteria), all of which could trigger cellular reactions within the lung tissue (Jester & Malone, 2003). Studies have identified that poultry workers’ exposure to bioactive dust affects the health of the lungs and is a potential occupational hazard (Health & Safety Executive, 2008; 2009).

As the dust is inhaled, the particles can deposit along the conducting airways, as well as reach the respiratory units of the lungs. The smaller the dust particle, the deeper they can reach within the lungs.

Dust within a poultry barn can range in size, from large visible-to-the-eye dust particles (greater than 20 microns), to microscopic dust particles (less than 0.3 microns). To put this in perspective, the diameter of human hair is approximately 80 microns, and the diameter of the respiratory bronchioles is between 500 and 800 microns (Sung Jin Kim et al., 1995).

Particles smaller than 10 microns in diameter have the potential of causing biologic harm to the lungs of susceptible individuals (Canadian Centre for Occupational Health, 2012; Lee & Khanlou, 2011). Over time, dust exposure can harm the respiratory units of the lungs, and start the progression of COPD. The good news is that COPD is a preventable and treatable condition (GOLD, 2017; Canadian Lung Association, 2014).

3.3 Protection of lung health

According to a Canadian study with non-smoking participants who have not previously been exposed to a swine barn environment, wearing of an N95 disposable
respirator can significantly reduce acute lung health effects (Dosman et al., 2000). Respirators, when fit-tested to reduce air leaks, will perform better, and have a greater ability to protect lungs from biohazardous dust. There is greater danger in wearing a respirator that has air leaks, since the worker will assume that he or she is protected.

The Canadian Standards Association (CSA) Z94.4-11 established best-practice recommendations for the “Selection, use and care of respirators” (2016), guiding workers how to select and wear respiratory protection at all times in areas with atmospheric hazards. The standard reviews how to inspect the respirator prior to use; maintain and store respirators in accordance with training and manufacturer’s recommendations; perform seal checks after donning (putting on) the respirator, ensure that the worker is clean shaven when wearing respirator to ensure proper seal and understand the limitations associated with the use of respiratory protection (CSA, 2016).

N95 is a designation of a respirator that has been approved by the National Institute of Occupational Safety and Health (NIOSH) to block at least 95% of very small (0.3 micron) airborne particles (NIOSH, 2014). Knowing the hazard within the poultry barn is essential to knowing which type of respirator to wear. Table 3.1 provides a summary of different types of respirators, matched to the lung health hazard.

Learning about the work of poultry farmers was essential for planning an effective lung health study. A series of meetings were held between the poultry farmers and the author, to plan for the outreach rural lung health clinics.
Table 3.1 Lung health hazards within poultry barns and recommended type of respirator

<table>
<thead>
<tr>
<th>Hazards found in Poultry Barns</th>
<th>Type of Respirator</th>
<th>How the respirator protects from the hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioactive dust</td>
<td>N95 disposable respirator</td>
<td>Needs respirator fit-testing in order to protect. “N” means the respirator is not resistant to oil and is 95% efficient (NIOSH, 2014).</td>
</tr>
<tr>
<td>Ammonia</td>
<td>Air-purifying, full-facepiece respirator (gas mask) with two canister providing protection specifically against ammonia</td>
<td>Needs respirator fit-testing in order to protect. The recommended level for short-term exposure (15 minutes) is no greater that 35 ppm. Many poultry producers become accustomed to the ammonia, and are less able to detect ammonia gas below 50 ppm Choinière &amp; Munroe (1997).</td>
</tr>
<tr>
<td>Carbon dioxide, hydrogen sulfide, carbon monoxide</td>
<td>Air-supplied respirator needed</td>
<td>Fit testing is not needed, since air is supplied within a hood over the head.</td>
</tr>
</tbody>
</table>

3.4 Methods

The lung health clinics’ times and locations were decided in collaboration with the farmers, to fit between harvest times, and in close proximity to their farms. The lung health clinic appointment sections devoted to lung health protection included 4 steps:
**Step 1:** Each participant completed a lung health questionnaire, developed specifically by this author for the poultry producers, which contained specific lung protection questions, asking each poultry farmer:

- the number of years working in a dusty environment,
- to identify from a list, the lung health risks in the poultry barn,
- how often they wear their respirators,
- what information they would find useful in protecting their lungs.

**Step 2:** After the questionnaire was completed, a review of the lung health risks and respirators types for each lung health risk was discussed.

**Step 3:** The farmers participated in a standardized N95 respirator fit test. Each participant was given a choice of three N95 respirators, to try on, and see which they found most comfortable and fit best. Next, each participant tested their respirator for leaks during inhalation and exhalation to confirm a suitable seal, and were asked if they tasted or smelled a scent when the respirator was on, under a paper-like hood.

Respirator training and fit-testing of N95 respirators included the following methodology:

a) Each participant chose one of the three N95 respirators that fit best,

b) Each participant demonstrated no air leaks (good seal) prior to N95 fit-test,

c) Each participant performed safe donning (putting on) and doffing (taking off) of respirators after demonstration.

**Step 4:** After three months, a questionnaire was sent to each participant, to ask how often they wear their fit-tested respirator.
3.5 Results

Two rural lung health clinics were held in Seaforth, Ontario and Clinton, Ontario, on August 3 and August 4, 2016, respectively. Eight participants per day attended 1-hour long appointments, for a total of 16 poultry farmers (N=16). The average age of participants was 56.8 years (SD 9.74), with 82% males, and 18% females. Table 3.2 summarizes the results of dust exposure, occupational risks which are present in poultry barns, respirator use all of the time, and information and resources that would be useful to help protect their lungs.

Table 3.2: Lung Health Questionnaire responses

<table>
<thead>
<tr>
<th>Lung health question</th>
<th>Result (N=16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average exposure to farm dust in years</td>
<td>38 yrs (SD 14.95)</td>
</tr>
<tr>
<td>Occupational risks identified</td>
<td>Organic dust 100%</td>
</tr>
<tr>
<td></td>
<td>Ammonia 81.2%</td>
</tr>
<tr>
<td>Wearing of respirator all of the time</td>
<td>Baseline 6.3%</td>
</tr>
<tr>
<td></td>
<td>3 months 18.8%</td>
</tr>
<tr>
<td>What information and resources would be useful to you in your job, to help you protect your lungs?</td>
<td>25 % requesting more information about respirators</td>
</tr>
</tbody>
</table>
3.6 Conclusion

There is a need for more outreach lung health clinics and respirator training opportunities for farmers in Ontario, to address the urgent need for protection of lung health and the prevention of COPD. The present study demonstrated that rural lung health clinic appointments are filled to capacity, when location (close proximity to the farming community), and timing (between harvests) are planned in collaboration with the farmers through knowledge exchange.

Rural lung health clinics offer one way to deliver N95 respirator-fit testing and choice of best respirator-to-hazard training. Websites dedicated to lung health protection, with videos, may be another way to reach to the farmers who live across large geographic areas of Ontario, however N95 fit-testing would require face-to-face appointments. Respiratory care professionals are needed to deliver this training, in our efforts to prevent chronic lung disease and promote lung health of farmers.
3.7 References

https://www.ccohs.ca/oshanswers/chemicals/how_do.html


https://www.nasdonline.org/197/d000146/respiratory-health-on-the-poultry-farm.html


National Institute of Occupational Safety and Health (NIOSH) (2014). Guide to the


Chapter 4 †

Components of lung health clinics for farmers

4.1 Introduction

Farming in Ontario and Canada has evolved over the past 100 years, from farms feeding their own families, to farms feeding thousands and millions of people. Large scale production farming is here to stay, in response to the shift of populations to large urban centres. With these changes in higher production farming, comes added risks for lung health of the farmer, from exposure to dust from outdoor work in the fields, as well as indoors, in the barn environment.

Occupational health nurses work in many sectors such as mining and manufacturing, which address lung health risks. Reaching out to farmers for lung health assessments can be a challenge, due to the time and seasonal demands of farming activities, harvest times, and distances to health care centres.

Bioactive dust is a potential occupational lung health hazard (Viegas et al., 2013) which may lead to chronic obstructive pulmonary disease (COPD). COPD is a treatable

and preventable disease (GOLD, 2017). The development of lung disease such as COPD is very gradual and tends to be noticed by farm workers only after there has been a significant loss of lung function, often up to 50-60%. (GOLD, 2017). People with COPD often present for health care far too late, because they accept cough or mild breathlessness as “normal” (GOLD, 2017).

Early detection of lung health changes is an important strategy in detecting and hopefully slowing down lung disease progression. COPD is still under-diagnosed, due to many adults not having or seeing their doctor or health care provider. Many farmers do not report symptoms until advanced disease is present. As well, screening spirometry, without the pre/post bronchodilator protocol, will often show normal lung function, and further testing may not be done or be delayed for many years (O’Donnell et al., 2008).

Occupational health nurses are in an ideal position to be able to detect lung health changes in its early stages and to provide occupational health services to farming communities. The difficulty is in reaching a population that normally does not seek health care or lives in an under-serviced area. There exists wide regional variation in spirometry utilization which may indicate inadequate access to spirometry due to health care facilities which located in distant geographic areas to the farming communities (Chan, Anderson, & Dales, 1997).

The Poultry Producers Lung Health Study aimed to provide proximal lung health clinics for poultry farmers, including measurement of lung function through pre-post spirometry and protection of lung health through respirator training and fit-testing, to ensure maximal protection from occupational lung hazards.
4.2 Planning and implementation of lung health clinics

The Poultry Producers Lung Health study, conducted in southwestern Ontario in August 2016, provided outreach community lung health clinics, with the goal to bring lung health first and foremost to the farmer. Due to poultry production methods moving towards industrial large-scale confinement facilities, poultry workers’ exposure to bioactive dust is a potential occupational hazard (Viegas et al., 2013).

The planning phase can take the longest time. This phase is essential for the success of the clinics to allow for a foundation of trust to occur; to establish supportive community networks; to become involved in rural community health organizations; to meet and listen to suggestions from the rural communities; to provide the best locations and times for clinics; and involve the farmers at all stages of preparation. The importance of involving the farmers at all stages of preparation was crucial to the success of the lung health clinics. Collaboration between the farmers and health care providers was established before any lung health clinics were scheduled, since harvest times needed to be confirmed close to the clinic times and weather dependent.

The clinics were held in rural communities in proximity to the farmers, and consisted of four parts: 1) a lung health questionnaire; 2) a review of respirator types (matched to particular lung health risks); 3) N95 respirator fit-testing; and 4) a pre/post spirometry lung function test.

Collaboration between the farmers and health care providers were established before any lung health clinics were scheduled, since harvest times needed to be confirmed. Consultations with two rural health care centres were done in the months of preparation, to arrange for space and time for the clinics. Due to the outreach nature of the clinics and need to ensure that calibrated equipment and standardized measurement
was performed, outsourcing of spirometry by a Registered Respiratory Therapist was done.

4.3 Description of the lung health clinic appointment

The lung health clinic appointment included the following components:

- Baseline lung health questionnaire
- Pre/post bronchodilator spirometry test
- Review of lung health risks and respirator types
- Post spirometry lung function testing
- N95 respirator fit-test

The fifteen-minute wait between pre and the post spirometry testing allowed time to review types of respirators which would be needed during poultry production work. The N95 fit-test was done after the post spirometry test, to avoid interference with the spirometry assessment.

An example of the set-up for the respirator training and review of types and sizes and fitting of respirators, as well as the N95 respirator fit test equipment is shown in Plate 4.1. Each lung health clinic can adapt according to resources within the setting and space allocation.
4.4 Rationale for pre/post bronchodilator spirometry

Pre/post spirometry is the gold standard to detect early onset of lung disease (GOLD, 2017). The post bronchodilator spirometry can provide important data on small airway changes, which can indicate early onset of bronchoconstriction, and can be missed if post bronchodilator spirometry is not performed.

Plate 4. 1: N95 respirator fit-testing equipment
4.5 Results

Sixteen poultry producers attended the two-day lung health clinics. The sample size was a convenience sample, based on the availability of the fully-booked, sixteen appointments for the two-day lung health clinics in Huron county of rural Ontario.

Each participant’s spirometry results were sent to each of their respective family physician, for follow-up care. De-identified data from the lung health questionnaire and spirometry were grouped and will be reported in a subsequent study report.

4.6 Discussion

The lung health clinic provided an opportunity to discuss measures to protect the lung health of the poultry farmer on an individual basis. The N95 respirator fit-testing provided an opportunity to discuss with the poultry farmer how to achieve a suitable seal, to ensure maximal protection. The key concept of having more danger in wearing a respirator that has a broken seal, and could have an air leak, and does not protect from the lung health hazards was emphasized.

COPD is preventable, easily detected, and treatable at any stage (Canadian Lung Association, 2014). Protecting the airways by wearing the appropriate fit-tested respirator reduces exposure to harmful lung health hazards. Respirator use can be promoted by offering a variety of types of respirators, as well as discussing the rationale for wearing the respirator, all the time during work within the poultry barn. A lung health clinic which includes both spirometry, the clinical components and respirator training, the educational components, makes the most of the appointment time, and provides an opportunity to ask questions, and focus on the importance of lung health. The farmers
can bring a wealth of knowledge about their work and the health care team can make the lung health clinic appointment more meaningful and focused to the needs of the farmer.

4.7 Conclusion

The lung health clinics for poultry farmers demonstrated a planning and delivery mode that provided farm-specific lung health education, pre-post spirometry testing, and N95 respirator-fit testing, all in the same appointment.

Results of the pilot study suggest that a clinical educational program approach for poultry farmers demonstrated an effective delivery method of occupational health services. The clinic appointment allowed for exchange of information, to increase awareness of the lung health risks, to potentially influence behaviour of wearing fit-tested respiratory protection therefore reducing the risk for the development or progression of lung disease.

The poultry farmers were included throughout the planning phase which resulted in full participation in the lung health clinics. The occupational health nurse ensured that rural health care centres had a voice in how, when and where the lung health clinics would run, synchronous with the other appointments and clinics within the rural health centre during the same days.

The present study demonstrated how to plan and implement proximal and well-attended lung health clinics for poultry producers. Including both educational and clinical components, made the best use of time between the farmers and health care providers.
4.8 References


Chapter 5

Results of a Cross-Canada Lung Health Survey

This Chapter will report on the findings from the cross-Canada distribution of the LHQ, and will compare the results obtained from the pilot study.

5.1 Method

The Poultry Producers Lung Health Questionnaire used in the pilot study was the same questionnaire distributed across Canada. Distribution of the online Lung Health Questionnaire was estimated to reach 500 poultry farmers (personal communication Canadian Poultry Research Council, April 2017). The survey was created within Qualtrics, hosted by the University of Western Ontario, and a link was then provided to the Canadian Poultry Research Council (CPRC) for distribution to the CPRC network of poultry producers across Canada.

5.2 Background

The results of the Poultry Producers Lung Health pilot study provided information on the health status of a group of poultry farmers in southwestern Ontario. The farmers indicated a need for more information regarding respirators.

The purpose of the cross-Canada Poultry Producers Lung Health portion of the study was to compare the data from the southwestern Ontario poultry farmers with other Canadian poultry producers, and well as determine the response to an online lung health questionnaire.
5.3 Results

Approximately five hundred poultry farmers across Canada received the link to complete the online Lung Health Questionnaire. This potential number of poultry farmers was provided by Dr. Bruce Roberts, Canadian Poultry Research Council (CPRC), based on the poultry producers network from the council.

Sixty three (63) responses were received, 13 of which were incomplete questionnaires. Fifty questionnaires were completed by farmers living in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, Nova Scotia and Prince Edward Island.

5.4 Comparison of pilot study and cross-Canada data

Data was grouped for the 50 complete questionnaires received, and Figure 5.1 provides a graph of the types of farming within both the pilot and cross-Canada groups. The variety of farming types can be seen for both groups. A higher percentage of farmers in the pilot study group grew and harvested wheat, soybean and corn, whereas the cross-Canada farmers were involved in beef cattle ranching. Equivalent percentages were seen at 18% in dairy, fruit, vegetable and equine farming.
The types of farming can influence lung health from the activities involved. For livestock, research has shown that farmers involved in livestock have higher incidences of lung disease, whereas crop farmers did not (May et al., 2012; McClendon, Gerald, & Waterman, 2015; Pickrell, 1991).

The pilot study and cross-Canada poultry farmer lung health questionnaire grouped responses are summarized in Table 5.1 for age, sex, education, current smokers, years of dust exposure, and breathlessness.

Both groups show comparable results, with an average farm dust exposure of more than 30 years in duration. The results also suggest a low incidence of current smokers, which supports research that has suggested that the prevalence of cigarette smoking in Canadian farmers is approximately one-half that of the general population (Cormier, 2007). Comparing both groups for exercise limitations, moderate physical activity by
breathlessness, according to the interpretation of the MRC levels 3, 4, and 5 (Stenton et al., 2008).

Table 5.1 Comparison of Pilot study and cross-Canada LHQ data

<table>
<thead>
<tr>
<th>Lung Health Questionnaire (LHQ)</th>
<th>Pilot Study LHQ (n=16) Aug 2016</th>
<th>Cross-Canada LHQ (n=50) Apr 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>56.8 (SD 9.74)</td>
<td>52.86 (SD 11.61) 95% CI [49.6, 56.1]</td>
</tr>
<tr>
<td>Sex</td>
<td>Females 3 (18%) Males 13 (82%)</td>
<td>Females 9 (18%) Males 41 (82%)</td>
</tr>
<tr>
<td>Years of formal education</td>
<td>13.9 (SD 0.71)</td>
<td>12.7 (SD 2.91) 95% CI [11.9, 13.5]</td>
</tr>
<tr>
<td>(elementary, secondary, college and university)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current smokers</td>
<td>1/16 (6.25%)</td>
<td>4/50 (8%)</td>
</tr>
<tr>
<td>Farm dust exposure (years)</td>
<td>38 (SD 14.95)</td>
<td>32 (SD 14.55) 95% CI [28.0, 36.3]</td>
</tr>
<tr>
<td>Exercise limitations (MRC* levels 3,4,5)</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>MD-confirmed bronchitis</td>
<td>18.75 %</td>
<td>28.0 %</td>
</tr>
<tr>
<td>Respirator use all of the time</td>
<td>6.25%</td>
<td>2.0%</td>
</tr>
</tbody>
</table>

*Medical Research Council Breathlessness Scale

5.5 Conclusion

The cross-Canada Poultry producers lung health survey provided a small sample of respondents for comparison to the pilot study of poultry producers from Huron county in Ontario. Comparable results were found in age, education, sex, current smokers, and years of dust exposure. This provides a snapshot of poultry producers across Canada, and
indicates similarities between the groups, with interesting comparisons on the types of farming occurring across Canada.
5.6 References


Chapter 6

Summary of the poultry producers lung health study.

6.1 Summary of project results

During the past four years of collaborating as a lung health researcher with the poultry producers of Huron county, the findings of this research identified a need for the continuation and provision of establishing sustainable and financially-supported lung health clinics for poultry farmers and all farmers. The farmers have identified the lung health risks encountered during their work in the poultry barns, however there is a need to monitor the lung health of this high-risk type of farming activity. Due to the high number of animals within the barn environment, dust exposure has increased, with bioactive dust being a major lung health hazard for the development of small airway disease. Occupational lung health risks related to bioactive dust have become an important reality for poultry farmers.

The null hypothesis of this dissertation was that there would be no evidence of lung disease in poultry farmers, associated with their work within the poultry barns. The pre-post spirometry was able to detect signals of small airway disease, and this is not exclusive to bioactive dust exposure, since all of the farmers were exposed to dust within the barns, as well as outside in the fields.
Respiratory training was presented to help farmers protect their lungs against the development of COPD when exposed to bioactive dust, and N95 respirators fit-testing was presented as the standard protocol for all poultry farmers.

A framework of how to run a rural outreach lung health clinics was developed, in collaboration with the rural health centres, and with the farmers. Combining both the measurement and protection aspects of promoting lung health of poultry farmers yielded successful attendance to the lung health clinic appointments.

The cross-Canada survey showed the similarities between the poultry farmers from Huron county and across Canada. The early identification of lung symptoms point to the need for measurement and protection of lung health for all farmers.

In summary, this thesis presents three manuscripts that address measurement and protection of lung health of poultry farmers, as well a cross-Canada survey comparator for the Huron county findings.

The health care system implications are to have available rural health care teams which include Registered Respiratory Therapists, RNs and MDs or NPs to run the clinics.

Two organizations are looking at solutions for rural health care resources. The Society of Rural Physicians of Canada (SRPC) has developed a National Rural Health Strategy that calls for a cross-Canadian solution to ensure a greater number of rural physicians are supported in rural health (Rourke, 2005). According to the Rural Health Strategy, ‘Twenty one per cent of the population is rural, fewer than ten per cent of physicians are rural, and only three per cent of specialists are rural.’ (Rourke, 2005). This points to the need for collaboration of available resources, to ensure efficient delivery of health services, such as outreach lung health clinics, which are planned with the farmers, and coincide with their harvest times.
In 2009, The Ontario Rural Council (TORC) REPORT brought out in their summation, an urgent need for rural health evidence-based research that is available to rural health care practitioners and across health networks.

The needs that TORC (2009) identified which coincide with this dissertation on rural lung health research are:

1. PREVENTION AND SELF-MANAGEMENT: Access to health care can be difficult in rural areas. It is also much more expensive to treat sickness than prevent illness where possible. Focus efforts on wellness education and illness prevention.

2. PARTNERSHIPS AND COORDINATED EFFORTS: Opportunities for collaboration are currently underutilized at the community, regional and provincial levels. Regulated health care partners specializing in health prevention strategies are not networked or made use of.

3. HUMAN RESOURCES: Barriers and challenges related to Human Resources within the health system need to be addressed. From the education and training of practitioners, to recruitment and retention challenges in rural areas; from pay equity issues, to utilizing providers in appropriate circumstances and to their full scope of practice - addressing these challenges must be part of any strategy aimed at benefiting rural communities. (TORC, 2009).

6.2 Overall contribution to the literature

The three articles contained within the dissertation proved to advance the knowledge on the creation of rural lung health clinics, as well as ensuring that N95 respirator fit-testing becomes the standard procedure for protection of the lungs of the
poultry production farmer. The identification of small airway disease in poultry farmers, not associated with asthma, and not associated strongly with smoking, was an important contribution to the COPD prevention literature. Although the sample size was small, each individual farmer presents with their own lung health picture, and need for ongoing monitoring.

6.3 Implications of the research

The implication of this research include:

1. the need to promote lung health for poultry farmers through respirator training to wear N95 fit-tested respirators all of the time when working within the poultry barns,

2. the need to perform pre-post spirometry, to ensure that changes in forced expiratory flow of 25 to 75% mid flow changes are captured, as signals of early detection of small airway disease,

3. the need to conduct a full scale epidemiological study across Canada, to determine prevalence of small airway disease in confinement industrial size farm operations.

6.4 Strengths and limitations

The strengths of this research are the collaboration of rural communities, to work together and support lung health of farmers. This research was made possible in great part to the rural community leaders, and great organizations of poultry farmers, supporting rural research. The excellent support of the rural community health centres was key in delivery of the lung health clinics, which supported the appointments,
proximal locations, office space and free parking. A strength of the cross-Canada survey was the ease in delivery and quick response times from the Qualtrics survey.

The limitations of the research were the availability of only two clinic days for the clinic study, due to lack of funding, which influenced the sample size of the pilot study. The Canada-wide study response was dependent on internet access, and this is not always available in all rural communities.

6.5 Future work

The continuation of rural lung health clinics and rural lung health research will be needed, to ensure that farmers have an established method to monitor their lung health.

A full-scale epidemiological study across Canada, to determine prevalence of small airway disease in confinement industrial size farm operations.

6.6 Concluding statements

The Poultry Producers Lung Health study provided a foundation for the provision of comprehensive rural lung health clinics for farmers involved with poultry production, as well as for all farmers across Canada. The research methodology was based on GOLD (2018) recommendations, to include a standardized lung health questionnaire to collect lung health symptoms, as well as the pre/post bronchodilator spirometry. The online lung health questionnaire provided an effective way to reach farmers across Canada, with real-time data capturing capability. The changes in agriculture to feed large urban centres have resulted in increased lung health risks for farmers.

To conclude... the air we breathe is the air we all breathe, and keeping farmers healthy benefits everyone.
6.7 References

https://doi.org/10.1097/00008483-200207000-00004

Ontario Legislative Assembly (2017). Lung Health Act. S.O. 2017, c.28
https://www.ontario.ca/laws/statute/17l28


http://www.ruralontarioinstitute.ca/file.aspx?id=1fb3035d-7c0e-4bfa-a8d7-783891f5c5dc
Appendices

Appendix A: List of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATS-DLD-78</td>
<td>American Thoracic Society and the Division of Lung Diseases (1978)</td>
</tr>
<tr>
<td>COPD</td>
<td>Chronic Obstructive Pulmonary Disease</td>
</tr>
<tr>
<td>FEF 25-75%</td>
<td>Forced expiratory flow between 25-75% of the complete (100%) forced expiration</td>
</tr>
<tr>
<td>FEV1</td>
<td>Forced expiratory volume expelled in the first second of a forced expiration.</td>
</tr>
<tr>
<td>FVC</td>
<td>Forced vital capacity is the volume of lungs from full inspiration to forced maximal expiration</td>
</tr>
<tr>
<td>FEV1/FVC</td>
<td>Percentage of FVC expelled in the first second of a forced expiration.</td>
</tr>
<tr>
<td>GOLD</td>
<td>Global Initiative for chronic Obstructive Lung Disease</td>
</tr>
<tr>
<td>PFT</td>
<td>Pulmonary Function Test</td>
</tr>
<tr>
<td>MRC</td>
<td>Medical Research Council</td>
</tr>
<tr>
<td>NHANES III</td>
<td>The third (III) National Health and Nutrition Examination Survey, nation-wide spirometry reference values</td>
</tr>
</tbody>
</table>
Appendix B: Occupational Health and Safety Act

ONTARIO REGULATION 414/05

Farming Operations.

Application of Act to farming operations

1. Subject to the limitations and conditions set out in this Regulation, the Act applies to farming operations. O. Reg. 414/05, s. 1.

Exception

2. Despite section 1, the Act does not apply to a farming operation operated by a self-employed person without any workers. O. Reg. 414/05, s. 2.

Limitations, joint health and safety committees

3. (1) Despite section 1, subsection 9 (2) of the Act applies only to farming operations where 20 or more workers are regularly employed and have duties that include performing work related to one or more of the operations specified in subsection (2). O. Reg. 414/05, s. 3 (1).

(2) The following are the operations referred to in subsection (1):

1. Mushroom farming.
2. Greenhouse farming.
3. Dairy farming.
5. Cattle farming.

(3) Despite section 1, where a joint health and safety committee is required at a farming operation, the requirement for certified members set out in subsection 9 (12) of the Act applies to that farming operation only if 50 or more workers are regularly employed at it. O. Reg. 414/05, s. 3 (3).

Application of certain regulations

4. (1) Despite section 1 and subject to subsection (2), the regulations made under the Act do not apply to farming operations. O. Reg. 414/05, s. 4 (1).

(2) The following regulations apply to farming operations:

2. Ontario Regulation 297/13 (Occupational Health and Safety Awareness and Training) made under the Act.
3. Ontario Regulation 381/15 made under the Act.O. Reg. 414/05, s. 4 (2); O. Reg. 90/13, s. 1; O. Reg. 298/13, s. 1; O. Reg. 385/15, s. 1.

O. Reg. 414/05, s. 3 (2).
Appendix C: Poultry Producers Lung Health Questionnaire (PPLHQ)

The Poultry Producers Lung Health Questionnaire is to be completed after you have read and reviewed the study information sheet.

Please answer each of the questions by filling in or choosing one of the choices for each of the questions. Thank you for participating in the study.

Q1 What is your age? _____

Q2 What is your gender?
   ☐ Male
   ☐ Female

Q3 How many people live in your household? (include children who return from school during the summer)
   ☐ Number of people ________________

Q4a How many years of full-time education have you completed?
   ☐ Elementary school years full-time ________________
   ☐ Secondary school years full-time ________________
   ☐ University/College/Trade School years full-time ________________

Q5 What is your employment status? (pick the one choice that fits the best)
   ☐ Self-employed farmer including other employment
   ☐ Self-employed farmer, full-time
   ☐ Homemaker and farmer
   ☐ Other ________________

Q6 How long have you lived in the same house (in years)?

Q7 Have you had your current house tested for radon gas?
   ☐ Yes
   ☐ No
Q8 Do you belong to an association of farmers?
- Yes
- No

Q9 Do you meet on a regular basis (at least yearly) with a group of farmers, for sharing of information?
- Yes
- No
- Does not apply

Q10 When was the last time you went to see your doctor or other health care provider?
- within the last month
- within the last 6 months
- within the last 12 months
- within the last 24 months
- over 24 months

Q10 a – Have you ever had a lung test, lung function test or spirometry test done?
- Yes
- No

Q11 Do you go for a yearly flu vaccination?
- Yes
- No

Q12 Where would you prefer to receive your flu vaccination?
- Doctors office
- Community Health Centre
- Pharmacy
- Other

Q13 What is the best month for you to receive your flu vaccination?
- November
- December
- January
- February
Q14 What type of farming do you do? (check as many as apply)
- Poultry production (chicken)
- Poultry production (turkey)
- Animal combination farming
- Beef cattle ranching and farming, including feedlots
- Corn farming
- Dairy cattle and milk production
- Egg production
- Fruit /apple / strawberry farming
- Hog & pig farming
- Horse and other equine production
- Soybean farming
- Vegetable farming
- Wheat farming
- Other ____________________

Q15-20 COUGH

Q15 Do you usually have a cough? (Count a cough with first smoke or on first going out-of-doors. Exclude clearing your throat)
- Yes
- No
If NO is Selected, Then Skip To PHLEG

Q16 Do you usually cough as much as 4 to 6 times a day (or more), 4 or more days a week
- Yes
- No

Q17 Do you usually cough first thing in the morning (i.e. when you first get up)?
- Yes
- No

Q18 Do you usually cough throughout the day or at night?
- Yes
- No
Q19 Do you usually cough on most days for 3 consecutive months or more during the year?
❖ Yes
❖ No

Q20 For how many consecutive years have you had a cough on most days?
❖ Number of years ________________

Q21-26 PHLEGM

Q21 Do you usually have or bring up phlegm (mucus from your chest, not from your sinuses. (Count phlegm with the first smoke or on first going out-of-doors. Exclude phlegm from the nose. Count swallowed phlegm.)
❖ Yes
❖ No
If No is Selected, Then Skip to Cough and Phlegm

Q22 Do you usually have or bring up phlegm as much as twice a day, 4 or more days out of the week?
❖ Yes
❖ No

Q23 Do you usually bring up phlegm first thing in the morning (i.e. when you first get up)?
❖ Yes
❖ No

Q24 Do you usually bring up phlegm at all during the rest of the day or at night?
❖ Yes
❖ No

Q25 Do you bring up phlegm like this on most days for 3 consecutive months or more during the year?
❖ Yes
❖ No

Q26 For how many years have you had trouble with phlegm?
❖ Number of years ________________
Q27-28 EPISODES OF COUGH AND PHLEGM

Q27 Have you had periods or episodes of cough and phlegm together, for 3 weeks or more each year?
- Yes
- No
If NO is Selected, Then Skip to WHEEZING

Q28 For how many years have you had cough and phlegm together?
- Number of years ________________

Q29-34 WHEEZING

Q29 Does your chest ever sound wheezy or whistling:
- Yes, when I have a cold
- Yes, occasionally apart from colds
- Yes, most days or nights
- No
If No is Selected, Then Skip to BREATHLESSNESS

Q30 For how many years has this been present?
- Number of years ________________

Q31 Have you ever had an attack of wheezing that has made you feel short of breath?
- Yes
- No

Q32 How old were you when you had your first such attack?
- Age in years ________________

Q33 Have you had 2 or more such episodes?
- Yes
- No

Q34 Have you ever required medicine or treatment for the(se) attack(s)?
- Yes
- No
Q35-40 BREATHLESSNESS

Q35 If disabled when walking by any condition other than heart or lung disease, please describe:
- Nature of condition ____________________
- Not disabled by any other condition when walking

Q36 Are you troubled by shortness of breath when hurrying on the level or walking up a slight hill?
- Yes
- No

Q37 Do you have to walk slower than people of your age on the level because of breathlessness?
- Yes
- No

Q38 Do you ever have to stop for breath when walking at your own pace on the level?
- Yes
- No

Q39 Do you ever have to stop for breath after walking approximately 100 metres or after a few minutes on the level?
- Yes
- No

Q40 Are you too breathless to leave the house or breathless on dressing or undressing?
- Yes
- No

Q41-44 CHEST COLDS

Q41 If you get a cold, does it usually go to your chest? (Usually means more than half the time)
- Yes
- No

If No is Selected, Then Skip to PAST ILLNESSES
Q42 During the past 3 years, have you had any chest colds that have kept you off work, indoors at home, or in bed?

- Yes
- No

Q43 Did you produce phlegm with any of these chest colds?

- Yes
- No

Q44 In the last 3 years, how many chest colds, with increased phlegm, did you have which lasted a week or more?

- Number of illnesses ________________
- None

Q45- PAST ILLNESSES

Q45 Did you have any lung trouble before the age of 16?

- Yes
- No

Q46 Have you had any attacks of bronchitis?

- Yes
- No

If No is Selected, Then Skip to Have you ever had pneumonia (include...

Q47 Was your bronchitis confirmed by a doctor?

- Yes
- No

Q48 At what age was your first attack of bronchitis?

- Age ________________

Q49 Have you ever had pneumonia (includes bronchopneumonia)?

- Yes
- No

If No is Selected, Then Skip to Have you ever had hay fever?

Q50 Was your pneumonia confirmed by a doctor?

- Yes
- No
Q51 At what age did you first have pneumonia?
   ○ Age ____________________

Q52 Have you ever had hay fever?
   ○ Yes
   ○ No
   If No is Selected, Then Skip to Have you ever had chronic bronchitis?

Q53 Was your hay fever confirmed by a doctor?
   ○ Yes
   ○ No

Q54 At what age did you first have hay fever?
   ○ Age ____________________

Q55 Have you ever had chronic bronchitis?
   ○ Yes
   ○ No
   If No is Selected, Then Skip To Have you ever had emphysema?

Q56 Was your chronic bronchitis confirmed by a doctor?
   ○ Yes
   ○ No

Q57 At what age did your chronic bronchitis start?
   ○ Age ____________________

Q58 Have you ever had emphysema?
   ○ Yes
   ○ No
   If No is Selected, Then Skip to Have you ever had asthma?

Q59 Was your emphysema confirmed by a doctor?
   ○ Yes
   ○ No

Q60 At what age did your emphysema start?
   ○ Age ____________________
Q61 Have you ever had asthma?
- Yes
- No
If No is Selected, Then Skip to Have you ever had any other chest ill...

Q62 Was your asthma confirmed by a doctor?
- Yes
- No

Q63 At what age did your asthma start?
- Age ________________

Q64 Have you ever had any other chest illness?
- Yes (please specify) ________________
- No

Q65 Have you ever had any chest operations?
- Yes (please specify) ________________
- No

Q66 Have you ever had any chest injuries?
- Yes, (please specify) ________________
- No

Q67 Has a doctor ever told you that you had heart trouble?
- Yes
- No
If No is Selected, Then Skip to Has a doctor ever told you that you h...

Q68 Have you ever had treatment for heart trouble in the past 10 years?
- Yes
- No

Q69 Has a doctor ever told you that you had high blood pressure?
- Yes
- No
If No is Selected, Then Skip to OCCUPATIONAL HISTORY
Q70 Have you had any treatment for high blood pressure (hypertension) in the past 10 years?
- Yes
- No

Q71-76 OCCUPATIONAL HISTORY

Q71 Have you worked in a dusty job (including poultry barns):
- Yes
- No
If No is Selected, Then Skip to What type of lung health hazard...

Q72 Total years worked in dusty jobs:
- Years ____________________

Q73 What type(s) of lung health hazards may be present during your farming work (choose as many as apply):
- ammonia gas
- nitrogen gas
- methane gas
- carbon dioxide
- carbon monoxide
- organic dust (poultry barn dust including bacteria, fungus, mold, feathers, litter, etc.)
- chemical dust (pesticides)
- fumes (welding)
- other ____________________

Q74 Do you wear a respirator when working in jobs when exposed to dust, gas and/or chemicals:
- never
- some of the time
- most of the time
- all of the time

Q75-80 TOBACCO SMOKING
Q75 Have you ever smoked cigarettes? (No means less than 100 cigarettes in your lifetime)
  ☑ Yes
  ☑ No
If No is Selected, Then Skip to Have you ever smoked a pipe regularly?

Q76 Do you now smoke cigarettes (as of 1 month ago)?
  ☑ Yes
  ☑ No
  ☑ Does not apply

Q77 How old were you when you first started regular cigarette smoking?
  ☑ Age in years ________________

Q78 If you have stopped smoking completely, how old were you when you stopped?
  ☑ Age stopped ________________
  ☑ Check if still smoking

Q79 How many cigarettes do you smoke per day now?
  ☑ Cigarettes per day ________________

Q80 On the average of the entire time you smoked, how many cigarettes (on average) did you smoke per day?
  ☑ Cigarettes per day ________________
  ☑ Does not apply

Q81 Have you ever smoked a pipe regularly?
  ☑ Yes
  ☑ No

Q82 Have you ever smoked cigars regularly?
  ☑ Yes
  ☑ No

Q83 What information and resources would be useful to you in your job, to help you protect your lungs?
  __________________________________________________________
  __________________________________________________________

Thank you for completing the Lung Health Questionnaire.
Appendix D: Western University HSREB 107685
Appendix E: Permission from Elsevier for Figure 1

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Appendix F: Curriculum vitae

Name: Rose-Marie Doyon Dolinar

Education: The University of Western Ontario, London, Ontario, Canada 2014-2018 PhD(C), Measurement & Methods Health & Rehabilitation Sciences, Faculty of Health Sciences

Ottawa University, Ottawa, Ontario, Canada 2000 Diploma, Primary Health Care Nurse Practitioner 1997 MScN

Laurentian University, Sudbury, Ontario, Canada 1987 BScN

Awards Northwater Capital Management Award in Aging 2018 Doctoral Award, 2018

Ontario Lung Association, Ontario Respiratory Care Society 2015-2017 Doctoral Fellowship Award

Publications and conference presentations

Doyon Dolinar, RM (2018). Item analysis (IA) & Exploratory Factor Analysis (EFA) of the Montreal Cognitive Assessment of older adults living in a rural community of northern Ontario (publication in progress). Poster presented at CPA 2017 (IA), Toronto ON and ICAP 2018 (EFA), Montreal QC.

Doyon Dolinar, RM (2018). The air we breathe: early detection of small airway disease in poultry production farmers. Update on Respiratory Health, Research and Education, Fall, Issue 6. (Accepted for publication). Poster presented at SRPC 2018, St. John’s NL.
