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Respiratory Symptoms and Lung Function in Pig Farmers

ACADEMIC DISSERTATION

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To my parents

Contents

Abbreviations

ATS	American Thoracic Society
BAL	Bronchoalveolar lavage
CD	Cluster of differentiation
CI	Confidence interval
COPD	Chronic obstructive pulmonary disease
EU	European Union
FEV_1	Forced expiratory volume in one second
FEF_{50}	Forced expiratory flow with 50% of the forced vital capacity remaining in the lung
FEF_{75}	Forced expiratory flow with 75% of the forced vital capacity remaining in the lung
FEF_{25-75}	Forced expiratory flow with 25-75% of the forced vital capacity remaining in the lung
FEV%	The ratio of forced expiratory volume in one second to forced vital capacity, presented as a percentage
FVC	Forced vital capacity
IFN	Interferon
Ig	Immunoglobulin
IL	Interleukin
MEF_{50}	Maximum expiratory flow with 50% of forced vital capacity remaining in the lung
MEF_{25}	Maximum expiratory flow with 25% of forced vital capacity remaining in the lung
MRC	Medical Research Council
NA	Not analysed
NHLBI	National Heart, Lung and Blood Institute
ODTS	Organic dust toxic syndrome
OR	Odds ratio
PAR	Population attributable risk
PEF	Peak expiratory flow
SD	Standard deviation
TLV	Threshold limit value
WHO	World Health Organization
WRS	Work-related respiratory symptoms

Abstract

The aim of this study was to assess the prevalence of chronic respiratory symptoms and spirometric lung function impairment among Finnish pig farmers in comparison to the population in general. The aim was also to analyse the associations of work environment and work practices in pig farming with respiratory symptoms and spirometric lung function. The data on chronic respiratory symptoms were obtained through a postal questionnaire from a random sample of pig farmers (n=383) living in Satakunta and from a random sample of the working-age Satakunta population (n=247). Two trained nurses performed the spirometries of 219 farmers during farm visits at 180 farms and that of 83 control subjects at local health care centres. The control subjects were matched to the farmers by grouping gender, age and smoking habits. The spirometry of the pig farmers was performed before and after a working shift in the swinery, and that of controls twice within two hours. The spirometric lung function measurements were repeated after a period of two years in 203 pig farmers and 72 control subjects in order to evaluate the progress of lung function impairment.

In the postal survey, the pig farmers (mean age 47.3 years) were slightly older than the control subjects (45.8 years), but the difference was not significant. There were more males among the pig farmers (71%) than among the controls (59%). Among the pig farmers there were less current smokers (11%) than among controls (30%). The main pig farming activity was piglet production or a combination with pigmeat production. The majority of the swineries had enclosed pens. Over half of the farms had entirely manual feeding systems and nearly half had entirely or partly manual manure removal. The number of animals varied from 26 to 1906 pigs.

The pig farmers had a higher prevalence of chronic bronchitis (16%) and work-related respiratory symptoms (48%) than the control subjects (9%, p=0.019, and 25%, p<0.001) despite fewer histories of smoking. Chronic bronchitis was defined as phlegm production on most days for at least three months in a year for at least two successive years concurrent with no physician-diagnosed asthma. Chronic bronchitis was associated with pig farming (OR 2.0, 95% CI 1.1-3.5), atopy (OR 1.6, 95% CI 1.0-2.7) and age (OR 1.03, 95% CI 1.00-1.06), analysed by multiple logistic regression including pig farming, age, sex, atopy and smoking. Among the pig farmers, the prevalence of chronic bronchitis was associated with a daily working time of 6 hours or more (OR 3.9, 95% CI 1.1-13.9)—the reference being less than three hours—and 20 or more working years (OR 3.3, 95% CI 1.4-7.8), with nine or less working-years as the reference. The type of farm, animal density or methods of feeding were not associated with chronic bronchitis. The prevalence of physician-diagnosed asthma and asthmatic symptoms were similar in the study groups. Symptoms referring to organic dust toxic syndrome or farmers' lung were rare among the pig farmers.

The pig farmers had better nonadjusted baseline FEV_1 and FVC than the controls (95% vs. 92% of predicted, p= 0.023, and 99% vs. 94% of predicted, p= 0.008, respectively). Changes in spirometric lung function across working shifts were small, and the changes observed in pig farmers did not differ from that of the control population. Pig farmers had an accelerated decline in FEV_1 and FVC over a two-year period compared with the control subjects when adjusted for age, smoking, atopy and across-shift change of FEV_1 (220 ml vs. 60 ml, p<0.001, and 310 ml vs. 130 ml, p<0.001, respectively).

Pig farmers continuing pig husbandry at the time of the second measurements did not differ considerably by age, sex or prevalence of chronic bronchitis from those (16%) changing the main farming activity or retiring during the two-year period. Those who had changed farming activity or retired had more work-related symptoms in the preceding year than farmers continuing pig husbandry (94% vs. 80%, p=0.045). Farmers discontinuing pig farming had also lower lung function (VC 93% vs. 99%, p=0.011, FEV_1 89% vs. 97%, p=0.006) and a higher proportion of obstruction (23% vs. 8%, p=0.006) than those continuing pig husbandry.

In conclusion, the prevalence of chronic bronchitis among Finnish pig farmers was two times higher than among the population in general. Pig farmers had nearly twice as much work-related symptoms than the general population as well as an accelerated decline in lung function within a period of two years. It was suggested that farmers staying in the profession were healthier than those discontinuing pig farming.

Lyhennelmä

Tutkimuksen tarkoituksena oli selvittää pitkäaikaisten hengityselinoireiden ja keuhkojen toimintahäiriön esiintymistä suomalaisilla sikatalouden harjoittajilla työikäiseen verrokkiväestöön verrattuna. Tutkimuksessa selvitettiin myös työympäristön ja työmenetelmien yhteyttä hengityselinoireisiin ja keuhkojen toimintakykyyn. Hengityselinoireiden esiintymistä tutkittiin kyselylomakkeella, joka postitettiin satunnaisille otoksille työikäisiä satakuntalaisia sikatalouden harjoittajia (n=383) ja vertailuhenkilöitä (n=247). Kaksi koulutettua tutkimushoitajaa suoritti spirometriamittaukset 219:lle sikatalouden harjoittajalle 180:n tilakäynnin yhteydessä. 83:n vertailuhenkilön spirometriamittaukset suoritettiin paikallisissa terveyskeskuksissa. Vertailuhenkilöt oli kaltaistettu sikataloudenharjoittajiin sukupuolen, iän ja tupakoinnin suhteen. Sikatilallisten spirometriamittaukset suoritettiin ennen ja jälkeen sikalatyövuoron. Tutkimushoitajat kirjasivat työolosuhteet ja -menetelmät. Vertailuhenkilöiden spirometriat mitattiin kahdesti, kahden tunnin välein. Tilakäynnit ja spirometriamittaukset toistettiin kahden vuoden kuluttua kullakin tutkittavalla samaan vuodenaikaan kuin ensimmäiset mittaukset. Toiseen mittauskertaan osallistui 203 sikatilallista ja 72 vertailuhenkilöä. Uusintatutkimuksen tavoitteena oli selvittää, tapahtuuko keuhkojen toimintakyvyssä pysyvämpiä muutoksia.

Kyselytutkimukseen osallistuneet sikatalouden harjoittajat olivat keski-iältään hieman vanhempia kuin vertailuhenkilöt (47,3 v ja 45,8 v), mutta ikäero ei ollut merkittävä. Sikatilallisten ryhmässä oli enemmän miehiä (71 %) kuin vertailuryhmässä (59 %). Sikatalouden harjoittajat tupakoivat vähemmän (11 %) kuin vertailuväestö (30 %). Sikatalouden yleisin tuotantomuoto oli porsastuotanto yksinään tai yhdistettynä lihasikojen kasvatukseen. Suurimmalla osalla sikaloista oli suljetut karsinat. Yli puolessa sikaloista ruokinta hoidettiin käsityönä ja lähes puolessa lannanpoisto tehtiin kokonaan tai osittain käsityönä. Tiloilla oli 26-1906 sikaa.

Sikatalouden harjoittajilla oli vähäisemmästä tupakoinnista huolimatta enemmän pitkäaikaista keuhkoputkitulehdusta (16 %) ja työhön liittyviä hengityselinoireita (48 %) kuin vertailuväestössä (9 %, p=0,019 ja 25 %, p <0,001). Vastaajalla katsottiin olevan pitkäaikainen keuhkoputkitulehdus, jos hänellä oli ollut päivittäistä tai lähes päivittäistä limannousua vähintään kolmen kuukauden ajan ainakin kahden peräkkäisen vuoden aikana eikä hänellä ollut samanaikaista lääkärin toteamaa astmaa. Pitkäaikaiseen keuhkoputkitulehdukseen liittyviä tekijöitä olivat sikatalouden harjoittaminen (OR 2,0, 95 % CI 1,1-3,5), atopia (OR 1,6, 95 % CI 1,0-2,7) ja ikä (OR 1,03, 95 % CI 1,00-1,06). Sikalatyössä pitkäaikaista keuhkoputkitulehdusta oli enemmän niillä, jotka työskentelivät sikalassa vähintään kuusi tuntia päivittäin (OR 3,9, 95 % CI 1,1-13,9) tai olivat harjoittaneet sikataloutta vähintään 20 vuotta (OR 3,3, 95 % CI 1,4-7,8). Sikalatyyppi, sikalan pinta-alaan suhteutettu eläinten määrä tai ruokintamenetelmät eivät olleet yhteydessä pitkäaikaisen keuhkoputkitulehduksen esiintymiseen. Lääkärin toteama astma ja astmaattiset oireet olivat yhtä yleisiä sikatalouden harjoittajilla ja vertailuhenkilöillä. Orgaanisten pö-

lyjen aiheuttamaan toksiseen oireyhtymään tai homepölykeuhkoon viittaavat oireet olivat harvinaisia sikatalouden harjoittajilla.

Sikatalouden harjoittajilla oli parempi lähtötilanteen FEV_1 ja FVC kuin verrokeilla (95 % vs. 92 % viitearvosta, p=0,023, ja 99 % vs. 94 % viitearvosta, p=0,008). Muutokset spirometria-arvoissa työvuoron aikana olivat pieniä, eivätkä ne eronneet vertailuryhmän kahden tunnin muutoksista. Kahden vuoden kuluessa FEV_1 ja FVC huononivat merkittävästi enemmän sikatalouden harjoittajilla kuin vertailuhenkilöillä (220 ml vs. 60 ml, p<0,001, ja 310 ml vs. 130 ml, p<0,001).

Niillä sikatalouden harjoittajilla (16 %), jotka vaihtoivat maatilan päätuotantosuuntaa tai jäivät eläkkeelle tutkimuskäyntien välisen kahden vuoden jakson aikana, oli edeltävän vuoden aikana enemmän työhön liittyviä oireita kuin niillä, jotka jatkoivat sikatalouden harjoittamista (94 % vs. 80 %, p=0,045). Sikatalouden lopettaneilla oli lisäksi huonompi lähtötilanteen keuhkojen toimintakyky kuin sikataloutta jatkavilla (VC 93 % vs. 99 %, p=0,011, FEV_1 89 % vs. 97 %, p=0,006).

Tässä tutkimuksessa todettiin, että suomalaisilla sikatalouden harjoittajilla oli pitkäaikaisen keuhkoputkitulehduksen oireita kaksi kertaa enemmän kuin vertailuväestössä. Työhön liittyvät hengityselinoireet olivat lähes kaksi kertaa yleisempiä sikatalouden harjoittajilla kuin vertailuhenkilöillä. Kahden vuoden aikana sikatalouden harjoittajien spirometria-arvot huononivat nopeammin kuin vertailuväestössä. Tutkimuksessa löytyi viitteitä siihen, että sikataloutta jatkavat olivat terveempiä kuin tuotantosuuntaa vaihtaneet.

1. Introduction

Agriculture is the seventh most common occupation today in Finland. In 1996, there were 94,114 active farms of which 5904 (6%) farms had pig husbandry as the main farming activity (Maatilarekisteri 1997). However, since 1995 the number of farms has fallen about 3% a year and even further in livestock production (Niemi and Ahlstedt 2005). In 2000, there were 4316 (5%) farms specialised in pig husbandry (Finfood 2005), concentrated in southern and western Finland.

Farmers are exposed to dusts and several types of gases in their working environment (Louhelainen 1997, Omland 2002). Dust is mainly composed of organic material from straw, hay, grain, animals, mites, and microorganisms. Of gases normally found in animal buildings, ammonia occurs most frequently in harmful concentrations (Kangas et al. 1987, Omland 2002). In swine confinement buildings, the two major constituents in total and respirable aerosol are grain particles and dried faecal material (Donham et al. 1986). Especially in piggeries, levels of airborne gases (Louhelainen 1997) and concentrations of total dust and endotoxins of gram negative bacteria (Schwartz et al. 1995) are higher than in other farms.

Among farmers, pig farmers have the highest risk of respiratory symptoms (Radon et al. 2002a). Harmful health effects are present even in modern, visibly cleaner facilities (Cormier et al. 2000). Possible etiological factors for increased risk of respiratory disease include organic dusts, micro-organisms and their endotoxins, and ammonia, which have been associated with respiratory symptoms and impaired lung function in epidemiological studies (Donham et al. 1989, Heederick et al. 1991, Reynolds et al. 1996, Vogelzang et al. 1998a). Thus far it is not clear which of these substances is responsible for the adverse health effects of the farming environment (Omland 2002). It is likely that the aetiology is multifactorial. Airway inflammation has been suggested as the main reason for the symptoms appearing after organic dust (Rylander 1994). Exposure to the swine confinement environment causes airway inflammation, which is present in the airways of pig farmers even with normal lung function (Pedersen et al. 1990, 1996).

In Finland, the high risk of occupational respiratory diseases among farmers is shown in the Finnish Registry of Occupational Diseases. The number of cases of respiratory diseases (occupational asthma, rhinitis, allergic alveolitis) in the agriculture and forestry sectors was the second highest after the food industry in 1996 (Karjalainen et al. 1997). Animal dander, especially cow dander, grain and flour dusts are etiologic factors in 60% of occupational asthma cases (Karjalainen et al. 2000). However, among farmers, chronic bronchitis is probably a greater problem than asthma (Monso et al. 2003). This is evident especially among pig farmers who, according to most studies, have an elevated prevalence of chronic bronchitis only and not of asthma (Donham 1993). Pig farmers seem to also have a higher risk for airflow obstruction than other farmers (Iversen 1992, Schwartz et al. 1995). Thus far chronic bronchitis and related symptoms are usually not defined as occupational diseases and thus not reported in the Finnish Registry of Occupational Diseases. The criteria for diagnosis of occupational chronic bronchitis have been suggested (Laasonen and Uitti 2001).

Interest for this study arose from clinical work as physicians encountered farmers with work-related respiratory symptoms not due to asthma. These cases address questions about the relevance of these symptoms in respect of the farmer's working capacity and respiratory health. In this study, respiratory symptoms, especially chronic bronchitis and related symptoms, and the spirometric lung function of pig farmers are studied in relation to their working environment and practices.

2. Review of the literature

2.1. Chronic bronchitis and chronic obstructive pulmonary disease

Chronic bronchitis is a clinical syndrome defined by chronic sputum production (American Thoracic Society 1962, World Health Organisation 1975) and occurs with or without airflow obstruction. Chronic obstructive pulmonary disease (COPD) is a disease state, characterised by a progressive airflow limitation that is not fully reversible and is associated with an abnormal inflammatory response of the lungs to noxious particles or gases (Pauwels et al. 2001). The risk of death from COPD is strongly correlated to the degree of airflow obstruction (Peto et al. 1983). Impaired lung function is highly associated with all cause mortality (Pelkonen et al. 2000). COPD accounts for increasing morbidity and mortality both worldwide and in Finland and is today the fifth leading cause of death worldwide (Pauwels et al. 2001).

The main etiological factor for chronic bronchitis and COPD is fumes from cigarette smoke (Fletcher et al. 1976, Huhti 1965, Huhti and Ikkala 1980). It is suggested that chronic bronchitis and development of airflow obstruction are independent responses to cigarette smoke occurring together due to the common factor of smoking (Fletcher et al. 1976, Peto et al.1983). It has been shown that the pattern of airway inflammation processes differs between smokers who develop chronic airflow obstruction and those who do not (O'Shaughnessy et al. 1997, Saetta et al. 1998). There is evidence that chronic bronchitis alone is not a harmless condition. Annesi and Kauffmann (1986) found that chronic mucus production was significantly related to an increased overall mortality. Further, according to Vestbo et al. (1996, 2002) chronic mucus hypersecretion is associated with an excessive FEV_1 decline. Chronic bronchitis alone identifies a population at risk for increased morbidity, while the presence of concomitant airflow obstruction is a factor of worsened prognosis (Levin and Griffith 1994). It has been shown that up to 35-50% of smokers develop COPD (Isoaho 1995, Lundbäck et al. 2003). There is a dose-dependent effect of smoking on lung function decline (Burrows et al. 1977, Xu et al. 1994). However, smoking cessation reduces the annual rate of decline in lung function to a non-smoking level (Fletcher et al. 1976, Anthonisen et al. 2002), also reducing the risk of COPD morbidity (Godtfredsen et al. 2002) and all cause mortality (Pelkonen et al. 2000, Doll et al. 2004).

Other factors shown to increase the risk of chronic bronchitis include occupational inorganic and organic agents (Levin and Griffith 1994, Burge 1994, ATS 2003), atopy

(Fletcher et al. 1976, Terho et al. 1987a, 1995) and a family history of obstructive airway disease (Lindström et al. 2001). Growing evidence is emerging from epidemiological studies suggesting that occupational exposures can also lead to clinically relevant chronic airflow limitation (Burge 1994, Hendrick 1996, Kennedy 1996, ATS 2003), although evidence includes conflicting elements (Hendrick 1996). Occupational exposure has been calculated to account for 10-20% of symptoms or lung function impairment of COPD (ATS 2003). Isoaho (1995) found that COPD was most common among those with low social status and a history of smoking and working in dusty occupations in the past. The same risk factors for COPD were found among middle-aged or elderly USA residents (Trupin et al. 2003).

Typical histological changes in smoking related chronic bronchitis are an increase in the number and size of submucosal gland cells and goblet cell hyperplasia in the surface epithelium (Reid 1954). Goblet cell appearance and hyperplasia in small airways contributes to small airway disease and the development of chronic obstruction (Cosio et al. 1980). In addition, chronic bronchitis is associated with an inflammation process of predominantly mononuclear cells (Salvato 1968, Mullen et al. 1985, Fournier et al. 1989, Saetta et al. 1993, O'Shaughnessy et al. 1997, Saetta et al. 1998). Smoking-induced inflammation is present in central airways (Mullen et al. 1985, Saetta et al. 1993), peripheral airways (Niewoehner et al. 1974, Cosio et al. 1980, Saetta et al. 1998), and lung parenchyma (Eidelman et al. 1990). The pattern of inflammation is different in smokers who develop chronic obstruction compared with smokers without obstruction. Smokers who develop COPD have an increased number of $CD8^+$ T-lymphocytes in both central and peripheral airways (O'Shaughnessy et al. 1997, Saetta et al. 1998). In severe COPD, airway inflammation is characterised by a prominent neutrophilia (Di Stefano et al. 1998).

2.1.1. Work-related bronchitis and chronic obstructive pulmonary disease

The symptoms and clinical findings in work-related bronchitis and in chronic obstructive pulmonary disease caused by occupational exposure are similar to those caused by smoking. Smoking is a widespread habit among industrial populations, which has delayed the recognition of other factors contributing to disease (Burge 1994). Exceptions to this are farmers, who smoke less than the population in general or non-farming control populations (Tammilehto et al. 1994, ATS 1998). Occupational factors may lead to chronic bronchitis and airway obstruction by promoting the deleterious effect of smoking or independently acting in a similar manner to tobacco smoking, requiring other promoting factors to have an effect (Burge 1994). Underestimating the risk of occupational exposures is enhanced by the "healthy worker effect": in jobs with a high risk of lung disease, a sector of the workforce with even better lung health than the general population is selected (Becklake and Lalloo 1990, Radon et al. 2002b). The selection may take place already at the time of hire or later during employment (Radon et al. 2002b). In a meta-analysis of occupational cohort studies of symptoms of chronic bronchitis, a significantly higher prevalence of chronic bronchitis was found for dropouts (pooled OR 1.2, 95% CI 1.0-1.4) compared with workers who remained under the studies (Radon et al. 2002b). Unless the healthy worker survivor effect is taken into account, the prevalence of respiratory symptoms among exposed workers may be underestimated (Radon et al. 2002b).

In population studies, exposure to occupational dusts and fumes has been shown to cause symptoms of chronic bronchitis and increase the risk of chronic obstructive pulmonary disease (Table 1). In a study of a random sample of the urban adult population in the United States, subjects exposed to occupational dust had adjusted relative odds for chronic respiratory symptoms (chronic cough, chronic phlegm, persistent wheeze, breathlessness) between 1.3 and 1.6 (Korn et al. 1987). For subjects with gas or fume exposure, the relative odds of symptoms ranged from 1.3 to 1.4. Occupational dust exposure was associated with a higher risk of chronic obstructive pulmonary disease (OR 1.5) when comparing exposed and unexposed subjects. Viegi et al. (1991) showed that work exposure in a rural Northern Italian population was associated significantly with a higher risk of chronic cough (OR 1.7) and chronic phlegm (OR 1.6) in men. Exposed men also had a higher risk of obstructive lung function decline (OR 1.4). In a random sample of the Norwegian general population, a history of occupational dust or gas exposure was associated with chronic cough and phlegm when coughing (OR 1.9) and asthma (1.8) (Bakke et al. 1991a). Bakke et al. (1991a) suggested that 11-19% (15% of phlegm with coughing) of the respiratory symptom load of the general population can be attributed to airborne occupational exposure. In a Chinese population, exposure to occupational dusts and gases/fumes were associated with chronic respiratory symptoms independent of smoking, gender, and each other (Xu et al. 1992). The estimated relative odds of chronic cough was 1.3 for dust and 1.2 for fumes and that of chronic phlegm 1.3 and 1.2, respectively. There was an increasing prevalence of symptoms with increasing dust and fume exposure. Dust exposure and increased gas/fume exposure levels were associated with lower levels of lung function compared to subjects without exposure. In the Zutphen study, Post and co-workers (1994) found that exposure to dust and solvents was significantly related to chronic non-specific lung disease, including episodes of chronic cough and phlegm or wheezing or a diagnosis of chronic non-specific lung disease by a clinical specialist. Being exposed to at least one agent resulted in an elevated relative risk of 1.5 compared to unexposed subjects. In a general population-based study of five areas in Spain, Sunyer et al. (1998) found that exposure to high levels of biological dust in young adults was associated with symptoms of chronic bronchitis and pulmonary ventilatory defects. However, in their analysis of complete data on young adults (aged 20-40 years) in 14 industrialised countries, Zock et al. (2001) found no association between occupational exposure and quantitative FEV_1 changes.

In longitudinal studies of general population samples, workers exposed to mineral dust (Kauffman et al. 1982, Bakke et al. 1991b), grain dust (Kauffman et al. 1982), sulphur dioxide gas and metal fumes (Humerfelt et al. 1993) or excess heat (Kauffman et al. 1982, Krzyzanowski et al. 1988) were at increased risk of accelerated decline in lung function, which for FEV_1 was approximately 55-60 ml/year (Humerfelt et al. 1993, Kauffman et al. 1982). The adjusted decline in FEV_1 has been shown to increase progressively in subjects exposed to increasing numbers of occupational agents (Humerfelt et al. 1993).

Trupin et al. (2003) estimated the occupational burden of COPD in a telephone interview study of a randomly selected sample of over 2000 USA residents aged 55-75 years. Occupational exposure during the longest-held job was determined by self-reported exposure to vapour, gas, dust or fumes and through a job exposure matrix. In this matrix, specific occupations were categorised as having a low, intermediate or high probability of dust exposure. COPD was defined by self-reported physician's diagnosis. Trupin and co-workers (2003) found that past occupational exposures significantly increased the likelihood of COPD. Self-reported occupational exposure was associated with a two-fold increase in risk of COPD (OR 2.0, 95% CI 1.6-2.5), resulting in an adjusted population attributable risk (PAR) of 20% (95% CI 13%-27%). According to the job exposure matrix, the risk of COPD was elevated for those with intermediate (OR 1.4, 95% CI 1.1-1.9) and high probabilities of dust exposure (OR 1.6, 95% CI 1.1-2.5). The combined PAR for intermediate or high probability exposure was 9% (95% CI 3%-15%). Trupin et al. (2003) found an interaction between smoking and occupational exposures, which seemed to be greater than strictly additive. The known association of low socio-economic status and COPD was obvious in this study. Those reporting COPD had lower levels of education and lower household incomes overall compared with subjects reporting asthma alone or no chronic airway disease. The great effect of COPD on work disability was also clearly supported by the findings of this study. Only 19% of respondents reporting COPD were employed at the time of their interview compared with 30% and 31% among respondents reporting asthma alone and no chronic airways disease, respectively.

In a study of a case-control design, Mastrangelo et al. (2003) showed a significant risk of chronic obstructive pulmonary disease (COPD) in occupations involving exposure to organic dust and gas/vapour. They compared the data of occupational and clinical histories of cases (COPD) and control subjects (other diseases) admitted to their Institute of Occupational Medicine. Past exposure was assessed by occupation, exposure assigned by a job-exposure matrix, and years spent in a given occupation. The risk of COPD in different occupations was estimated with respect to a control group (office workers) among whom there were no cases of occupational COPD. The risk of COPD was highest (age-smoking-adjusted OR 8.9, 95% CI 2.3-34.3) in workers exposed to biological dust, intermediate (OR 5.8, 95% CI 1.8-18.6) in workers exposed to gas/vapours/fumes and lowest (OR 3.8, 95% CI 1.2-12.0) in those exposed to mineral dust. The age-smoking-adjusted risk for COPD, estimated in different occupations, was highest in farmers (OR 15.1, 95% CI 3.2-71.6). Significant risk for COPD was also found in cotton workers (OR 7.2, 95% CI 1.3-41.1), welders (OR 6.4, 95% CI 1.6-25.5), painters (OR 4.7, 95% CI 1.3-16.4), foundry workers (OR 12.1, 95% CI 1.3-108.0), refractory brick workers (OR 6.5, 95% CI 1.14-37.0) and construction workers (OR 3.1, 95% CI 1.0-9.5). Farmers, cotton textile workers, welders and painters represented a significant increase (6-9%) in COPD risk for each extra year of work, which indicates an exposure-effect relationship.

To conclude, there is mounting evidence from population studies that exposure to occupational dusts and fumes increases the risk of chronic bronchitis and COPD. One of the most important occupational agents in this respect seems to be organic dust. The role of occupational agents in the development of chronic bronchitis and COPD, however, has been underestimated for several reasons.

Table 1. *The risk of work-related chronic respiratory symptoms or diseases in studies of the general population.*

Study	N	Chronic respiratory symptom or disease		Lung function	
		Definition	Work-related OR[1] (95% CI)	Criteria	Work-related OR[1] (95% CI) and/or agent associated with obstruction
Kauffman et al. 1982, France	556			Accelerated decline in FEV_1 (follow-up of 12 yrs)	Mineral and grain dust, heat
Korn et al. 1987, USA	8515	Chronic cough, chronic phlegm[2]	Cough 1.3 (1.1-1.5), phlegm 1.4 (1.2-1.6) for dust	$FEV_1/FVC < 0.6$	1.5 (1.2-2.0), dust
Krzyzanowski et al. 1988, Poland	1679			Accelerated decline in FEV_1 (follow-up of 13 yrs)	Prolonged, continuing exposure to variable temperature
Krzyzanowski et al. 1990, Poland	2730	Chronic bronchitis (ATS)	2.6 (1.5-4.6) (men 41–50 yrs), 2.1 (1.3-3.4) (women) for dust		
Bakke et al. 1991a,b, Norway	4469 (a), 714 (b)	Chronic cough[2], phlegm when coughing	Cough 1.8 (1.4-2.2), phlegm 1.9 (1.6-2.2) for dust or gas	$FEV_1/FVC < 0.7$ and $FEV_1 < 80\%$ pred	1.4 (0.3-5.2) for high degree of airborne exposure; in aged >50: 2.8 (1.1.-7.3) for asbestos, 3.7 (1.2-11.0) for quartz
Humerfelt et al. 1993, Norway	1933			Accelerated decline in FEV_1 (follow-up of 20 yrs)	Sulphur dioxide gas, metal fumes, numbers of specific agents
Viegi et al. 1991, Italy	1635	Chronic cough[2], chronic phlegm[2] for ≥2 yrs	Cough 1.7 (1.2-2.4), phlegm 1.6 (1.1-2.4) in men	$FEV_1/FVC\% < 70$	1.4 (1.0-2.0) in men
Xu et al. 1992, China	3606	Chronic cough or phlegm[2], breathlessness or persistent wheeze	1.3 (1.1-1.5) for dust, 1.3 (1.1-1.5) for gases/fumes	Pulmonary function compared with unexposed	Dust exposure a significant predictor of FEV_1, FEV_1/FVC and $FEF_{25-75.}$
Post et al. 1994, Netherlands	878	Chronic nonspesific lung disease (asthma, COPD)	1.5 (1.1-1.9) for at least one exposure (dust, fume or solvents)		
Sunyer et al. 1998	1735	Cough, phlegm[2]	Cough 1.9 (1.0-3.7), phlegm 2.0 (1.1-3.8) for biological dust	Decrease in FEV_1,FEF_{25-75} (ref. unexposed)	151 ml for FEV_1, 478 ml for FEF_{25-75}

1 adjusted for age, gender and smoking

2 >3 months/year

2.1.2. Chronic bronchitis among industrial and mine workers

The earliest evidence of work-related bronchitis was shown among coal workers. Higgins et al. (1959) noticed that current or former coal workers had more chronic respiratory symptoms and worse lung function, independent of smoking, than workers with no dust exposure. Oxman et al. (1993) reviewed the most valid studies available on workers exposed to inorganic occupational dust. Thirteen reports of coal workers and gold miners fulfilled their inclusion criteria. They concluded that occupational dust is an important cause of chronic bronchitis and clinically important losses of lung function in both smokers and non-smokers. The risk of COPD was greater for gold miners than for coal miners, probably due to the higher silica content in gold mine dust. The studies showed a significant association between loss of lung function and cumulative respirable exposure.

Workers exposed to welding fumes have been shown to have symptoms of chronic bronchitis twice or three times as often as other workers (Cotes et al. 1989, Bradshaw et al. 1998, Erkinjuntti-Pekkanen et al. 1999). Among these workers, the risk of loss of lung function has been demonstrated in smokers and ex-smokers (Cotes et al. 1989, Özdemir et al. 1995, Erkinjuntti-Pekkanen et al. 1999). Erkinjuntti-Pekkanen et al. (1999) found a significant association between acute across-shift change and the annual decline in FEV_1. The same kind of association has been found in studies among cotton (Christiani et al. 1994, Glindmeyer et al. 1994) and agricultural workers (Schwartz et al. 1995).

Workers exposed to organic dust have an increased risk of work-related respiratory symptoms, chronic bronchitis and pulmonary ventilatory defects (Simpson et al. 1998, Sunyer et al. 1998, Mastrangelo et al. 2003). Besides agriculture, exposure to organic dust occurs in the wood and textile industries. Wood dust may cause various pulmonary diseases, of which the most common are simple chronic bronchitis and non-asthmatic chronic airflow obstruction (Enarson and Chang-Yeung 1990). Mandryk et al. (1999, 2000) found that woodworkers and sawmill workers had a significantly higher prevalence of respiratory symptoms and significantly lower mean percentage predicted lung function compared with controls. Changes in lung function were correlated with work-related respiratory symptoms (Mandryk et al. 1999, Mandryk et al. 2000) and with personal exposure (Mandryk et al. 2000).

Cotton textile workers have more symptoms of chronic bronchitis than controls, independent of smoking (Christiani et al. 1994, Niven et al. 1997). Niven et al. (1997) found that the risk of chronic bronchitis associated with cotton dust exposure was more marked in workers over 45 years of age (OR 2.5) and showed a significant association between cumulative exposure to cotton dust and chronic bronchitis. In cotton workers, longitudinal changes in pulmonary function are associated with the diagnosis of chronic bronchitis (Niven et al. 1997), cotton dust exposure (Glindmeyer et al. 1994, Christiani et al. 2001), high levels of exposure to endotoxin (Christiani et al. 2001) and across-shift drops in FEV_1 (Glindmeyer et al. 1994, Christiani et al. 2001).

The data of studies on different industries is comparable with population studies, and further supports evidence that exposure to occupational dusts, especially organic dust, increases the risk of chronic bronchitis and COPD. The association of acute cross-shift changes and long-term effects found in welders and textile workers refers to the role of airway hyperreactivity and host factors in COPD. However, it is not clear whether the acute responses are always the cause of chronic response or are independently related to exposure, or whether both mechanisms are operative (Becklake 1994).

2.1.3. Chronic bronchitis among farmers

Epidemiological studies on farming populations have shown that chronic bronchitis and related symptoms are common (Table 2). The prevalence of chronic bronchitis among farmers ranges between 4% to 34% (Katila 1979, Dosman et al. 1987, Vohlonen et al. 1987, Terho et al. 1987b, Iversen et al. 1988, Tammilehto et al. 1994, Melbostad et al. 1997, Danuser et al. 2001) depending on farming type, smoking and atopy. The prevalence depends also on the varying definitions of chronic bronchitis used (Table 2). In an epidemiological survey of Finnish farmers, the prevalence of chronic bronchitis was 7.9% (Tammilehto et al. 1994). In the same study, the odds ratio for chronic bronchitis among farmers was 1.5 (1.1-2.0). In a large cross-sectional study of prevalence and regional risk factors for respiratory symptoms in European and Californian farmers, the prevalence of chronic bronchitis in non-smoking European farmers was 10% (Monso et al. 2003). Prevalence rates in most studies are higher among farmers than non-farming control subjects (Saia et al. 1984, Dosman et al. 1987, Dalphin et al. 1989, 1998, Cormier et al. 1991, Carvalheiro et al. 1995) or the general population in the same area (Radon et al. 2002a). In a sample of dairy farmers, the adjusted odds ratio for chronic bronchitis was 11.8 (Dalphin et al. 1998). The effect of exposure on chronic bronchitis and related symptoms was greater than or of the same magnitude as that of smoking. The excess of asthma or related symptoms was weak and nonsignificant. In the European farming population, chronic bronchitis is probably a greater problem than asthma (Saia et al. 1984, Terho 1990, Dalphin et al. 1998, Monso et al. 2003). In contrast, in a five-year survey of USA farmers, Brackbill and co-workers (1994) did not find any elevated prevalence of chronic respiratory diseases compared to other USA workers. Similar results were found in a cross-sectional study of a sample of farmers in England and Wales, where the prevalence of chronic bronchitis did not differ between farmers and controls working in industries in the same areas (Heller et al. 1986)

The causative role of the agricultural environment for chronic bronchitis is further suggested by incidence studies. The annual incidence rate for chronic bronchitis among Finnish farmers is 202/10,000, which is three times higher among farming subjects than non-farmers (Terho 1990).

2.1.4. Chronic bronchitis among pig farmers

Excesses of chronic bronchitis or related symptoms among pig farmers have been found in several studies in different countries (Table 3). Donham and colleagues (1984a) found that swine producers working inside confinement buildings had a significantly higher prevalence of chronic bronchitis and wheezing (OR 7 and 4, respectively) than nonconfinement swine producers. In their later study, nearly 20% of swine confinement workers reported chronic cough, and 25% reported phlegm (Donham et al. 1990). Both symptoms were significantly more prevalent among confinement workers than in a blue-

Table 2. *The prevalence of chronic bronchitis in general and dairy farming compared with the non-farming population.*

		Chronic bronchitis		
Study	N	Criteria	Prevalence and/or OR (95% CI)[1]	Factors associated with increased risk
Farming				
Saia et al. 1984, Italy	2,932	ATS[2] and significant FEV_1 reduction	10% vs. 5%	Small farms and traditional cowhouses
Dosman et al. 1987, Canada	1,824	As with WHO[3] but consecutive months	11% vs. 8%	
Vohlonen et al. 1987, Finland	12,056	ATS[2]	8% in livestock production, 6% in grain production	Swine tending (13%), methods of grain handling and drying
Iversen et al. 1988, Denmark	1,175	Cough and phlegm on most days	24%	Age: OR 2.5 (1. 8-3.5), smoking: OR 2.4 (1.7-3.3), pig farming: OR: 1.5 (1.1-2.1)
Tammilehto et al. 1994, Finland	3,237	WHO[3]	8% vs. 7%, OR 1.5 (1.1-2.0)	Dairy farming 9%, pig farming 8%; in pig farming work-related phlegm: OR 1.5 (1.1-2.3) and cough: OR 1.3 (1.1.-1.7)
Vergnenegre et al. 1995, France	1,122	ATS[2]	8%	
Melbostad et al. 1997, Norway	10,792	Cough and phlegm for ≥3 months/year during the last 2 years	8%	Full-time farming: OR 1.3 (1.1-1.6), livestock production: OR 1.3 (1.0-1.6), dusty occupation outside farming: OR 1.3 (1.1-1.6), current smoking: OR 2.5 (2.1-3.0)
Danuser et al. 2001, Switzerland	1,542	Phlegm on most days ≥3 months each year	16%	Crop farming: OR 2.3 (1.0-5.2), age >60 years: OR 2.4 (1.4-4.0), former smoker: OR 1.6 (1.0-2.5), >4 hr in animal confinement: OR 2.6 (1.0-6.8)

Radon et al. 2002a, Europe	7,752	Cough and phlegm on most days ≥3 months during the preceeding year	10%	Pig farmers at highest risk of work-related respiratory symptoms (WRS), a dose response relationship between daily hours and WRS
Dairy farming				
Katila 1979, Finland	325	Phlegm for ≥2 years	34% vs. 14% in men, 13% vs. 8% in women	Harmful effect of farming dusts more marked in smokers than in non-smokers
Dalphin et al. 1989, France	250	ATS[2]	12% vs. 6%. OR: 2.1 (1.1-4.1)	Age of >40 years: OR 3.1(1.3-8.0)
Dalphin et al. 1993a, France	5,703	ATS[2]	9%	Male sex: OR 1.6 (1.3-2.0), age: OR 2.8 (1.7-4.6) in age of 30-39 years (ref. <30 years), smoking: OR 5.0 (4.0-6.3), altitude
Dalphin et al. 1998, France	265	ATS[2]	17% vs. 1%. OR 11.8 (1.4-97.1); chronic cough 12% vs. 4%, chronic phlegm 14% vs. 2%	Smoking and farming had a synergistic effect for chronic cough
Chaudemanche et al. 2003, France	215	ATS[2]	7% vs. 2%; chronic cough:16% vs. 8%, chronic phlegm: 16% vs. 10%	Smoking significantly influenced chronic bronchitis and related symptoms

1 adjusted for age, sex and smoking

2 ATS: cough and phlegm on most days for at least three months per year during at least two consecutive years

3 WHO: daily phlegm for at least three months per year during at least two years

collar comparison group, but only phlegm was more prevalent compared to nonconfinement farmers. The prevalence of three or more symptoms of bronchitis was higher in Swedish swine producers (34%) than that of welders (17%) (Wilhelmsson et al. 1989). Heederick et al. (1991) showed an elevated prevalence of chronic cough, sputum and wheezing in pig farmers compared to workers in other industries. Iversen and co-workers (1988) showed that pig farming was a risk factor for asthma (OR 2.0), chronic bronchitis (OR 1.5) and wheezing during work (OR 3.3) among Danish farmers. However, in their further study, Iversen and Pedersen (1990) found that in pig farming, wheezing, shortness of breath and dry cough during work occurred more often than symptoms of chronic bronchitis, and they suggested that symptoms of chronic bronchitis are not sufficient to explain work-related respiratory symptoms in farmers. Dalphin et al. (1993b) found no relationship between chronic bronchitis and exposure in a study of French male dairy farmers. Chronic bronchitis occurred most frequently in farmers with previous episodes of acute lung reactions after organic dust exposure in the work environment. A similar association between chronic bronchitis and acute effects of organic dust has been reported in European farmers (Monso et al. 2003). These studies suggest that chronic bronchitis is related to organic dust toxic syndrome (ODTS).

2.1.5. Other risk factors associated with chronic bronchitis among farmers

Besides pig farming, factors associated with the risk of chronic bronchitis in the farming population are age (Iversen et al. 1988, Dalphin et al. 1989, 1993a, Melbostad et al. 1997), atopy and smoking (Katila 1979, Terho et al. 1987a, Terho 1990, Melbostad et al. 1997). However, Vogelzang et al. (1999a) did not find an association between atopy in childhood and chronic bronchitis among Dutch pig farmers.

In a study of Danish farmers, Iversen et al. (1988) found that the prevalence of chronic bronchitis increased from 18% in 31-50-year-old farmers to 33% in 51-70-year-old farmers. In French dairy farmers, chronic bronchitis was more common in patients aged over 40 years (8% vs. 17%) (Dalphin et al. 1989). Age reflects the duration of exposure, since most farmers have worked in farming since their youth. In contrast, Donham et al. (1984a) did not find any correlation between duration of exposure and length of time that symptoms had been experienced. However, in the majority of cases, chronic symptoms were reported within 2 years after the beginning of confinement work. Cormier and co-workers (1991) showed that workers who spent more than 3 hours daily in swine confinement buildings had a higher prevalence of chronic bronchitis (22% versus 13%) than those with shorter daily contact. In a sample of farm workers in Swedish swine confinement buildings, the increased frequency of symptoms of chronic bronchitis was related both to the number of years and percentage of the day spent working with swine (Donham et al. 1989)

Other factors found to be associated with increased risk of chronic bronchitis in the farming population are small farms and traditional cowhouses (Saia et al. 1984), work inside confinement buildings (Donham et al. 1984a, Cormier et al. 1991, Monso et al. 2003) and greenhouses (Monso et al. 2003), and methods of grain handling and drying (Vohlonen et al. 1987).

In a study of Norwegian farmers, Melbostad et al. (1997) found that full-time farming, livestock production and dust exposure outside agriculture were risk factors for chronic bronchitis and related symptoms, as well as current smoking. A combination of work exposure factors and smoking enhanced the risk from 2- to 6-fold. The effect of smoking seems to be additive to the occurrence of chronic bronchitis in farming work (Donham et al. 1984a, Donham et al. 1990, Terho et al. 1987a, Dalphin et al. 1998). Wilhelmsson et al. (1989) found a positive interaction between smoking habits and exposure in swine confinement buildings. Exposure had a strong influence on the number of respiratory symptoms in smokers but not in never-smokers. Dalphin et al. (1998) found the combined effect of farming and smoking to be more than additive (synergistic) on chronic cough, but larger samples might have revealed a significant synergistic effect also for other symptoms (chronic bronchitis and related).

Erkinjuntti-Pekkanen (1996) found chronic bronchitis to be twice as prevalent among patients with previous clinically diagnosed farmer's lung disease and their matched control farmers examined clinically (about 20%) than among all control farmers (about 10%). Most subjects with chronic bronchitis were non-smokers. Despite a possible self-selection bias, Erkinjuntti-Pekkanen concluded that farmer's lung might be an additional risk factor for the development of chronic bronchitis. A strong positive relation between chronic bronchitis and clinical farmer's lung has also been reported among French farmers (Dalphin et al. 1993a).

Host factors seem to have an important role in the genesis of chronic bronchitis in farming populations. Terho et al. (1987a) found that both the prevalence and incidence of chronic bronchitis among atopic farmers were approximately twice that of nonatopic farmers. This finding was confirmed in a cross-sectional and longitudinal study of a Finnish twin cohort, which showed that atopy predisposes the development of chronic bronchitis in the non-farming population as well (Terho et al. 1995).

In conclusion, the data of epidemiological studies carried out in several countries show that chronic bronchitis and related symptoms are more common among farmers than non-farming populations. Pig farming seems to be associated with a higher risk of chronic bronchitis than with other types of farming.

Table 3. *The prevalence of chronic bronchitis in pig farming compared with the non-farming population.*

Study	N	Chronic bronchitis Criteria	Prevalence and/or OR (95% CI)[1]	Factors associated with increased risk
Donham et al. 1984a, USA	24 out of 2,459	Chronic episodic cough with phlegm	29% in confinement vs. 4% in nonconfinement workers (OR 7.0)	Symptoms within 2 years after beginning of work; smoking had an additive effect with exposure
Bongers et al. 1987, Netherlands	174	Daily cough >3 months/year, daily phlegm >3 months/year	Cough: 10%, phlegm 5%	Pig breeding: chronic phlegm 12%; 28% of pig farmers had WRS
Dosman et al. 1988, Canada	504	As with WHO[3] but consecutive months	13% vs. 8%	
Wilhelmsson et al. 1989, Sweden	209	≥3 yes answers to any of the respiratory symptom questions	34% vs. 17% in welders	Smoking, accumulated exposure in 1 year, a positive interaction between these
Donham et al. 1990, USA	207	Usual cough for 3 months, usual phlegm for 3 months	Cough: 20% vs. 7%, phlegm 25% vs. 10%	87% of confinement workers had WRS; smoking had an additive effect with exposure
Iversen and Pedersen 1990, Denmark	124	MRC criteria	24% vs. 19% in dairy farmers (n.s.)	39% of pig farmers had WRS vs. 5% of dairy farmers
Cormier et al. 1991, Canada	488	ATS[2]	17% vs. 12%	Working time >3 h/d (22% vs. 13%)
Heederick et al. 1991, Netherlands	183	Daily cough >3 months/year, daily phlegm >3 months/year	Cough: 16%, phlegm 12%	WRS 52%
Vogelzang et al. 1996, Netherlands	1 432	Productive cough on most days >3 months/year during the last 2 years	14%	Prevalence of one or more chronic respiratory symtoms associated with >2 pig houses, natural ventilation, mechanical feeding, use of bedding
Vogelzang et al. 1999a, Netherlands	239	Productive cough on most days >3 months/year during the last 2 years	15% vs. 4%	

[1] adjusted for age, sex and smoking

[2] ATS: cough and phlegm on most days for at least three months per year during at least two consecutive years

[3] WHO: daily phlegm for at least three months per year during at least two years

2.2. Pulmonary function in farmers

Cross-sectional epidemiological studies among farmers have shown that farming is a risk factor for chronic airflow limitation (Saia et al. 1984, Dosman et al. 1987, Iversen 1989, Dalphin et al. 1989, Iversen and Pedersen 1990, Vergnenegre et al. 1995, Melbostad et al. 1997, Dalphin et al. 1998, Chaudemanche et al. 2003). These findings were confirmed in a study of a case-control design, where Mastrangelo et al. (2003) found that farmers had the highest risk (OR 15.1, 95% CI 3.2-71.6) of chronic obstructive pulmonary disease among 16 occupational groups studied.

Dosman et al. (1987) found that farmers in Saskatchewan had significantly lower values for forced vital capacity (FVC), forced expired volume in one second (FEV_1) and maximum mid-expiratory flow rate than nonfarming rural control subjects. Danish farmers who reported asthma, wheezing, shortness of breath, or dry cough had severe airway obstruction with an increased residual volume, whereas symptomless farmers had normal lung function (Iversen et al. 1989). Farmers with symptoms related to chronic bronchitis were not included in this study. The number of years in pig farming was associated with a low FEV_1. The results in the study of Iversen et al. (1989) also suggested that farmers have increased bronchial reactivity. In a more detailed cross sectional study of Danish pig and dairy farmers, Iversen and Pedersen (1990) found that pig farmers had a slightly lower FEV_1 than dairy farmers, and that symptomatic farmers had significantly lower FEV_1 than symptomless farmers which confirmed his earlier findings. They showed that there was an additional decline in FEV_1 associated with pig farming (12 ml/year) and smoking (23 ml/pack year) in addition to the age-related decline of 32 ml/year. In French dairy farmers, all respiratory function parameters measured were lower in farmers than in administrative worker-controls, matched in regard to sex, age, height, and smoking habits (Dalphin et al. 1989). The differences between the two groups were more marked in patients aged 40 years and over and in non-smokers. Vergnenegre et al. (1995) showed in a cross-sectional study of French farmers and spouses that the prevalence of distal airway obstruction (11.4%) was higher than that of chronic bronchitis (7.7%). Distal airway obstruction was assessed from the forced expiratory flow between 25% and 75% of vital capacity (FEF_{25-75}). The odds ratio for distal airway obstruction was 2.1 in subjects >50 years old compared with younger subjects and 3.0 in the smaller farms compared with larger ones. In a cross-sectional study of Norwegian farmers and spouses, Melbostad and co-workers (1997) found that chronic bronchitis was a risk factor for airway obstruction for both non-smokers (OR 2.8) and smokers (OR 8.5) over the age of 50 years. Finnish farmers with clinically-diagnosed farmer's lung developed airway obstructions more often than control farmers (33% versus 17%, p=0.01) during a follow-up time of mean 14 years (Erkinjuntti-Pekkanen 1996). In these patients, airway obstruction was associated with emphysematous changes on high-resolution computed tomography (HRCT). In a longitudinal study of French dairy farmers and non-farming controls, farming was associated with an accelerated decline in expiratory flows (Chaudemanche et al. 2003).

2.2.1. *Pulmonary function in pig farmers*

The risk of obstructive lung function values among pig farmers has been shown in several studies (Brouwer et al. 1986, Dosman et al. 1988, Schwartz et al. 1995, Senthilselvan et al. 1997a, Vogelzang et al. 1998a, Iversen and Pedersen 1990, Iversen and Dahl 2000). Clinically significant lung function decrements have been found in 15-20% of pig farm workers (Brouwer et al. 1986, Dosman et al. 1988). Brouwer et al. (1986) found the prevalence of abnormal values significant compared to the European Community of Coal and Steel normal values. Breeders had the lowest pulmonary function values, but the differences between the groups (pig fattening, pig breeding, both breeding and fattening) were not significant. In a study by Dosman et al. (1988), 15-20% of swine producers had values of FVC and FEV_1 of 85% predicted or less (depending on age), which was a significantly greater percentage in all age categories than that of nonfarming control subjects. Their results were suggestive of restrictive disease or a mixed restrictive/ obstructive condition in swine producing farmers. In a follow-up study of two years, Schwartz and colleagues (1995) found that longitudinal declines in lung function were independently related to cross-shift declines in lung function, higher concentrations of endotoxin present in the bioaerosol, and working in the swine confinement setting. In a 7-year follow-up study of Danish farmers, Iversen and Dahl (2000) confirmed their earlier finding that working in swine confinement units causes an accelerated decline (mean additional decline 17 ml/year) in FEV_1. This was not found in FVC, in contrast to previous Canadian and Dutch studies (Senthilselvan et al. 1997a, Vogelzang et al. 1998a). Canadian swine confinement workers had an excess annual decline of 26.1 ml in FEV_1 and 33.5 ml in FVC over non-farming control subjects (Senthilselvan et al. 1997a). Dutch pig farmers had an excess decline in FEV_1 of 10-70 ml/year, depending on endotoxin exposure (Vogelzang et al. 1998a). The excess decline in FEV_1 due to pig farming corresponds to approximately 0.5 l during a working life, meaning that some farmers will develop clinically significant airway obstruction before the age of sixty (Iversen and Dahl 2000). Smoking would aggravate this further. Schwartz et al. (1992) found that symptomatic swine confinement workers had significant elevations of residual volume in the absence of spirometric alterations, suggesting that early airway injury may not be readily apparent using only spirometric measures of lung function.

The present knowledge indicates that farming is a risk factor not only for symptoms of chronic bronchitis but also for declining values in spirometry. In most studies, abnormal lung function is of an obstructive nature. However, some studies suggest a restrictive impairment as well. The lengthy follow-up studies in Danish and Canadian pig farmers show that the excess decline of FEV_1 related to pig farming may lead to a clinically significant airway obstruction, as in COPD.

2.2.2. *Across-shift changes in lung function among pig farmers*

Declines in lung function across a working shift or workday in a swine confinement building have been reported in several studies (Donham et al. 1984b, 1989, 1995, Schwartz et al. 1995, Cormier et al. 2000, Radon et al. 2000). Donham et al. (1984b) showed significant decreases in spirometric values ranging from 3.3% (mean FVC) to 11.9% (mean FEF_{25-75}) over a 4-hour work period in swine confinement. According to Donham and co-workers (1995) acute responses are influenced by chronic (6 years or more) exposure. They found a much higher correlation of exposure with cross-shift change in pulmonary functions after 6 years of exposure than after shorter durations. Exposure to total dust, respirable dust, ammonia, and respirable endotoxins had a positive correlation with changes in pulmonary function over a work period. Smoking seems to have an additive relationship with exposure on decline in lung function (Donham et al. 1984b, 1995). In a study of Swedish swine confinement workers, Donham et al. (1989) found a dose-response relation between work period changes in FEV_1 and area total endotoxin levels. Nearly 50% of the workers experienced a decrement in FEV_1 and FVC over their work period, but the mean value was small and insignificant. Small but significant decrements in pulmonary function over the working shift were seen in FEF_{50} (6%) and FEF_{75} (4.3%) but only in smokers. Schwartz et al. (1995) found that swine confinement operators tended to have greater working shift declines in FEV_1, FVC, and mid-expiratory flow (FEF_{25-75}) than neighbourhood farmer controls. They showed that acute declines in airflow across the working shift and higher concentrations of endotoxin in the bioaerosol were associated with accelerated declines in airflow during the follow-up of approximately 2 years. Their results indicated that acute airway responses are predictive of chronic changes in lung function. Radon et al. (2000) showed that the lung function decline during the morning feeding period persisted throughout the workday.

Acute across-shift changes in the lung function of pig farmers may be related to bronchial hyperreactivity. Several studies have suggested that farmers in general (Iversen et al. 1989, Iversen and Pedersen 1990, Choudat et al. 1994, Carvalheiro et al. 1995) and especially swine confinement workers (Schwartz et al 1992, Bessette et al. 1993, Iversen and Pedersen 1990) have increased bronchial reactivity. In a study of a group of Dutch pig farmers, Vogelzang and co-workers (1997) found that the prevalence of mild bronchial responsiveness increased with the number of working years. However, Cormier et al. (2000) found that in healthy volunteers decrements in FEV_1 and FVC after a 4-hour exposure in a swine confinement building were not associated with significant differences in airway responsiveness. Further, in a 7-year follow-up study, Iversen and Dahl (2000) did not find any significant difference in bronchial reactivity between pig and dairy farmers nor any increase during the follow-up period.

2.3. Other respiratory diseases in farmers

2.3.1. Asthma and atopy

Asthma is a chronic disease whose main characteristics are variable airflow obstruction, bronchial hyperresponsiveness, and airflow inflammation (Busse and Lemanske 2001). The international definition of asthma by Global Strategy for Asthma Management and Prevention Report highlights the role of airway inflammation, which causes recurrent episodes of wheezing, breathlessness, chest tightness and cough in susceptible individuals.

The symptoms are associated with variable airflow obstruction that is at least partly reversible, either spontaneously or with treatment (NHLBI/WHO 1995).

Atopy is defined as a personal or familiar tendency to produce immunoglobulin E (IgE) antibodies in response to a low dose of allergens, and to develop typical symptoms such as asthma, rhinoconjunctivitis, or eczema/dermatitis (Johansson et al. 2001). Atopy is closely related to asthma in Finnish adults (Karjalainen 2003). A farm environment during childhood has been found to protect against asthma and atopic disorders in children (Braun-Fahrländer et al. 1999, Riedler et al. 2000, von Ehrenstein et al. 2000) and in young adults (Kilpeläinen 2001, Pekkanen et al. 2001). Animal husbandry in adulthood may also provide protection against pet- and pollen-induced upper airway symptoms (Koskela et al. 2003). On the other hand, studies in Dutch pig farmers have suggested disinfectant use as a risk factor for atopic sensitisation and symptoms consistent with asthma (Preller et al. 1996, Vogelzang et al. 1999a).

Occupational factors are more strongly associated with adult-onset asthma than have been previously assumed (Kogevinas et al. 1999, Karjalainen 2003). This is most clearly seen in agricultural, manufacturing and service work. In a 12-year follow-up survey of the employed Finnish population, Karjalainen et al. (2001) estimated the attributable fraction of work-related factors in adult-onset persistent asthma to be 29% for men and 17% for women. The age-adjusted relative risk of incident asthma was highest in agricultural occupations, 2.1 (95% CI 2.0-2.3) in men and 1.8 (95% CI 1.8-1.9) in women. In a large population-based study on occupational asthma in 12 industrialised countries, Kogevinas et al. (1999) found that farmers had the highest risk of asthma (OR 2.6, 95% CI 1.3-5.3). Among the adult population of New Zealand, farmers and farmworkers had the highest risk of asthma (OR 4.2, 95% CI 1.3-13.1 for the combination of wheezing and bronchial hyperresponsiveness) (Fishwick et al. 1997). Among female agricultural workers in Sweden, namely poultry and dairy farmers, the annual self-reporting rate of occupational asthma was among the highest (Toren 1996). Occupational asthma in the agriculture sector is more common in Finland (2.7 cases/1000 workers) than in Sweden (0.6) or Denmark (0.6) (Nordiska ministerrådet 1996).

A large number of substances, mainly of animal protein or plant origin, can cause occupational asthma in agriculture (Venables and Chang-Yeung 1997). Cow dander, flour/grain dust and storage mites cause most cases of Finnish farmers' occupational asthma (Karjalainen et al. 2000, Iivonen 2001).

Despite farming being a risk factor for adult-onset asthma, the prevalence of asthma among Finnish farmers is no higher than among the rest of the population. In a large epidemiological survey of Finnish farmers, the prevalence of self-reported asthma and atopy did not differ between farmers and non-farming controls (Tammilehto et al. 1994). The prevalence of atopy and asthma were 32% and 4% among farmers and 36% and 5% among non-farming controls. The adjusted odds ratio for asthma among farmers was 0.9 (95% CI 0.6-1.3), which was lower than other respiratory diseases (chronic bronchitis, organic dust toxic syndrome) or respiratory symptoms. The prevalence for asthma was not associated with the type of farming. Iversen et al. (1988) found asthma in 8% of Danish farmers. In their study, both age and pig farming were risk factors for self-reported asthma with an odds ratio of 5.8 (95% CI 2.8-12.2) and 2.0 (95% CI 1.2-3.5), respectively. In the study of Melbostad et al. (1998), the lifetime prevalence of self-reported asthma among the Norwegian farming population was 6%. Their results showed interaction between genetic factors and exposure from animal production in the aetiology of asthma. In French dairy farmers, the prevalence of self-reported asthma did not differ from that of control subjects (5% and 3%, respectively, OR 2.0, 95% CI 0.6-6.1) (Dalphin et al. 1998). However, elderly French farmers were found to have a higher prevalence of cumulative (9%) and current asthma (6%) with odds ratio of 2.3 (95% CI 1.0-5.5) and 5.3 (95% CI 1.3-21.5), respectively, compared with white-collar workers (Nejjari et al. 1996). In a large cross-sectional survey of European and Californian farmers, the prevalence of rhinitis and asthma were lower in European (13% and 3%) than in Californian farmers (24% and 5%) (Monso et al. 2003). Asthma was related to poultry farming and flower growing. Terho (1990) has estimated the annual incidence of asthma among Finnish farmers at 3.5/1000, which is much lower than that of chronic bronchitis (20/1000).

Iversen and co-workers (1988) were the first to report that pig farming is a risk factor not only for chronic bronchitis but also for self-reported asthma. In their study among Danish farmers, the prevalence of asthma increased from 5% in dairy farmers to 11% in pig farmers, with an odds ratio of 2.0 for pig farming. This finding has not been confirmed elsewhere. Despite the abundance of environmental factors which predispose to asthma, most studies among pig farmers report an elevated prevalence of chronic bronchitis only, but not of asthma (Donham 1993, Tammilehto et al. 1994, Vogelzang et al. 1999a). Dutch pig farmers reported an elevated prevalence of chronic bronchitis (20% versus 8%), but not of asthma (6% versus 5% for chest tightness) compared with their rural controls (Vogelzang et al. 1999a). Atopy in childhood was strongly associated with the prevalence of asthma symptoms among both pig farmers and controls. The authors suggested that a health-based selection of nonasthmatics for pig farming explains the absence of an elevated prevalence of asthma symptoms. Radon and co-workers (2002a) found a high risk of work-related asthma-like syndrome but not allergic asthma among European pig farmers. An asthma-like syndrome was defined as a self-limited inflammatory event with symptoms of shortness of breath, cough without phlegm and wheezing. Symptomatic pig farmers had significant lung function decline after a working period in confinement buildings, which according to the authors may be related to the asthma-like syndrome.

Interestingly, the farming environment includes several factors associated with adult-onset asthma. On the other hand, living in this same environment has been suggested to have a protective effect against asthma and atopy at least in childhood and in young adulthood, and perhaps also in older age. In most studies, asthma prevalence is not higher among farmers than nonfarming controls. One explanation for this could be health-based selections and/or the protective effect of the farming environment on atopy.

2.3.2. Farmer's lung

Farmer's lung is a form of extrinsic allergic alveolitis caused by the inhalation of mouldy hay or straw. There is an immunologically mediated inflammation of the lung parenchyma and bronchioles as a result of inhaled antigens (Zejda and Dosman 1993). Respiratory symptoms may last several years after the diagnosis of farmer's lung (Mönkäre and Haahtela 1987). Long-term consequences are the permanent impairment of pulmonary diffusing capacity and in some cases airway obstruction (Mönkäre and Haahtela 1987, Erkinjuntti-Pekkanen 1996). The main long-term radiological sequel is an increased risk of emphysema, even among lifetime non-smokers (Erkinjuntti-Pekkanen 1996). Farmer's lung is the most common form of allergic alveolitis in Finland (Karjalainen et al. 1997) and is more common in non-smokers than smokers (Terho et al. 1987b). In pig farming it occurs far less frequently than in other types of farming, especially dairy farming (Tammilehto et al. 1994).

Farmer's lung is associated with daily exposure over several weeks to high concentrations of airborne spores released from baled hay and straw (Kotimaa 1990, Malmberg et al. 1993). The combination of baled hay for feeding and straw as bedding material causes the highest microbial concentration found in farm work (Kotimaa 1990). The peak incidence of farmer's lung occurs in late spring at the end of the indoor feeding period of cattle (Terho et al. 1987c). During storage, both qualitative and quantitative changes occur in the microbial content of hay and straw (Kotimaa et al. 1987), which is one explanation for the increased risk of farmer's lung in spring. Storage drying of hay decreases the spore content compared with baled hay without storage drying or hay dried on the ground (Kotimaa 1990).

The prevalence of allergic alveolitis among the agricultural population is uncertain due to diagnostic limitations of epidemiological studies. In Finland, the prevalence among dairy farmers has been between 1% and 3% (Terho 1990, Tammilehto et al. 1994). Elsewhere a prevalence of about 1% (Saia et al. 1984, Dalphin et al. 1993a) has been reported.

2.3.3. Organic dust toxic syndrome

Organic dust toxic syndrome (ODTS) is a febrile illness caused by inhaled exposure to different organic dusts. It has been proposed to rename ODTS and other febrile responses to inhaled agents (for example metal fume fever, humidifier fever) as inhalation fever (Rask-Andersen and Pratt 1992) or toxic pneumonitis for its pathology which causes reduced alveo-capillary diffusion (Rylander 1994). The nature of ODTS is benign but symptoms may be severe, dominated by fever and chills. Other typical symptoms are myalgias, cough, headache, and chest discomfort (Rask-Andersen 1995). Unlike hypersensitivity pneumonitis, ODTS may occur even in nonsensitized subjects not previously exposed. Thus no allergy mechanisms are involved (Rask-Andersen 1995).

In farmers, ODTS is usually provoked by handling grain, cleaning grain or hay storage areas or grain or hay driers (Rask-Andersen 1989, Husman et al. 1990). Other exposures precipitating ODTS include hay, straw, wood chips, and silo capping material (Rask-Andersen 1989). The known etiologic components of organic dust causing ODTS are bacterial endotoxins and high concentrations of moulds (Rylander 1994). ODTS is usually associated with extreme exposure occurring in a single day, whereas allergic alveolitis occurs after an exposure period of weeks (Malmberg et al. 1993). In ODTS, symptoms begin after a latent interval approximately 4-8 hours after exposure, and are resolved 24-48 hours after termination of exposure (Rask-Andersen 1995). In general, ODTS causes no permanent impairment in lung function. There is some evidence that ODTS may be a risk factor in chronic bronchitis (Dalphin et al. 1993b, Monso et al. 2003).

ODTS is common in farmers, with an incidence 30-50 times higher than that of allergic alveolitis (Malmberg et al 1988). In Sweden, 6-19% (Malmberg et al. 1985, 1988), in Finland, 10-15% (Husman et al. 1990, Tammilehto et al. 1994) and in United States, 36% of farmers (Von Essen et al. 1999) have experienced febrile attacks. In a Swedish study of 76 non-smoking farmers, Carvalheiro and co-workers (1995) found that 25% of vegetable/grain or swine farmers, 10% of other farmers, and <5% of urban controls reported symptoms consistent with ODTS. In Finnish male farmers, ODTS was most common in crop farmers of whom 19% had had ODTS symptoms, while 15% of pig farmers and 10% of dairy farmers reported ODTS (Tammilehto et al. 1994). In an earlier Finnish study, ODTS was more often related to cattle tending (14%) than pig farming (8.5%) (Husman et al. 1990). In a United States study, both swine confinement farmers (34%) and non-confinement farmers (42%) commonly reported episodes of ODTS (Donham et al. 1990). Grain handling was the main source of symptoms in both groups, but the swine confinement building was also a very significant source of the syndrome. In another US study, Von Essen et al. (1999) found that farmers working in swine confinement were almost twice as likely to report ODTS symptoms compared to those who did not work in swine confinement (OR 2.0, 95% CI 1.1-3.4). They found a strong significant association between ODTS and cough or chest tightness after handling grain. Monso and co-workers (2003) found that ODTS was more prevalent in European (12%) than in Californian farmers (3%).

The prevalence values of ODTS depend on the definition used. In earlier Swedish studies, the definition was strict, requiring not only fever and chills related to work, but symptoms severe enough to make work difficult or require bed rest (Malmberg et al. 1985, 1988). Carvalheiro et al. (1995) and Von Essen et al. (1999) used a less strict definition, including symptoms not requiring bed rest or work impairment. Vogelzang et al. (1999b) have compared both definitions in a Dutch study of pig farmers and rural non-agricultural controls. By the strict definition, only 6% of the pig farmers had ODTS. Using the broader definition, 26% of the pig farmers met the criteria of ODTS, but 17% of the controls did as well. There is no golden standard for the definition of ODTS in epidemiological surveys. The prevalence of ODTS might be overestimated when using a broader definition.

2.4. Associations of respiratory symptoms and lung function impairment with exposure

Donham et al. (1977) was among the first to report hazardous concentrations of gases in swine confinement buildings. They also found that a high percentage of dust measured in confinement units was of respirable size. In their preliminary study, over half of swine confinement workers suffered adverse respiratory symptoms. These findings have been later confirmed (Donham and Popendorf 1985, Donham et al. 1986, Attwood et al. 1987). Swinehouse dust contains bacteria, fungi and actinomycetes as well as proteolytic enzymes, thus containing multiple suspected allergenic and other biological potential (Donham et al. 1986). Concentrations of airborne dust, endotoxin, bacteria and ammonia within swine confinement buildings are commonly at levels where adverse health effects have been observed (Attwood et al. 1987). It has been shown that swine confinement workers have far greater exposure to total dust and endotoxin than other farmers (Schwartz et al. 1995).

Respiratory symptoms among swine workers are associated with respirable dust, total dust, endotoxin in total dust and gram-negative bacteria in the air of the work environment (Donham et al. 1989, Attwood et al. 1987, Heederick et al. 1991). However, contrasting results have also been found (Preller et al. 1995a). Endotoxin exposure is related to changes in FEV_1 over a work period (Donham et al 1989, Donham et al. 1995, Reynolds et al. 1996), to the baseline pulmonary function (Heederick et al. 1991, Zejda et al. 1994), and to longitudinal declines in lung function (Schwartz et al. 1995, Vogelzang et al. 1998a). Exposure to total dust, respirable dust and ammonia has a positive correlation with changes in pulmonary function over work periods (Donham et al. 1995, Reynolds et al. 1996). Preller et al. (1995a) found that ammonia exposure was significantly associated with baseline lung function, but the association between exposure to endotoxins and baseline lung function was only borderline. They were the first to report that the use of disinfectants has potential respiratory health effects among pig farmers, and later confirmed that use of quaternary ammonium compounds as disinfectants was associated with mild bronchial hyperresponsiveness (Vogelzang et al. 1997) and with a longitudinal decline in FEV_1 (Vogelzang et al. 1998b).

Exposure to grain dust is associated with ODTS, asthma, chronic bronchitis, and chronic airflow limitation (Zejda et al. 1993a). Other biological constituents of grain dust such as endotoxins, storage mites and moulds can cause respiratory disorders (Zejda et al. 1993a, Rylander 1997). Inhalation of grain dust is associated with nonimmunological and immunological responses of the lower respiratory tract (Zejda et al. 1993a). In farmers, acute exposure to grain dust during harvest causes acute bronchitis, and may contribute to the presence of chronic alveolitis found during late postharvest bronchoscopies with a bronchoalveolar lavage (Von Essen et al. 1990). Moderate grain dust exposure not causing acute airflow obstruction can result in changes of several inflammatory parameters in peripheral blood and chronic airflow obstruction (Borm et al. 1996). Longitudinal studies have shown that exposure to grain dust is associated with long-term deterioration of lung function with simultaneous changes in FEV_1 and FVC (Zejda et al 1993a). The predominant pattern of pulmonary function decline seems to be restrictive but not obstructive (Zejda et al 1993a). However, in a cross-sectional Canadian study of a rural population, Manfreda et al. (1989) found no association between symptoms and exposure to grain or farming category. They did find a large number of former farmers with worsened lung function, which related more to farming than to grain exposure. The probable explanation of inconsistent results is that farmers are exposed to grain dust intermittently, less frequently and at lower concentrations than grain elevator workers (Manfreda et al. 1989).

Airway inflammation has been suggested as the major reason for symptoms appearing after organic dust exposure (Rylander 1994). Symptomatic swine confinement workers have a thickening of the epithelial basement membrane of the lobar bronchi when compared to either neighbourhood farmers or blue collar workers (Schwartz et al. 1992). Pedersen et al. (1990, 1996) have shown that non-smoking pig farmers with normal lung function have macroscopic signs of bronchial wall inflammation and increased numbers of neutrophils in the bronchoalveolar lavage fluid (BAL), and their alveolar macrophages have signs of activation. In contrast, Schwartz et al. (1992) did not find any alteration in BAL fluid cellularity between swine confinement workers and controls. Larsson et al. (1994, 1997) and Palmberg et al. (2002) have shown that acute exposure to the swine confinement environment among previously unexposed healthy non-smoking subjects induces an intense inflammatory reaction in the airways characterised by a dramatic increase in neutrophils. Chronic exposure may lead to adaptation mechanisms in pig farmers, since the inflammatory response to an acute exposure in a swine confinement building is greater in nonfarming subjects than in pig farmers (Palmberg et al. 2002, Von Essen and Romberg 2003).

Pig farmers are sensitised to many of the agents that they are exposed to during their work, but no single antigen seems to be of special importance (Katila et al. 1981). Iversen (1992) found that the majority of pig farmers with work-related respiratory symptoms had no allergy, and allergy to pig proteins rarely occurred. The pig farmers have been shown to have IgG responses to feed and pig antigens (Brouwer et al. 1986, Virtanen et al. 1990, Crook et al. 1991, Larsson et al. 1992), but the IgG response has not been related to respiratory symptoms (Crook et al. 1991) or lung function (Brouwer et al. 1986).

In conclusion, pig farmers are exposed to various substances which can cause harmful health effects. These include organic dusts, microorganisms and their endotoxins, and ammonia, which have been associated with respiratory symptoms and impaired lung function in epidemiological studies. Thus far it is not clear which of these substances is responsible for the negative health effects of the pig farming environment (Omland 2002). It is likely that the aetiology is multifactorial. Exposure is associated with bronchial hyperreactivity and respiratory tract and systemic inflammation. The inflammatory reaction, however, seems to be more intense in subjects with no prior exposure than in pig farmers. Thus, chronic exposure probably leads to adaptation or tolerance mechanisms.

2.5. Prevention

Farm environments include several agents hazardous to a farmer's respiratory health. A combination of preventative measures is needed in order to prevent work-related illnesses in farming (Bauer and Coppolo 1993). These include ventilation controls, optimal use of personal protective equipment, and an awareness of proper work practices.

Optimal ventilation systems provide an environment which maintains animal health and productivity, minimises the adverse health effects of dusts and fumes on the farmer, and protects the building and equipment from corrosion and physical damage (Wathes et al. 1983). However, ventilation designs are rarely concerned with farmers' health (Bauer and Coppolo 1993, Louhelainen 1997). Louhelainen found severe defects in the planning and construction of ventilation systems in Finnish dairy barns. Humidity values exceeded recommended levels in several buildings. He stated that the supply air should be warmed in wintertime to maintain temperature and air velocities inside the animal house within the recommended values. Increasing airflow can increase ammonia emission in piggeries and broiler houses by increasing air movement around the manure surface (Gustafsson 1988). Dynamic insulation (a breathing ceiling) for inlet air combined with exhausts in the manure channels is the most effective means of ventilation designed to remove air pollutants (Gustafsson 1993). In Finnish dairy barns, the level of ammonia was lower with ventilation through manure channels compared with ventilation systems with other types of air exhaust (Linnainmaa et al. 1993). Further, in swine confinement houses, air exhausted through the pit is associated with a lower exposure to endotoxin (Preller et al. 1995b). The importance of ventilation for the prevention of lung function impairment is confirmed by the studies of Radon et al. (2000, 2001) which demonstrated that air outlets in the wall (Radon et al. 2000) and a low standard of ventilation control (Radon et al. 2001) were associated with decreased lung function.

Respirators suitable for agriculture are disposable filtering facepieces, reusable quarter-masks or half-masks, and powered respirators, where a powered unit blows filtered air to a face piece. Respiratory protectors used in agriculture should be approved by the European Union. The Ministry of Labour demands that respirators available in Finland fulfil regulations. There are several standards for testing different types of respirators. The air-purifying capacity of the filtering mechanism in the respirator is classified in three categories for particulate exposure. P1 has the lowest filtering capacity, and can be used to protect from irritating dusts. P2 filters protect from solid and liquid particles with health risks, and P3 has the best protective capacity, also filtering toxic solid and liquid particles, bacteria and viruses. Filters for gases are divided into four types (A, B, E, and K) according to the gas to be filtered and into three categories depending on protection effectiveness. Several models of respirators provide comfortable and effective protection for agricultural workers in their routine tasks (Manninen et al. 1988). Powered respirators are more comfortable to use than other masks due to their lower breathing resistance (Manninen et al. 1988). However, agricultural workers rated the powered helmets as worst for weight and convenience in a study of respirator protection and acceptability of four classes of respirators (Popendorf et al. 1995). Thus, the reusable quarter-mask or half mask is most often the best compromise for respirators (Popendorf et al. 1995). Powered respirator helmets equipped with type P2 filters provide protection against farmer's lung, which is, however, not absolute (Nuutinen et al. 1987, Erkinjuntti-Pekkanen 1996). The same respirator type protects farmers with occupational atopic asthma (Taivainen et al. 1998). However, Müller-Wening and Neuhauss (1998) have shown in challenge tests that the protective effect of these devices is not absolute. It has been demonstrated that personal respirator devices have filter- and face-seal leakage (Lacey et al. 1982, Manninen et al. 1988, Pickrell et al. 1995). However, Dosman et al. (2000) have shown that a properly fitted disposable half mask can significantly reduce the acute negative health effects of exposure in a swine barn environment.

In Finland, the use of dust respirators has increased from a quarter of farmers in 1979 (Virolainen et al. 1987) to approximately 61% of farmers in 1992 (Susitaival 1994). According to telephone interviews with active farmers in 1992, 10% of farmers having respiratory protectors used them nearly always during feeding in confinement buildings, 13% during grain grinding, and 17% during pesticide handling (Susitaival 1994). Thirteen percent of farmers did not use a respirator regularly in any work task. Finnish farmers with previous clinically-diagnosed farmer's lung used an efficient (half-mask or powered dust respirator helmet) personal dust respirator more often than the matched control farmers (55% versus 10%) (Erkinjuntti-Pekkanen 1996). Farmers with farmer's lung had used the respirator significantly more often in all tasks on the farm than control farmers. The use of respirators was more regular among those farmers who had the lowest pulmonary function values.

In a cross-sectional study of farmers with a history of ODTS symptoms, Von Essen et al. (1999) found a strong association between ODTS history and occasional or frequent use of a respirator while working in grain bins (OR 3.4, 95% CI 1.6-7.1 and OR 3.9, 95% CI 1.6-9.4, respectively). For farmers using respirators in swine confinement buildings, a positive correlation was found between ODTS history and farmers who "sometimes" used a respirator compared to those never using respirators (OR 3.4, 95% CI, 1.5-7.7) (Von Essen et al. 1999). In a cross-sectional survey of Zejda et al. (1993b) 30% of swine producers usually used a dust mask when working inside a barn. The respiratory health (symptoms and lung function) of farmers using a dust mask did not differ significantly from those not using one. However, those swine producers who wear dust masks for preventive purposes had better respiratory health than those who began to wear protection because of pre-existing respiratory symptoms or those who did not use personal respiratory protection at all. In order to assess the effect of personal respiratory protection, individual reasons for beginning dust mask usage should be examined (Zejda et al. 1993b).

The high levels of airborne contaminants present in the swine confinement building and the exposure time of the farmer can be reduced by changing work practices. Airborne dust concentrations can be reduced by decreasing the number of pigs in nursery and farrowing units (Attwood et al. 1987) or by spraying a mixture of water and rapeseed oil or canola oil inside the swinery (Takai et al. 1993, Senthilselvan et al. 1997b). Automating the feeding system reduces working time inside the confinement building. However, automatic dry feeding systems are associated with high dust levels, chronic symptoms and bronchial reactivity (Vogelzang et al. 1996, 1997). The use of wet feeding systems has been advised (Attwood et al. 1987, Vogelzang et al. 1997). The use of wood-shavings as bedding material is associated with chronic respiratory symptoms and bronchial reactivity, and their use is discouraged (Vogelzang et al. 1996, 1997). In newer on-site composting swineries, pigs are raised on an enclosed compost bed. Louhelainen et al. (2001) has shown that a farmer's exposure to ammonia and sulphur compounds in a well-functioning compost swine building is lower than in traditional swineries. However, airborne concentrations of microorganisms in compost swine buildings are higher than in swineries with traditional slatted-floor pit systems (Rautiala et al. 2003). The use of personal respirators is strongly recommended during work in composting swineries, especially during the turning of the compost bed (Rautiala et al. 2003).

3. Aims of the study

The aim of this study was to evaluate the respiratory health of Finnish pig farmers compared to the population in general.

The detailed objectives of the study were:

1. To evaluate the repeatability and validity of the questionnaire used in this study.
2. To investigate the prevalence and type of chronic respiratory symptoms in Finnish pig farmers and to compare symptom patterns with the population in general.
3. To compare the spirometric lung function of pig farmers with the population in general.
4. To analyse the associations of work environment and work practices in pig husbandry with respiratory symptoms and spirometric lung function.
5. To evaluate the changes in prevalence of chronic respiratory symptoms and spirometric lung function in pig farmers over two years.

4. Study design

The present study was conducted in Satakunta, a district in southwestern Finland, where the main occupations are agriculture and industry. Finnish pig husbandry is concentrated in western and southwestern Finland. In the Satakunta area, there were approximately 600 pigmeat producing farms with at least 100 pigs in 1996. The following study protocols were approved by the Ethics Committee of the Tampere University Hospital.

4.1. Questionnaire study

The prevalence and type of chronic respiratory symptoms among pig farmers in the Satakunta area and among the population in general in the same area was investigated by a respiratory symptom questionnaire. The questionnaire was mailed in June 1996 with a cover letter and a postage-paid return envelope. Those who did not respond in three weeks received up to two reminders to complete and return the questionnaire.

4.2. Spirometry study

Two qualified study nurses measured the spirometric lung function of pig farmers and control subjects twice, with an interval of two years. Spirometries of the pig farmers were measured during farm visits and those of the control subjects at local health care centres. The study nurses visited farms for the first time between February and September 1997. The re-visit was done in 1999, when each farm was visited in the same month as the first visit. During the farm visits, the nurses interviewed the study subjects about their history of respiratory symptoms during the last 12 months and within a work shift, and collected information about the working environment and work tasks in the swinery. The nurses measured spirometry before and after a work period in the swinery. Those using respiratory protectors during their work shift were visited twice in both years. During the latter visit, the work shift was done without the respiratory protector.

Spirometries of the control subjects were measured in seven health care centres of Satakunta district and in Satalinna Hospital during the study periods in 1997 and 1999. The same study nurses who visited the farms did the measurements. The spirometry of each control subject was measured twice in an interval of two hours.

5. Subjects and methods

5.1. Study populations

A sample of 400 farmers in Satakunta district engaged in pig husbandry in farms of at least 100 pigs was randomly selected from the registry of the Ministry of Agriculture and Forestry. In 1996, there were 531 such farms with the age of the registered farmer being ≤ 65 years. The registry of the Ministry of Agriculture and Forestry provides information on the owners of the farms, who are mainly males. Supplementary information on other active workers in the farms, usually spouses or other family members, was provided by the questionnaire replies of the original sample of farmers. These reported active workers were also included in the study population.

For the control group, 400 subjects between the ages of 18-65 years living in the Satakunta district were randomly selected from the registry of the Population Register Centre. The control group represented the population of Satakunta in general, including farmers.

Two hundred and seventy-two of the original sample of 400 pig farmers, 113 of 177 spouses and family members and 248 of 400 control subjects returned the questionnaire. The response rate was 68% among the original sample of pig farmers, 64% among spouses and other family members and 62% among the control group (Table 4).

We asked all farmers (including spouses and family members) who returned the questionnaire to participate in the spirometry study. Of these 385 farmers, 219 (57%) in 180 farms participated. Eight of these were excluded from the analyses because of technically unacceptable flow-volume curves or technical problems with the spirometer. For the second spirometry measurement after a period of two years 203 farmers, of whom 34 (17%) were retired or had ceased pig husbandry participated (Table 4).

For spirometries of the control subjects, 100 subjects were selected from the controls answering the respiratory symptom questionnaire. Group matching was done by dividing the farmers and the control subjects into strata on the basis of gender, age (≤39, 40-49, ≥50 years) and smoking habits (0, <6, ≥6 pack years) at the time of the questionnaire reply. The controls were randomly selected within the strata in an approximate ratio of 2 controls: 5 farmers. If the invited control subject refused to participate, a vice-control was randomly invited from those not yet invited within the same stratum or from another stratum (three subjects) with the same sex and closest to age and smoking habits. Thirty-seven (37%) persons refused to have spirometric measurements taken. However, 31 similar control subjects were found as replacements. Of these vice-controls 10 persons refused, for whom four similar vice-controls were found. Finally, five invited persons did not visit the study place on the planned day. Altogether, spirometries were measured in 83 control subjects. Seventy-two control subjects participated in the second spirometry measurement (Table 4).

Table 4. *Number of participants in the questionnaire and spirometry studies.*

Study phase	Pig farmers			Control subjects
	Farm owners	Family members	Total	
1. Questionnaire study				
Mailed questionnaires	400	177	577	400
Respondents[1]	272 (68%)	113 (64%)	385 (67%)	248 (62%)
Address unknown				3
Nonrespondents	128	64	192	149
2. Spirometry study				
First measurement	156 (57%)[2]	63 (56%)[2]	219 (57%)[2]	83 (83%)
Excluded	5	3	8	0
Second measurement	145 (93%)[3]	58 (92%)[3]	203 (93%)[3]	72 (87%)[3]
Excluded	0	0		0

1 including two respondents among pig farmers and one among controls with unfilled questionnaire form (not included in any analysis)

2 per cent of those participating in the questionnaire study

3 per cent of those participating in first spirometric measurements

5.1.1. Study populations in the questionnaire study

The characteristics of the study groups are shown in Table 5. The groups were similar in age but differed significantly by sex, state of employment, smoking habits and atopy. Two-thirds of pig farmers were male, while in the control group sex distribution was even. The control subjects were more often retired (19%) or unemployed (16%) than the pig farmers (4% and 1%, respectively). There were fewer current smokers among pig farmers (10%) than among the control group (30%). Pig farmers had less atopy (34%) than control subjects (44%).

The pig farmers had worked for a mean of 18 years (range 0-45 years) in swine confinement buildings. The mean duration of working time in swineries was 4.5 hours per day (0-11 hours). Nearly two-thirds of the pig farmers (61%) used a personal dust respirator. More than half (57%) of those using dust respirators had a half-mask or powered dust respirator. The main work tasks for which personal dust respirators were nearly always used were feeding (27%), cleaning the swine building (36%) and cleaning grain silos (29%).

Table 5. *Characteristics of the study populations in the questionnaire study.*

Variable	Pig farmers (n=383)	Control subjects (n=247)
Mean age in years, (range)	47.3 (21-70)	45.8 (20-65)
Sex, n (male) (%)	271 (71)	145 (59)
Employment, n (%)		
Working	360 (94)	146 (59)
Retired	15 (4)	47 (19)
Unemployed	3 (1)	38 (16)
Other reason for not working	5 (1)	16 (6)
Duration of current work, years (SD)	22.6 (12.1)	15.5 (10.2)
Smoking history, n (%)		
Non-smokers	241 (63)	110 (45)
Ex-smokers	99 (26)	62 (25)
Current smokers	40 (10)	73 (30)
Pack-years, mean (range)	4.7 (0-75)	8.0 (0-150)
Atopy, n (%)	126 (34)	105 (44)

5.1.2. Characteristics of respondents versus non-respondents

When comparing responding pig farmers with those not responding, information on the source population available in 1996 from the registry of the Ministry of Agriculture and Forestry (age, sex, production, number of pigs) was used. Additional information (change of main farming activity or owner of the farm) was provided by updated information from the year 2000 in the registry of the Ministry of Agriculture and Forestry.

Responding and non-responding pig farmers were similar in age and gender. The mean age (SD) for responding pig farmers was 48.3 (9.4) years and 46.7 (9.5) years for non-responding pig farmers. Of the responding pig farmers 257 (95%) were men and 13 (5%) were women. Among non-responding pig farmers there were 121 (93%) men and 9 (7%) women. The selected features of the farms of responding and non-responding pig farmers are given in Table 6. In 1996, both groups had a similar number of farms with pig husbandry or dairy cattle as the main operation line. The pig husbandry farms had a similar number of animals. The farms of respondents had less beef cattle and more other (special plant production, organic production) main operation lines than those of non-respondents. In the period between the questionnaire study and the year following the second farm visit, the number of farms with pig husbandry as the main farm operation had increased equally in both groups (Table 6). The number of farmers with no production or who were retired was the same in both groups. The number of animals was equal on active farms of both responding and non-responding farmers.

Table 6. *Selected features of pig farms in 1996 and 2000, comparing respondents with non-respondents. Information acquired from the registry of the Ministry of Agriculture and Forestry.*

Feature of farm	In 1996		In 2000	
	Responding farms (n=270)	Non-responding farms (n=130)	Responding farms (n=269)	Non-responding farms (n=130)
Main farming activity, n (%)				
Pig husbandry	88 (33)	39 (30)	193 (72)	94 (72)
Dairy cattle	124 (46)	53 (41)	4 (1)	0 (0)
Beef cattle	21 (8)	23 (18)	2 (1)	0 (0)
Grain production	27 (10)	15 (12)	35 (13)	20 (15)
Other	10 (4)	0 (0)	14 (5)	5 (4)
No production or retired, n (%)			21 (8)	11 (8)
Number of pigs, mean (SD), (range)	275 (189), (100-1940)	260 (158), (100-1003)	229 (278), (0-1472)	241 (316), (0-2194)
Change of owner, n (%)			33 (12)	13 (10)

In the comparison of respondent and non-respondent control subjects, basic information given by the registry of the Population Register Centre (age, sex, and profession) was used. Social class was defined by the profession according to Classification of socio-economic groups (Statistics Finland 1989).

The characteristics of respondent and non-respondent control subjects are given in Table 7. The groups of responding and non-responding control subjects were similar in age but differed by gender and social class. The response rate was higher among women (71%) than among men (57%). There were more clerical personnel and students and less workers in the responding group.

Table 7. *Characteristics of respondent and non-respondent control subjects by age, gender and social class.*

Variable	Respondents (n=247)	Non-respondents (n=153)
Mean age in years (SD)	45.8 (12.3)	45.7 (12.1)
Sex, n (male) (%)	145 (59)	110 (72)
Social class, n (%)		
Farmers	11 (4)	5 (3)
Entrepreneurs	8 (3)	7 (5)
White-collar employees	80 (32)	39 (25)
Workers	112 (45)	78 (51)
Students	12 (5)	2 (1)
Retired	8 (3)	3 (2)
Other (housewives, unemployed)	4 (2)	1 (1)
Unknown	12 (5)	18 (12)

5.1.3. Study populations in the spirometry study

The farmers with farm visits and spirometric measurements and the control subjects with spirometries were similar in age, gender and atopic status (Table 8). The groups differed by smoking status; among pig farmers there were more ex-smokers and less current smokers than among the controls. However, the groups did not differ by smoking history defined as pack-years.

Two hundred and eleven farmers (55% of the farmers responding to the questionnaire) had farm visits with spirometric lung function measurements. They were slightly younger than farmers who refused visits, but the groups were similar in gender, duration of work, smoking history and history of respiratory symptoms. The farms visited were larger than those not visited. (Table 9).

Table 8. *Characteristics of farmers and control subjects with spirometric lung function measurements.*

Variable	Pig farmers (n=211)	Controls (n=83)
Mean age in years (range)	46.3 (24-65)	47.8 (27-66)
Sex, n (male) (%)	155 (73)	60 (72)
Smoking history, n (%)		
Non-smokers	129 (62)	49 (59)
Ex-smokers	56 (27)	12 (14)
Current smokers	23 (11)	22 (26)
Pack-years, mean (range)	4.5 (0-70)	5.7 (0-62)
Atopy, n (%)	69 (34)	34 (42)

Table 9. *Characteristics of pig farmers with farm visits and pig farmers who refused a farm visit with selected features of their pig husbandry.*

Variable	Pig farmers with farm visits (n=211)	Pig farmers without farm visit (n=172)
Mean age in years (range)	46.3 (24-65)	48.5 (21-70)
Sex, n (male) (%)	155 (73)	116 (67)
Duration of current work, (years), mean (SD)	22.7 (12.3)	23.2 (12.8)
Smoking history, n (%)		
Non-smokers	129 (62)	112 (65)
Ex-smokers	56 (27)	43 (25)
Current smokers	23 (11)	17 (10)
Pack-years, mean (range)	4.8 (0-75)	4.5 (0-70)
Area of pig house (m^2), mean (SD)	527 (391)	397 (221)
Number of pigs, mean (SD)	351 (268)	246 (209)
Respiratory symptoms, n (%)		
Chronic bronchitis (WHO)	33 (16)	26 (16)
Shortness of breath in adult age	25 (12)	31 (18)
Work-related respiratory symptoms ever	100 (47)	70 (41)
Respiratory symptoms worsened at work	101 (48)	76 (44)

5.2. Farming conditions

5.2.1. Farming conditions in the questionnaire study

The pig farmers in the study lived and worked on 270 farms. The main type of production of pig husbandry was exclusively piglet production (42% of farms) or a combination with pigmeat production (38%). Sixty-eight farms (25%) were engaged only in pigmeat production. Half of the farms had plant production as another main activity. At the time of the questionnaire study, there were five farms (2%) with no active production.

Over half of the farmers had a family member helping with work in the pig houses. Spouses worked daily in piggeries of 151 (56%) farms. In 26 (10%) farms, a daughter or son participated daily in the work. There were only eight (3%) farms with an employee outside the family.

The majority of swineries had enclosed pens (91%). There were only three farms (1%) with an exclusively on-site composting swinery. Twenty-two swineries (8%) had both traditional confinement buildings with enclosed pens and a composting swine building. Sixty-six percent of the farms had entirely manual feeding systems and nearly half had entirely or partly manual manure removal. The majority of the farms (93%) had a mechanical ventilation system in all or part of the swine buildings. The size of the farms varied from small, entirely or partly manually handled to large automated pig houses (Table 10).

Table 10. *Size of pig houses and cubicles, number of pigs, and density of pigs in the farms of studied pig farmers.*

Farm variable	Mean	Median	Range
Area of pig houses (m^2)	450	362	80-2440
Total area of cubicles	340	270	50-2300
Number of pigs, total	260	239	26-1906
Sows	46	32	5-660
Piglets	174	150	30-1500
Fattening pigs	149	100	4-900
Boars	1.5	1	1-9
Density of pigs, animals/m^2	1.03	0.87	0.13-12.36

5.2.2. Farming conditions in the spirometry study

During the pig farmers' working shift, the study nurses collected information about the swinery and work practices. The main types of production, pig units, feeding and manure removal were similar as at the time of questionnaire (Table 10) and thus not repeated here. Ninety per cent of swineries had a mechanical ventilation system in all or part of the pig house. The supply air was warmed in the wintertime in 19% of the pig houses. The exhaust air outlets were in the majority of cases in the roof (88%) or walls (24%). Only in four per cent of the swineries was the exhaust air sucked through manure channels.

The work shifts lasted a mean of 1.2 hours (range 0.5-3 hours). During the work shift, the majority of pig farmers performed manual feeding (86% and 87%, in 1997 and 1999, respectively). In 1997, 27% of farms (29% in 1999) had totally automatic dry feeding and only 18% (19%) used automatic liquid feeding. The filling system of feeding vans was enclosed only in a tiny minority of farms (1%). In the majority of cases (70%), open feeding vans or pails were filled directly from a silo or manually from a bin or sack. In 15%-18% of cases, feeding vans or pails were filled within the animal compartment. The farmers delivered hay or litter (70%-74%) and manually cleaned the pens (74%-76%) or removed manure from the whole swinery (18%-15%). The majority of farms (87%) used some bedding material, in most case straw (71%-68%). Sawdust (11%-2%), wood-shavings (36%-44%) or peat (17%-15%) were also used. Eighteen farms (8.5%) had an on-site composting swinery.

5.3. Study questionnaire

The respiratory symptom questionnaire used in this study (Appendix 1, page 116) was derived from the Tuohilampi questionnaire, a pool of questions and question sets for environmental studies of asthma and respiratory disease created by Finnish researchers from the Finnish Institute of Occupational Health, the National Public Health Institute and four university hospitals (Susitaival and Husman 1996). The Tuohilampi questionnaire includes questions based on several different questionnaires (Medical Research Council (MRC) 1960, 1966 and 1986; European Community for Coal and Steel (ECCS) 1987; American Thoracic Society, National Heart, Lung and Blood Institute, Division of Lung Diseases (ATS-DLD-78) 1978; International Union against Tuberculosis and Lung Diseases (IUATLD) 1986) (Susitaival and Husman 1996). At the time of the beginning of this study, the Tuohilampi questionnaire was prepared for the final version and not yet validated. The applied questionnaire used in this study consisted of 48 questions, five on cough, five on phlegm, three on factors aggravating symptoms, two on dyspnoea and wheezing, and one on symptoms during working hours. The questionnaire included the questions of WHO and the ATS criteria for chronic bronchitis. There were also questions concerning respiratory infections, atopy, physician-diagnosed respiratory diseases and smoking. It included several identical question sets from the final version of the Tuohilampi questionnaire (e.g. smoking, atopy, physician-diagnosed diseases, and symptoms during working hours). In the Tuohilampi questionnaire, the presence of the two main symptoms (cough, phlegm) indicating bronchitis are included in the same main question as well as dealing with qualification (about duration) of symptoms and including further multiple choice questions on the time of occurrence. In the study questionnaire, however, primary questions about symptoms (cough and phlegm) were expanded into four further questions including qualifications concerning their time, regularity and duration of occurrence. The questionnaire mailed to pig farmers had 45 additional questions concerning work history in pig husbandry, work environment and working patterns.

5.3.1. Validation of the questionnaire

The validity and repeatability of the questionnaire was evaluated by mailing the questionnaire to 103 subjects who had been referred to a pulmonary clinic due to symptoms of asthma, chronic bronchitis, or chronic cough. Two to four weeks after the first mailing, the questionnaire was re-mailed to 85 subjects who responded to the first questionnaire, of which 64 replied. The sensitivity and specificity of the questionnaire-based diagnosis of asthma, chronic bronchitis and chronic cough was assessed with respect to clinical diagnosis.

The clinical definitions for the diagnoses were based on both the patient histories of symptoms and clinical findings. Every patient record was evaluated by the same study physician to state the clinical diagnosis according to the criteria. For asthma at least one of five symptoms (attacks of shortness of breath, cough, phlegm, wheezing, sensitivity to dust or fumes) and at least two of the following findings: spirometric reversibility ≥15% (250ml) in FEV_1, diurnal variation ≥20% (50 l/min) or reversibility ≥15%

(50 l/min) at least three times in serial PEF measurements over two weeks was required. If one or none of the preceeding findings was present, two or three (respectively) following supplementary findings were needed: increased count of blood eosinophils (>0.40), bronchial hyperreactivity (PD20FEV$_1$ ≤500 µg of methacholine), occasional wheezing in auscultation, an exercise-induced asthma reaction (≥15% decrease in PEF or FEV$_1$ during exercise on a treadmill), a positive reaction (≥15% immediate or ≥20% late decrease in FEV$_1$) in a specific allergen challenge test or a significant increase (≥20%) in PEF or spirometric values during treatment. Chronic bronchitis was diagnosed according to WHO (1975) criteria (see the chapter 5.3.3). Chronic cough was diagnosed for subjects with a cough on most days for at least three months of the year for at least two successive years, no etiologic findings in a chest X-ray, and no asthma by clinical definitions.

The questionnaire-based definitions were either pyhsician-diagnosed or symptom-based. Subjects with an affirmative answer to the question about physician-diagnosed asthma were considered to have physician-diagnosed asthma. Those reporting cough or phlegm with attacks of shortness of breath or wheezing together with at least three aggravating factors were also classified as asthmatics (symptom-based asthma). The subjects with an affirmative answer to the question about physician-diagnosed chronic bronchitis were considered to have chronic bronchitis if they did not report physician-diagnosed asthma. Those reporting phlegm production on most days for at least three months a year for at least two successive years were also considered to have chronic bronchitis (symptom-based chronic bronchitis) if they did not report physician-diagnosed asthma or attacks of shortness of breath or wheezing. The subjects reporting cough on most days for at least three months a year for at least two successive years were considered to have chronic cough if they did not report chronic bronchitis or asthma (according to the preceding definitions).

5.3.2. Respiratory symptom questionnaire used at farm visits

During the farm visits, the nurses completed a respiratory symptom questionnaire (Appendix 2, p. 128) consisting of 23 questions about respiratory symptoms during the preceding year and their relation to work tasks. The questionnaire was a shortened version of the questionnaire used in the questionnaire study. The nurses were trained to conduct interviews according to the questionnaire. Further, the questionnaire consisted of 29 items designed to collect information about the working environment and work tasks in the swinery, with two additional questions about respiratory symptoms after work periods in the swinery.

5.3.3. Definitions

The presence of atopy was defined as a clinical history of atopic dermatitis or allergic rhinitis.

In terms of smoking history, the study subjects were classified as current smokers, ex-smokers or non-smokers. Ex-smokers were subjects who had smoked at least one cigarette, cigar or pipe daily or almost daily for as long as one year and who at the time of the questionnaire had not smoked for six months or more (Medical Research Council 1986). Current smokers were all other smokers fulfilling the criteria of daily tobacco product consumption mentioned above. Non-smokers were all others. The life-long smoking history was also expressed as pack-years by multiplying the daily cigarette packet consumption by the years of regular smoking. One cigarette packet was defined to contain 20 cigarettes.

Subjects were classified as having chronic bronchitis by two definitions. Those reporting phlegm production on most days for at least three months of a year for at least two successive years had chronic bronchitis according to criteria of WHO (1975). Chronic bronchitis according to criteria of ATS (1962) required cough at the same time as phlegm production. The WHO criteria are used to report the results of chronic bronchitis, if not mentioned otherwise. Subjects who fulfilled the criteria of chronic bronchitis but had answered “yes” to a question about having physician-diagnosed asthma or bronchiectasis were excluded from the chronic bronchitis group.

ODTS was likely if the farmer had work-related fever or shivering and laryngeal irritation, rhinitis or dermal or eye symptoms and the symptoms had lasted less than a day or one to three days (Susitaival and Husman 1996). Farmer’s lung was likely if the farmer had had work-related dry cough, fever or shivering, shortness of breath or dyspnoea, and muscle aching, joint symptoms, headache or fatigue, and the symptoms had started later than half an hour after beginning the work task or entering the workplace and had lasted more than three days (Susitaival and Husman 1996).

5.4. Quality validation of work of study nurses

The farm visits and spirometric measurements were done by two trained nurses living in the Satakunta district. The measurements were done at the same time of day, in the morning. The farms were not situated close to each other, so it was possible to do only one farm visit daily. Two nurses were needed because with only one nurse the time period of farm visits and spirometric measurements of control subjects would have been too long.

The nurses were trained for flow-volume spirometric measurements by the same laboratory nurse of the Department of Clinical Physiology at Tampere University Hospital. After the training period, the nurses were tested in order to validate their supervised measurements. The spirometric lung function of 14 patients of the outpatient clinic of the Department of Pulmonary Diseases of Tampere University Hospital and two volunteers was measured twice during the same day with the supervising nurse changing between measurements. The order of the nurses was random. The measurements were done with the same spirometer as in the actual study. For the second farm visits and spirometry measurements in 1999, one of the study nurses was replaced. She had a similar training period with the same laboratory nurse as the previous ones and was tested against the continuing nurse. The nurses supervised in random order the spirometric measurements of 15 patients and volunteer personnel of the Department of Pulmonary Diseases of Tampere University Hospital.

In comparison analyses the method of Bland and Altman (1986) was used. The limits of agreement were estimated using the formula: mean difference d (the result obtained by nurse one minus the result obtained by nurse two) ± 1.96 s_d, where s_d is the standard deviation of the difference. These values define the range within which most (95%) differences between measurements obtained by the two nurses will lie, assuming a normal distribution. The smallest differences could be seen in values of forced expiratory volume in one second (FEV_1) and ratio of FEV_1 to forced vital capacity (FVC), where the limits of agreement were –0.18 to 0.24 litres and –5% to 7%, respectively. The greatest difference between the nurses was seen in values of maximal expiratory flow when 50% of FVC was left to expire (MEF_{50}, MEF%), where the limits of agreement were –0.96 to 1.53 litres and –25 to 39% of predicted.

5.5. Spirometric lung function measurements

A spirometer with an interchangeable disposable pneumotachograph (Medikro 905, Kuopio, Finland) was used to measure the spirometric lung function of the farmers and the control subjects. The disposable flow transducers give an accuracy of +/- 2% in flow volume curves with volume calibration according to the manufacturer's guarantee. At the start of each measurement session, the pneumotachograph was calibrated volumetrically using a standard 3-litre pulmonary calibration syringe. Indoor temperature was recorded at the time of calibration.

Each subject performed a minimum of three technically acceptable maximal flow-volume curves, with a variation of less than 5% between the two best FEV_1 and FVC. A noseclip was applied at every manoeuvre. The best curve, with the greatest sum of FEV_1 and FVC, was recorded (ATS 1987). Measurements of volumes and ventilatory flows were also expressed as percentages of reference (predicted) values for adult Finns (Viljanen et al. 1982).

The ventilatory function of pig farmers and controls was regarded as abnormal when FEV_1 (% of predicted) was <80%. Obstructive lung function impairment was defined as FEV_1/FVC <88% of predicted.

5.6. Measurements and observations in swineries

The study nurses collected details of swinery buildings and work tasks and methods by interviewing the workers and by their own observations (Appendix 2). Type of swinery building, type of ventilation, patterns of pig husbandry, number of animals, area of swinery and cubicles, methods of feeding and manure removal, and work tasks during the work shift were registered. Some additional information was also collected which was not used in this thesis.

Symptoms and complaints during or immediately after the work shift were noted.

5.7. Statistical methods

In validation of the questionnaire, the repeatability of responses to all individual questions was estimated by kappa statistics (Altman 1991). The kappa values were interpreted using the following guidelines: kappa value <0.20 indicates poor agreement, 0.21-0.40 fair, 0.41-0.60 moderate, 0.61-0.80 good and 0.81-1.00 very good agreement. The validity of the questionnaire was assessed by calculating the sensitivity and specificity of the questionnaire-based diagnoses against the clinical diagnoses. The sensitivity and specificity of the individual questions were also analysed.

The prevalence of respiratory symptoms and diagnoses were compared between pig farmers and control subjects using the Chi-square test or Fisher's exact test when appropriate. The unadjusted odds ratios (OR) with 95% confidence intervals (CI) were calculated using univariate logistic regression analysis. Multiple logistic regression was used to find risk indicators for selected respiratory symptoms and chronic bronchitis. The following potential risk indicators were included: pig farming, age (years), sex, atopy, and smoking (non-smokers, ex-smokers and current smokers). The analysis started with all potential risk factors in the model (full model). In addition, a forward stepwise logistic regression analysis was conducted. The study group was constrained to the model at the beginning and the criteria for entering and removing other variables were: probability of F-to-enter ≤ 0.10 and probability of F-to-remove ≥ 0.15. The results are given with adjusted odds ratios with 95% confidence intervals. Univariable logistic regression analysis was conducted to study the effects of work history and working conditions on the prevalence of respiratory symptoms and chronic bronchitis in the pig farming group. The McNemar test was used to compare the prevalences of respiratory symptoms and diagnoses in 1997 and 1999.

Within group changes in spirometric variables after the work-shift and after the period of two years were analysed using a paired samples t-test. The study groups were compared with respect to these changes using a t-test for independent samples. In addition, the groups were compared using the analysis of covariance (ANCOVA), where smoking, chronic bronchitis and symptoms were included as categorical covariates. The results are given as adjusted lung function means. Pearson correlation coefficients were calculated to study the associations between continuous variables.

The statistical analyses were performed using the SPSS (Version 11.1) program.

The 95% confidence intervals not including 1.0 and p-values below 0.05 were regarded as statistically significant.

6. Results

6.1. Validation of the questionnaire

The repeatability of selected questions is presented in Table 11. Both the questions about smoking history and atopic symptoms showed excellent agreement. The questions about symptoms (cough, phlegm) and their duration had good agreement, while the repeatability of their seasonal variability was lower, but still acceptable. The question on alternatives for aggravating factors had good repeatability. The questions ”Have you ever, in your adult life, had cough or phlegm with shortness of breath or wheezing?” and ”Does dyspnoea or wheezing appear in attacks?” had good repeatability as well.

Table 11. *Repeatability (kappa coefficient) of selected questions in a sample of 64 subjects.*

Question	Repeatability[1]
Cough on most days for three months a year	0.70
Cough on most days for three months a year for two years or more	0.68
Cough in different seasons (winter, spring, summer, autumn)	0.49[2] (0.41 winter – 0.68 summer)
Phlegm on most days for three months a year	0.67
Phlegm on most days for three months a year for two years or more	0.80
Phlegm in different seasons (winter, spring, summer, autumn)	0.53[2] (0.49 autumn – 0.54 spring)
Provoking factors (outdoor or indoor dust, tobacco smoke, smells, warm or cold climate, draft, exercise, stress)	0.71[2] (0.43 draft – 0.94 smells)
Cough or phlegm with shortness of breath or wheezing ever in adult life	0.71
Shortness of breath or wheezing with attacks	0.77
Atopic symptoms (atopic dermatitis, allergic rhinitis, allergic eye symptoms)	0.90[2] (0.84 rhinitis – 0.96 eye symptoms)
Physician-diagnosed asthma	0.73
Physician-diagnosed chronic bronchitis	0.84
Smoking regularly	1.00

1 kappa value <0.20 indicates poor agreement, 0.21-0.40 fair, 0.41-0.60 moderate, 0.61-0.80 good and 0.81-1.00 very good agreement

2 mean of the alternatives, range of different alternatives in parenthesis

The sensitivity of the questionnaire-based definitions for detecting clinical asthma or chronic bronchitis varied from 14% to 80% (Table 12). The lowest sensitivity was calculated for the questions about physician-diagnosed asthma and physician-diagnosed chronic bronchitis. The sensitivity of the question on symptom-based asthma was good. Of the selected questions, those including the terms ”shortness of breath or wheezing” and ”attacks of shortness of breath or wheezing” had the best sensitivity. The criteria of the WHO for chronic bronchitis (1975) had a good sensitivity (77%), but was much lower (29%) if a “no” answer was required in the question concerning physician-diagnosed asthma (symptom-based chronic bronchitis).

The specificity of questions concerning physician-diagnosed asthma and chronic bronchitis were high (93% and 86%, respectively) (Table 12). The WHO criteria for chronic bronchitis had a moderate specificity (71%), but it was higher (92%) if a “no” answer was required in the question of physician-diagnosed asthma. The specificity of the symptom-based asthma diagnosis was low.

Table 12. *Sensitivity (Se) and specificity (Sp) of questionnaire-based diagnosis of asthma and chronic bronchitis and selected questions against the clinical diagnoses of asthma and chronic bronchitis (95% confidence intervals in parentheses).*

	Clinical definitions Asthma		Chronic bronchitis	
Questionnaire diagnosis	Se (%)	Sp (%)	Se (%)	Sp (%)
Physician-diagnosed disease	30 (2-58)	93 (88-99)	14 (0-29)	86 (77-94)
Symptom-based disease[1]	80 (55-100)	40 (29-51)	29 (9-48)	92 (86-99)
Question				
Cough on most days for 3 months a year	70 (42-98)	29 (19-40)	67 (47-87)	28 (17-39)
Cough on most days for 3 months a year for two years or more	38 (4-71)	57 (44-69)	67 (42-87)	64 (51-77)
Phlegm on most days for 3 months a year	70 (42-98)	33 (23-44)	86 (71-100)	39 (27-51)
Phlegm on most days for 3 months a year for two years or more	22 (0-49)	57 (44-69)	77 (56-97)	71 (59-83)
Phlegm on most days for 3 months a year for two years or more and no physician-diagnosed asthma	0	85 (77-93)	29 (9-48)	92 (86-99)
Cough or phlegm with shortness of breath or wheezing ever in adult life	90 (71-100)	38 (26-49)	62 (41-83)	33 (21-45)
Attacks of shortness of breath or wheezing	90 (71-100)	41 (29-53)	53 (30-75)	33 (21-46)

[1] asthma: cough or phlegm with attacks of shortness of breath or wheezing and ≥ three provoking factors; chronic bronchitis: phlegm on most days for ≥3 months a year for ≥2 successive years and not physician-diagnosed asthma or attacks of shortness of breath or wheezing

6.2. Respiratory symptom questionnaire

6.2.1. Prevalence of respiratory symptoms

The observed prevalences in the study groups and non-adjusted odd ratios of different respiratory symptoms are given in Table 13. Pig farmers had more cough (42%) and phlegm (36%) than the control subjects (31% and 28%, respectively, p-value for the difference 0.007 and 0.046). Pig farmers had nearly twice as much chronic bronchitis as the control subjects, which was statistically significant by the criteria of WHO (OR 1.9, 95% CI 1.1-3.1) but not significant by ATS criteria. As to the prevalence of asthmatic symptoms, shortness of breath or shortness of breath with wheezing, there were no differences between the groups. The prevalence of physician-diagnosed asthma was similar in both groups. Pig farmers had more work-related respiratory symptoms than the control subjects (48% vs. 25%, p<0.001) and their symptoms were more often worsened by work-related dusts or fumes (46% vs. 26%, p<0.001).

Table 13. *The number and percentage of subjects with different respiratory symptoms in pig farmers and control subjects. The total number of subjects in each symptom varies because of a few incomplete replies. Pig farmers are compared to controls using univariate logistic regression analysis. The results are given by non-adjusted odds ratios (95% confidence intervals).*

Symptom	Pig farmers		Controls			
	N[1]	(%)	N[1]	(%)	OR (95% CI)	p-value
Cough	157/376	(42)	75/242	(31)	1.6 (1.1-2.2)	0.007
Phlegm	135/373	(36)	67/236	(28)	1.4 (1.0-2.0)	0.046
Chronic cough[2]	61/370	(16)	32/239	(13)	1.3 (0.8-2.0)	0.30
Chronic phlegm[2]	74/365	(20)	38/234	(16)	1.3 (0.8-2.0)	0.22
Chronic bronchitis (WHO)	59/364	(16)	22/233	(9)	1.9 (1.1-3.1)	0.019
Chronic bronchitis (ATS)	30/355	(8.5)	10/230	(4)	2.0 (0.97-4.2)	0.055
Shortness of breath in adult age	56/371	(15)	36/240	(15)	1.0 (0.6-1.6)	0.98
Shortness of breath with wheezing	29/369	(8)	22/236	(9)	0.8 (0.5-1.5)	0.53
Physician-diagnosed asthma	11/383	(3)	8/247	(3)	0.9 (0.3-2.2)	0.79
Work-related respiratory symptoms ever	170/352	(48)	58/232	(25)	2.8 (1.9-4.0)	<0.001
Respiratory symptoms worsened at work[3]	164/354	(46)	38/144	(26)	2.4 (1.6-3.7)	<0.001

[1] number of subject having symptoms/number of all subjects answering the question

[2] for three months per year

[3] unemployed subjects excluded from analysis

In the multiple logistic regression analysis, pig farming and age had significant associations with chronic bronchitis (WHO) (Table 14). Among pig farmers the probability of having chronic bronchitis was 2-fold compared to controls. The effect of atopy was almost significant. Smoking appeared not to have any independent effect on chronic bronchitis in this analysis.

Table 14. *The number and percentage of subjects with chronic bronchitis (WHO) in pig farmers and controls and according to background variables. Associations analysed by multiple logistic regression analysis are shown with adjusted odds ratios (95% confidence intervals). All potential explanatory variables (pig farming, age, gender, atopy and smoking) are included in the model.*

Explanatory variable	N[1]	(%)	OR (95 % CI)	p-value
Group				
Controls	20/225	(9)	1.0 (reference)	
Pig farming	58/350	(17)	2.0 (1.1-3.5)	0.02
Gender				
Male	57/378	(15)	1.0 (reference)	
Female	21/197	(11)	0.8 (0.4-1.4)	0.37
Atopy				
No	42/360	(12)	1.0 (reference)	
Yes	36/215	(17)	1.6 (0.97-2.6)	0.06
Smoking				
Non-smokers	41/323	(13)	1.0 (reference)	
Ex-smokers	27/145	(19)	1.4 (0.8-2.4)	0.27
Current smokers	10/107	(9)	0.95 (0.4-2.1)	0.90
Age (years)			1.03 (1.0-1.06)	0.019

[1] number of subjects with chronic bronchitis/number of all subjects in the category

Stepwise logistic regression showed a significant effect of atopy on chronic bronchitis in addition to pig farming and age (Table 15).

Table 15. *The number and percentage of subjects with chronic bronchitis (WHO) in pig farmers and controls and according to atopy. The associations analysed in stepwise logistic regression analysis are given by adjusted odds ratios (95% confidence intervals). The study group (pig arming or controls) was forced to the model and other potential explanatory variables (age, gender, atopy and smoking) were included by the following criteria: p-in ≤0.10 and p-out ≥0.15*

Explanatory variable	N[1]	(%)	OR (95 % CI)	p-value
Group				
Controls	20/226	(9)	1.0 (reference)	
Pig farming	58/353	(16)	2.0 (1.2-3.5)	0.010
Atopy				
No	42/362	(12)	1.0 (reference)	
Yes	36/217	(17)	1.6 (1.0-2.7)	0.047
Age (years)			1.03 (1.01-1.06)	0.009

[1] number of subjects with chronic bronchitis/number of all subjects in the category

The multiple logistic regression analysis of the associations of pig farming, gender, age, atopy and smoking with chronic cough, chronic phlegm and asthmatic symptoms are presented in Table 16. Pig farmers had a 1.5-fold increase in the prevalence of chronic cough and chronic phlegm compared to the controls; however, the association with chronic cough was not statistically significant. The effect of pig farming on asthmatic symptoms (shortness of breath when adult, shortness of breath with wheezing) was small and insignificant. Subjects with atopy had up to 2-fold more chronic cough and chronic phlegm and 3- to 5-fold more asthmatic symptoms than subjects with no atopic disorders. Current smokers had twice as much chronic phlegm (on most days for at least three months a year) and shortness of breath in adult age compared with non-smokers.

Table 16. *The number and percentages of subjects with chronic cough, chronic phlegm and asthmatic symptoms in pig farmers and controls and according to background variables. The associations analysed in multiple logistic regression analysis are given with adjusted odds ratios (95% confidence intervals). All potential explanatory variables (pig farming, age, gender, atopy and smoking) are included in the model.*

Explanatory variable	Chronic cough[1]				Chronic phlegm[1]			
	N[2]	(%)	OR (95 % CI)	p-value	N[2]	(%)	OR (95 % CI)	p-value
Group								
Controls	31/230	(13)	1.0 (reference)		35/226	(15)	1.0 (reference)	
Pig farming	59/353	(17)	1.6 (0.98-2.7)	0.06	72/350	(21)	1.6 (1.0-2.6)	0.046
Gender								
Male	59/383	(15)	1.0 (reference)		72/378	(19)	1.0 (reference)	
Female	31/199	(16)	1.3 (0.8-2.1)	0.38	35/198	(18)	1.2 (0.7-1.9)	0.55
Atopy								
No	44360	(12)	1.0 (reference)		57/361	(16)	1.0 (reference)	
Yes	46/223	(21)	2.0 (1.2-3.1)	0.004	50/215	(23)	1.7 (1.1-2.6)	0.022
Smoking								
Non-smokers	43/328	(13)	1.0 (reference)		50/323	(15)	1.0 (reference)	
Ex-smokers	25/146	(17)	1.3 (0.8-2.4)	0.31	37/146	(25)	1.8 (1.1-3.1)	0.020
Current smokers	22/109	(20)	2.3 (1.2-4.4)	0.009	20/107	(19)	1.7 (0.9-3.1)	0.11
Age (years)			1.02 (1.00-1.04)	0.06			1.02 (1.00-1.04)	0.09

	Shortness of breath when adult				Shortness of breath with wheezing			
Explanatory variable	N[2]	(%)	OR (95 % CI)	p-value	N[2]	(%)	OR (95 % CI)	p-value
Group								
Controls	36/231	(16)	1.0 (reference)		22/227	(10)	1.0 (reference)	
Pig farming	55/357	(15)	1.2 (0.7-2.0)	0.46	29/355	(8)	1.0 (0.5-1.8)	0.94
Gender								
Male	61/385	(16)	1.0 (reference)		32/381	(8)	1.0 (reference)	
Female	30/203	(15)	1.1 (0.6-1.8)	0.84	19/201	(9)	1.1 (0.6-2.1)	0.77

Explanatory variable	Shortness of breath when adult				Shortness of breath with wheezing			
	N[2]	(%)	OR (95 % CI)	p-value	N[2]	(%)	OR (95 % CI)	p-value
Atopy								
No	35/366	(10)	1.0 (reference)		15/362	(4)	1.0 (reference)	
Yes	56/222	(25)	3.3 (2.1-5.4)	<0.001	36/220	(16)	4.8 (2.5-9.0)	<0.001
Smoking								
Non-smokers	43/331	(13)	1.0 (reference)		29/329	(9)	1.0 (reference)	
Ex-smokers	28/123	(23)	1.3 (0.7-2.3)	0.32	11/149	(7)	0.7 (0.3-1.4)	0.31
Current smokers	20/106	(19)	2.1 (1.1-4.0)	0.031	11/104	(11)	1.5 (0.6-3.3)	0.37
Age (years)			1.03 (1.01-1.06)	0.004			1.03 (1.00-1.06)	0.030

[1] on most days for at least three months per year

[2] number of subjects with symptoms/number of all subjects in the category

The multiple logistic regression analysis of the associations of pig farming, gender, age, atopy and smoking with respiratory symptoms worsened at work and work-related respiratory symptoms ever is presented in Table 17. The pig farmers had almost three times more respiratory symptoms worsening at work by dust and fumes and over three times more work-related symptoms than the controls. Atopic subjects had over a 2-fold increase in the prevalence of respiratory symptoms worsened at work and over 2.5-fold increase in the prevalence of work-related respiratory symptoms ever compared to non-atopic subjects.

6.2.2. Smoking history and respiratory symptoms

Subjects with a smoking history of 16 pack-years or more had significantly more chronic cough and chronic phlegm than subjects with fewer pack-years (pig farming-, age-, sex- and atopy-adjusted OR 3.2, 95% CI 1.7-6.1 and OR 2.6, 95% CI 1.4-4.9, respectively). The prevalence of chronic bronchitis (by WHO criteria) increased with pack years but was not significant even with 16 pack-years or more (OR 1.5, 95% CI 0.7-3.1).

6.2.3. Pig farming and respiratory symptoms

The proportion of pig farmers with symptoms of chronic bronchitis (WHO) increased with daily working time in swine buildings, and the association was statistically significant when the daily working time was six hours or more (non-adjusted OR 3.9, 95% CI 1.1-13.9, Table 18). Chronic bronchitis was also associated with working-years in swine buildings. The pig farmers with a working history of 20 years or more had over three times more chronic bronchitis compared with those of nine years or less (Table 18).

The daily working time was not associated with asthmatic symptoms (Table 18). Pig farmers with a working history of 20 years or more had greater shortness of breath with wheezing than those with nine working years or less, although this did not reach statistical significance (Table 18).

Table 17. *The number and percentage of subjects with respiratory symptoms worsening by dusts and fumes at work and work-related respiratory symptoms ever in pig farmers and controls and according to background variables. The associations analysed in multiple logistic regression analysis are given by adjusted odds ratios (95% confidence intervals). All potential explanatory variables (pig farming, gender, age, atopy and smoking) are included in the model.*

Explanatory variable	Respiratory symptoms worsened at work[1]				Work-related respiratory symptoms ever			
	N[2]	(%)	OR (95 % CI)	p-value	N[2]	(%)	OR (95 % CI)	p-value
Group								
Controls	38/141	(27)	1.0 (reference)		58/225	(26)	1.0 (reference)	
Pig farming	158/337	(47)	3.0 (1.8-4.8)	<0.001	164/336	(49)	3.4 (2.3-5.1)	<0.001
Gender								
Male	137/326	(42)	1.0 (reference)		162/371	(44)	1.0 (reference)	
Female	59/152	(39)	1.0 (0.6-1.5)	0.90	60/190	(32)	0.7 (0.5-1.1)	0.11
Atopy								
No	106/301	(35)	1.0 (reference)		112/346	(32)	1.0 (reference)	
Yes	90/177	(51)	2.2 (1.5-3.3)	<0.001	110/215	(51)	2.7 (1.8-3.9)	<0.001
Smoking								
Non-smokers	113/281	(40)	1.0 (reference)		116/314	(37)	1.0 (reference)	
Ex-smokers	50/117	(43)	1.1 (0.7-1.8)	0.70	64/141	(45)	1.4 (0.9-2.2)	0.15
Current smokers	33/80	(41)	1.51 (0.9-2.6)	0.15	42/106	(40)	1.6 (0.97-2.7)	0.07
Age (years)			1.00 (0.98-1.02)	0.82			1.01 (0.99-1.02)	0.45

1 unemployed subjects are excluded from analysis

2 number of subjects with symptoms/number of all subjects in the category

Table 18. *The number and percentage of farmers with chronic bronchitis (WHO) and asthmatic symptoms in three categories of daily working-time and total working years in pig farming. The total number of subjects in each category varies because of a few incomplete replies. The associations analysed in logistic regression analysis are given by non-adjusted odds ratios (95% confidence intervals).*

Working time	Chronic bronchitis				Shortness of breath when adult				Shortness of breath with wheezing			
	N[1]	(%)	OR (95% CI)	p-value	N[1]	(%)	OR (95% CI)	p-value	N[1]	(%)	OR (95% CI)	p-value
Daily hours in swine building												
< 3	3/48	(6)	1.0 (reference)		11/50	(16)	1.0 (reference)		6/49	(12)	1.0 (reference)	
3-5.9	36/210	(17)	3.1 (0.9-10.5)	0.07	27/216	(10)	0.5 (0.2-1.1)	0.10	12/210	(6)	0.4 (0.1-1.2)	0.11
≥ 6	19/92	(21)	3.9 (1.1-13.9)	0.036	17/96	(12)	0.8 (0.3-1.8)	0.53	10/95	(10)	0.8 (0.3-2.5)	0.76
Working-years												
≤ 9	7/87	(8)	1.0 (reference)		13/88	(15)	1.0 (reference)		4/87	(5)	1.0 (reference)	
10-19	16/114	(14)	1.9 (0.7-4.8)	0.19	13/117	(11)	0.7 (0.3-1.6)	0.44	5/117	(4)	0.9 (0.2-3.6)	0.91
≥ 20	35/156	(22)	3.3 (1.4-7.8)	0.006	28/158	(18)	1.2 (0.6-2.5)	0.55	19/157	(12)	2.9 (0.9-8.7)	0.06

[1] number of subjects with symptom/number of all subjects in the category

Symptoms of chronic bronchitis were not associated with the type of production (piglet, pigmeat or combinations, p=0.08 for WHO chronic bronchitis), the number of animals per area (<1, 1-1.25, <1.25 animals/m^2, p=0.58) or the methods of manure removal (only liquid, other and combinations, p=0.109). The method of feeding had no statistically significant effect on symptoms of chronic bronchitis. However, there was a trend that farmers who used exclusively automatic feeding would have less chronic bronchitis (OR 0.3, 95% CI 0.1-1.2) and chronic phlegm (OR 0.4, 95% CI 0.1-1.0) than farmers who used manual feeding with or without a combination with automatic feeding. There were no statistically significant associations between asthmatic symptoms and the type of production, number of animals per area, methods of feeding or manure removal.

Farmers who had histories of shortness of breath in adulthood or shortness of breath with wheezing were more likely to use personal dust respirators than those with no problems (Table 19). This difference was seen among farmers having a working history of 20 years or more (data not shown). Using a dust respirator was significantly associated with ever having respiratory symptoms worsened at work or work-related symptoms as well. Over half of the farmers using dust respirators had these symptoms (Table 19). This phenomenon was seen in all categories of working history (<10, 10-19, >20 years), but seemed most marked among farmers with working history of 20 years or more (data not shown).

Table 19. *The number and percentage of farmers with different respiratory symptoms according to not using or using personal dust respirators always or nearly always during at least one work task in swine buildings. The total number of subjects in each category varies because of a few incomplete replies. The statistical difference between the groups is given by a p-value.*

Symptom	Farmers not using a dust mask N[1]	(%)	Farmers using a dust mask N[1]	(%)	p-value[2]
Chronic bronchitis (WHO)	18/139	(13)	41/218	(19)	0.15
Chronic cough	22/138	(16)	38/219	(17)	0.80
Chronic phlegm	24/139	(17)	50/219	(23)	0.21
Shortness of breath when adult	12/140	(9)	42/224	(19)	0.008
Shortness of breath with wheezing	5/140	(4)	24/223	(11)	0.014
Respiratory symptoms worsened at work	49/142	(34)	124/233	(53)	<0.001
Work-related respiratory symptoms ever	39/131	(30)	126/214	(59)	<0.001

[1] number of subjects with symptom/number of all subjects in the category

[2] Chi-square test

6.3. Respiratory symptom interview

6.3.1. Respiratory symptom history during the preceding year

During the farm visits in 1997 and 1999 the nurses interviewed the pig farmers about their respiratory symptom history of the preceding year. The prevalences of the symptoms are presented in Table 20. Symptom patterns did not change significantly during the two-year period, except for shortness of breath which was more common in 1999 than in 1997. Respiratory symptoms (cough or phlegm) occurred most often in the mornings (45% of those with symptoms). Respiratory symptoms (cough, phlegm or shortness of breath) relieved or disappeared during vacations in half (50%) of the symptomatic farmers.

Table 20. *The number and percentage of pig farmers with different respiratory symptoms during the preceding year (nurse's interview during the farm visit) in 1997 and 1999. The statistical difference of the change in prevalences of symptoms among those farmers who continued pig husbandry from 1997 to 1999 is given by a p-value.*

Symptom	All pig farmers with farm visit (n=211)		Pig farmers who continued pig husbandry from 1997 to 1999 (n=170)				
	1997		1997		1999		p-value[1]
	N	(%)	N	(%)	N	(%)	
Chronic cough	50	(24)	37	(22)	36	(21)	1.000
Chronic phlegm	42	(20)	31	(18)	31	(18)	1.000
Chronic bronchitis (WHO)	36	(17)	28	(16)	25	(15)	0.68
Shortness of breath	25	(12)	19	(11)	33	(19)	0.013
Shortness of breath with wheezing	7	(3)	5	(3)	5	(3)	1.000

1 McNemar test

Eighty-two per cent of the pig farmers reported one or more work-related symptoms in 1997 and 76% in 1999. The numbers and percentages of pig farmers with different symptoms are presented in Table 21. Cough was the most common symptom, starting or worsening during or after work tasks. Phlegm, laryngeal irritation, as well as nose, eye and dermal symptoms were also common in 1997. In 1999, the proportion of farmers with shortness of breath or dyspnoea had increased and those with dermal and eye symptoms decreased. The symptoms were related to cleaning the swine house (37%), drying or transporting grain (38%), grain threshing (34%), handling grain or flour indoors (28%), cleaning hay or grain storage houses (14%), handling bedding material (10%) or the removal of animals (7%). The symptoms usually started within half an hour (61%) after beginning the work task or entering the working place and lasted less than a day (59%) or one to three days (25%). Only five farmers (2%) had symptoms referring to ODTS and in four farmers the symptom pattern might be related to farmer's lung.

Table 21. *The number and percentage of pig farmers with work-related symptoms (symptoms starting during or after work tasks) during the preceding year in 1997 and in 1999. The statistical difference of the change in prevalences of symptoms among those farmers who continued pig husbandry from 1997 to 1999 is given by a p-value.*

Symptom	All pig farmers at farm visit in 1997 (n=211)		Pig farmers who continued pig husbandry from 1997 to 1999 (n=170)				
	1997		1997		1999		p-value[1]
	N	(%)	N	(%)	N	(%)	
Dry cough	88	(42)	67	(39)	64	(38)	0.78
Phlegm	49	(23)	36	(21)	39	(23)	0.71
Laryngeal irritation	49	(23)	36	(21)	47	(28)	0.12
Shortness of breath or dyspnoea	25	(12)	13	(8)	26	(15)	0.011
Rhinitis	41	(19)	29	(17)	38	(22)	0.15
Stuffed nose	19	(9)	17	(10)	26	(15)	0.11
Dermal symptoms	50	(24)	41	(24)	17	(10)	<0.001
Eye irritation	47	(22)	36	(21)	20	(12)	0.017
Fever or shivering	14	(7)	11	(6)	18	(11)	0.12
Muscle aching	14	(7)	11	(6)	7	(4)	0.45
Joint symptoms	10	(5)	4	(2)	9	(5)	0.23
Headache	13	(6)	8	(5)	8	(5)	1.00
Fatigue	14	(7)	10	(6)	6	(3)	0.42
Other	6	(3)	5	(3)	8	(5)	0.55

[1] McNemar test

6.3.2. Across-shift effects in respiratory symptoms

After the work shift in the swinery, the nurses interviewed the study subjects about respiratory symptoms during or immediately after the work shift. Over a quarter of the pig farmers (27%) reported one or more symptoms. The most common symptoms were dry cough, phlegm and laryngeal irritation (Table 22). Less common symptoms were rhinitis, eye irritation or dermal symptoms. Only one farmer reported shortness of breath or dyspnoea in 1997. None reported fever or chills during or after the work shift. The changes in prevalences of symptoms after the period of two years were not statistically significant.

Table 22. *The number and percentage of respiratory symptoms during or immediately after the work shift reported by pig farmers in 1997 and in 1999. The statistical difference of the change in prevalences of symptoms among those farmers who continued pig husbandry from 1997 to 1999 is given by a p-value.*

Symptom	All pig farmers 1997 (n=211)		Pig farmers who continued pig husbandry from 1997 to 1999 (n=170)				
	1997		1997		1999		p-value[1]
	N	(%)	N	(%)	N	(%)	
Dry cough	30	(14)	23	(14)	25	(15)	0.86
Phlegm	22	(10)	17	(10)	24	(14)	0.19
Laryngeal irritation	21	(10)	17	(10)	14	(8)	0.66
Rhinitis	9	(4)	8	(5)	8	(5)	1.00
Shortness of breath or dyspnoea	1	(0.5)	1	(0.5)	0	(0)	NA
Eye irritation	4	(2)	3	(2)	3	(2)	1.00
Dermal symptoms	1	(0.5)	0	(0)	0	(0)	NA
Other	13	(6)	6	(4)	10	(6)	0.45

[1] McNemar test

6.4. Spirometric lung function

6.4.1. Baseline spirometric lung function

The spirometric lung function of the pig farmers was slightly but significantly better than that of the control subjects (Table 23). Between the pig farmers and the controls, the mean difference of FEV_1 was 0.27 L (95% CI 0.04-0.49) and that of FVC was 0.36 L (95% CI 0.10-0.63). Lung function parameters of FEV%, MEF_{50} and MEF_{25} did not differ significantly between the groups. The proportion of subjects with abnormal spirometric lung function was similar between the groups. Twenty-five (12%) pig farmers and 15 (18%) control subjects had an abnormal lung function (FEV_1 <80% of predicted) (p=0.16). Obstructive (FEV_1/FVC <88% of predicted) lung function was found in 22 pig farmers (10%) and in 10 control subjects (12%) (p=0.69).

Table 23. *The baseline lung function parameters in flow-volume spirometry in pig farmers and control subjects.*

Lung function parameter	Pig farmers (n=211)			Controls (n=83)			p-value[1]
	Mean	(SD)	Range	Mean	(SD)	Range	
VC (L)	4.95	(1.13)	2.28-8.07	4.56	(1.10)	2.33-6.74	0.007
VC (% pred)	98	(12)	63-142	94	(14)	66-125	0.013
FVC (L)	4.81	(1.06)	2.53-7.45	4.45	(1.03)	2.28-6.67	0.008
FVC (% pred)	99	(12)	70-128	94	(14)	56-133	0.014
FEV_1 (L)	3.78	(0.89)	1.68-6.62	3.52	(0.91)	1.75-5.95	0.023
FEV_1 (% pred)	95	(14)	60-129	92	(15)	46-130	0.049
FEV_1/FVC (%)	79	(7)	51-98	79	(7)	58-99	0.78
MEF_{50} (L)	3.93	(1.48)	0.92-9.37	3.79	(1.58)	0.68-9.72	0.50
MEF_{50} (% pred)	76	(26)	6-165	75	(26)	14-153	0.71
MEF_{25} (L)	1.22	(0.75)	0.16-5.98	1.19	(0.96)	0.23-6.67	0.74
MEF_{25} (% pred)	74	(36)	11-259	72	(40)	19-252	0.70

[1] difference between pig farmers versus controls, t-test

6.4.2. Smoking and spirometric lung function

Among the pig farmers, smoking status or smoking history defined as pack-years (<15 pack-years, ≥15 pack-years) was not associated with obstructive impairment of lung function (Table 24). However, in the control subjects, current smokers and smokers with 15 pack-years or more had significantly more often obstructive lung function than non-smokers and ex-smokers or smokers with smoking history of less than 15 pack-years.

Table 24. *The number and percentage of pig farmers and control subjects with obstructive lung function impairment (FEV_1/FVC < 88% of predicted) in different smoking categories. Associations between smoking category and obstructive lung function impairment among pig farmers and control subjects are given by a p-value.*

Smoking	Pig farmers			Controls		
	N[1]	(%)	p-value[2]	N[1]	(%)	p-value[2]
Non-smokers	16/129	(12)		3/49	(6)	
Ex-smokers	3/56	(5)		1/12	(8)	
Current smokers	3/23	(13)	0.33	6/22	(27)	0.037
Pack-years						
<15	9/186	(10)		6/72	(8)	
≥15	2/19	(10)	0.97	4/11	(36)	0.008

[1] number of subjects with obstructive lung function impairment/number of all subjects in the category

[2] Chi-square test

6.4.3. Pig farming and spirometric lung function

Among the pig farmers, spirometric lung function did not differ between men and women. Those farmers 50 years of age or older had lower FEV% (95% versus 98%, p=0.02) and MEF_{50} (69% versus 80%, p=0.003) than younger. The pig farmers with atopy had slightly lower FEV% (95% versus 98%, p=0.07), MEF_{50} (71% versus 78%, p=0.07) and MEF_{25} (65% versus 78%, p=0.006) than those with no history of atopy. However, the difference was statistically significant only for MEF_{25}. Daily working hours or years in pig farming defined as three classes (0-3.5, 4-5, ≥5.5 hours daily; <10 years, 10-19 years, ≥20 years) did not affect the spirometric lung function as a continuous variable. Spirometric lung function was similar in the pig farmers with one or more chronic respiratory symptoms or chronic bronchitis as in those without symptoms.

There was a trend for pig farmers aged 50 years or more to have greater spirometric lung function impairment (FEV_1 <80%) than those younger (OR 2.4, 95% CI 0.9 to 6.2). Those who spent 5.5 hours or more in swine buildings daily seemed to have a greater prevalence for abnormal lung function compared with those with 3.5 or less daily working hours (OR 2.4, 95% CI 0.8 to 7.7); however, this was not statistically significant. The prevalence of obstruction (FEV_1/FVC <88% of predicted) was 2.3-fold in those 50 years of age or older compared with those younger, but this did not reach statistical significance (95% CI 0.8 to 6.1). The prevalence of obstruction was more than three times greater among farmers with chronic cough compared with farmers without (OR 3.1, 95% CI 1.1 to 9.0).

6.4.4. Across-shift effects in spirometric lung function

Changes in spirometry after a work-shift in the swine confinement building were small. Statistically significant changes were found in FEV_1, in MEF_{50} and in MEF_{25} (Table 25). However, none of these changes differed significantly from that of control subjects.

Table 25. *The changes in spirometric lung function parameters of pig farmers across a work-shift in the swine confinement building and of control subjects during an interval of two hours.*

Lung function parameter	Pig farmers (n=211)		Controls (n=83)		Difference between pig farmers and controls	
	Mean change (95% CI)	p-value[1]	Mean change (95% CI)	p-value[1]	Mean (95% CI)	p-value[2]
VC (L)	-0.01 (-0.08 to 0.07)	0.89	0.01 (-0.05 to 0.08)	0.73	-0.02 (-0.14 to 0.11)	0.80
FVC (L)	-0.02 (-0.07 to 0.02)	0.33	-0.04 (-0.11 to 0.03)	0.25	0.02 (-0.07 to 0.10)	0.68
FEV_1 (L)	-0.03 (-0.06 to –0.01)	0.02	-0.03 (-0.07 to -0.00)	0.07	0.00 (-0.04 to 0.05)	0.90
FEV_1/FVC (%)	-0.21 (-0.92 to 0.50)	0.56	-0.07 (-1.29 to 1.15)	0.91	-0.15 (-1.50 to 1.21)	0.83
MEF_{50} (L)	-0.09 (-0.18 to –0.00)	0.049	-0.08 (-0.21 to 0.05)	0.20	-0.01 (-0.17 to 0.15)	0.94
MEF_{25} (L)	-0.08 (-0.14 to –0.02)	0.008	-0.12 (-0.20 to -0.04)	0.004	0.04 (-0.07 to 0.14)	0.52

1 paired samples t-test

2 independent samples t-test

Table 26. *Lung function parameters in flow volume spirometry (given as a mean value) of the pig farmers and the controls in 1997 and 1999, as well as the mean change after two years. The results include only those subjects with both measurements. An analysis of variance for the differences in the mean changes between the pig farmers and the controls was applied.*

Lung function parameter	Lung function of pig farmers[1] (n=203)			Lung function of controls (n=72)			Difference between pig farmers and controls	
	1997	1999	Mean change (95% CI)	1997	1999	Mean change (95% CI)	Mean difference (95% CI)	p-value[2]
VC (L)	4.97	4.83	-0.14 (-0.19 to -0.10)	4.56	4.56	0.00 (-0.08 to 0.07)	-0.14 (-0.23 to –0.05)	<0.001
FVC (L)	4.83	4.52	-0.31 (-0.37 to -0.26)	4.43	4.30	-0.13 (-0.24 to 0.03)	-0.18 (-0.29 to –0.07)	<0.001
FEV_1 (L)	3.79	3.58	-0.22 (-0.25 to -0.18)	3.50	3.44	-0.06 (-0.13 to 0.01)	-0.15 (-0.23 to –0.08)	<0.001
FEV_1/FVC (%)	79	79	0.69 (0.04 to1.34)	79	80	1.19 (-0.21 to 2.59)	-0.50 (-1.87 to 0.87)	0.68
MEF_{50} (L)	3.94	3.61	-0.33 (-0.44 to -0.22)	3.76	3.68	-0.08 (-0.31 to 0.16)	-0.25 (-0.48 to –0.02)	0.022
MEF_{25} (L)	1.24	1.07	-0.17 (-0.24 to 0.10)	1.18	1.12	-0.06 (-0.19 to 0.07)	-0.11 (-0.25 to 0.03)	0.19

[1] including farmers who were retired or had ceased pig husbandry during the 2-year period between the first and the second measurement

[2] difference between pig farmers and controls, adjusted for age, smoking, atopy and across-shift change of FEV_1

6.4.5. Spirometric lung function after a period of two years

The spirometry measurements of pig farmers and controls were repeated after a period of two years. The pig farmers had accelerated lung function decline compared with the control subjects (Table 26). The mean decline of FEV_1 was 220 ml in the pig farmers and 60 ml in the controls ($p<0.001$, adjusted for age, smoking, atopy and across-shift change of FEV_1) and that of FVC 310 ml in the pig farmers and 130 ml in the controls ($p<0.001$). Significant differences were also observed in mean declines of VC and MEF_{50}.

The association with smoking, defined in three classes (non-, ex-, and current smokers) with the decline of spirometric lung function was seen only in the group of controls. The mean decline of FEV_1 was 20 ml in the non-smoking, 110 ml in the ex-smoking and 260 ml in the current smoking controls ($p=0.003$). The mean declines of FVC were 60 ml, 30 ml, and 360 ml, respectively ($p=0.034$). The mean declines of MEF_{50} were 10 ml, 480 ml, and 650 ml, respectively ($p=0.006$). The decline of FVC was associated with age among the pig farmers but not among the controls. The mean decline of FVC was 150 ml in farmers aged 20-34 years, 300ml in those aged 35-49 years and 390 ml in those aged 50-70 years ($p=0.014$). The association with age was not seen in the decline of FEV_1. Subjects with chronic bronchitis (WHO) had a faster decline in FVC than subjects without (380 ml versus 240 ml, $p=0.05$). Following that, the change of FEV_1/FVC was positive in subjects with chronic bronchitis compared with those without (2.7% versus 0.5%, $p=0.027$). These correlations with chronic bronchitis were seen only when the groups were analysed together, and not in any other lung function parameter. The decline of lung function did not differ significantly in subjects with one or more chronic respiratory symptoms compared with subjects with no symptoms. Atopy was not associated with the decline in lung function in either group.

Among the pig farmers, age and the number of years in pig farming had a significant linear association with the decline of FVC and FEV_1/FVC in the period of two years (Table 27). The across-shift change in FEV_1 in 1997 correlated significantly with the change of FEV_1 during the 2-year period ($r=0.37$, $p<0.001$). No significant associations were found between the daily working hours or symptoms during or after the work shift in 1997 and the change in lung function during the 2-year period.

Table 27. *The mean changes of spirometric lung function parameters of pig farmers after a period of two years in three age groups and in three groups of working years with an analysis of linear association.*

Lung function parameter	Age groups of pig farmers (n=203)					Years in pig farming (n=201)				
	20-34 (n=31)	35-49 (n=95)	50-70 (n=77)	r[1]	p-value	0-9 (n=43)	10-19 (n=72)	>20 (n=86)	r[2]	p-value
VC (L)	-0.01	-0.16	-0.17	-0.091	0.20	-0.12	-0.17	-0.14	-0.057	0.42
FVC (L)	-0.15	-0.30	-0.39	-0.192	0.006	-0.19	-0.31	-0.37	-0.199	0.005
FEV_1 (L)	-0.20	-0.22	-0.22	-0.041	0.57	-0.19	-0.21	-0.23	-0.088	0.21
FEV_1/FVC (%)	-1.69	0.39	2.01	0.238	0.001	-0.87	0.71	1.38	0.182	0.010
MEF_{50} (L)	-0.34	-0.31	-0.35	-0.058	0.41	-0.24	-0.28	-0.42	-0.097	0.17
MEF_{25} (L)	-0.39	-0.14	-0.11	0.119	0.09	-019	-0.18	-0.15	0.054	0.45

[1] correlation between age and change in lung function variable

[2] correlation between years in pig farming and change in lung function variable

6.5. The use and effects of a personal dust respirator

In 1997, 49 (24%) pig farmers used a personal dust respirator during one or more work tasks. The majority of them (73%) had a disposable dust protector. Twelve (24%) farmers used a half mask, and only two had a powered respirator. Over half (55%) of the respirators had P2-type filters. Three (6%) of the respirators had P3 filters, but many (22%) used only P1-type filters. In 1999, the proportion of farmers using a respirator was similar (25%) as in 1997, but the number of half- or total-face masks (38%) had increased and the filtering capacity of respirators was improved (P2 or P3 filters in 86% of the respirators).

The across-shift changes in spirometry and respiratory symptoms were measured both with and without dust respirators for 42 farmers wearing personal dust respirators during their first farm visit. There were no significant differences in across-shift changes of spirometric lung function during work shifts with personal dust respirators compared with work shifts without them. Respiratory symptoms increased during the second farm visit when the farmers were not using dust respirators during the work shift compared with the first one. Twenty-five farmers (59%) had one or more respiratory symptoms during the second work shift when not using the respirator. During the first work shift with the respirator, only fourteen (33%) had one or more respiratory symptoms (p=0.007). The most common symptom was laryngeal irritation.

6.6. Farmers discontinuing pig husbandry during the study

During the 2-year period between the first farm visits in 1997 and the second visits in 1999, 34 farmers (16% of the farmers with a farm visit in 1997) changed the main farm operation or retired. Fifteen farmers had no production and twelve farmers had changed to grain production. Four farmers reported pig husbandry as their main farm operation after changing from something else. The main reasons for changing the main farm operation or discontinuing pig farming were economic (47%) and retirement (35%). Only two farmers reported respiratory disease as the main reason for discontinuing pig farming. One-third of the farmers had changed the operation or retired over a year before the second farm visit, and the rest of them during the preceding year.

The discontinued pig farmers and the continuing pig farmers were alike in age, gender and smoking status. The mean age of the discontinuing farmers was 49.2 (SD 10.0) years and that of the continuing farmers was 47.1 (9.9) years (p=0.24). Twenty-three (68%) of the discontinuing and 248 (71%) of the continuing pig farmers were male (p=0.68). Five (15%) of the discontinuing farmers and 35 (10%) the continuing farmers were current smokers (p=0.40). The number of ex-smokers among the groups of pig farmers was also similar, 8 (23%) and 91 (26%), respectively. The groups were alike also by the proportion experiencing chronic bronchitis (13% and 16%, respectively, p=0.60). However, the discontinued farmers had had significantly more work-related symptoms during the preceding year than those who continued farming (Table 28). The baseline spirometric lung function was significantly lower in farmers changing the main operation or retiring than in farmers continuing pig husbandry (Table 28).

Table 28. *The number and percentage of work-related and acute symptoms as well as the spirometric lung function parameters (mean, standard deviation in parenthesis) in 1997 of the pig farmers continuing and discontinuing pig farming two years later.*

Symptom and lung function parameter	Pig farmers continuing (n=177)		Farmers changing operations or retired (n=34)		p-value
Work related symptoms[1], n (%)	141	(80)	32	(94)	0.045
Acute symptoms[2], n (%)	48	(27)	9	(26)	0.94
VC (L),	5.03	(1.15)	4.54	(0.96)	0.021
VC (% pred)	99	(12)	93	(12)	0.011
FVC (L),	4.88	(1.07)	4.48	(0.94)	0.046
FVC (% pred)	99	(12)	95	(12)	0.07
FEV_1 (L),	3.85	(0.89)	3.40	(0.79)	0.006
FEV_1 (% pred)	97	(14)	89	(15)	0.006
FEV_1/FVC (%)	79	(7)	76	(7)	0.013
MEF_{50} (L),	4.06	(1.46)	3.23	(1.39)	0.002
MEF (% pred)	78	(25)	63	(29)	0.002
MEF_{25} (L), mean	1.27	(0.77)	1.00	(0.57)	0.054
MEF_{25} (% pred)	76	(37)	65	(33)	0.12
FEV_1 <80% of predicted, n (%)	15	(8)	10	(29)	0.001
FEV_1/FVC <88% of predicted, n (%)	14	(8)	8	(23)	0.006

[1] one or more work-related symptoms during the preceding year

[2] one or more symptoms during or immediately after the work shift

7. Discussion

7.1. Selection of study samples

The pig farmers studied were randomly selected from the Satakunta district where the proportion of farmers engaged in pig husbandry is among the highest in Finland. This makes it possible to investigate a representative sample of pig farmers within an area of reasonable size without large climate differences.

In this study, 16% of the farmers left pig husbandry during the two-year period between the first and the second farm visits. In Finland, selection among farmers has been an ongoing process at least since 1990. During the past 10 years when Finland has been the member of the European Union (EU), the structure of Finnish farming has changed rapidly. The number of active farms has decreased by 20% during 1995-2000 (Niemi and Ahlstedt 2005). The decrease has been even higher among livestock farms. The number of farms with pig husbandry as the main activity decreased by 31% during 1995-2000 or 6% annually (Finfood 2005) although this restructuring began before Finland's entry into the EU. While the number of farms has decreased, the average size and productivity of farms have increased (Niemi and Ahlstedt 2005). Further, the pluriactivity of farm families is on the increase (Peltola 2000). It is obvious that there was a selection bias among the sample of pig farmers at the beginning of this study because of the above-mentioned selection process among the source population of pig farmers in the Satakunta district. The sample of pig farmers was drawn from the registry of the Ministry of Agriculture and Forestry, which includes only active farmers. In the setting of this study, it was not possible to search those who had left the source population before the sampling. The role of health-based selection is discussed later.

The controls were a random sample of the general population in the same area, as in the recent European Farmers' Project (Radon et al. 2002a). Controls representing only non-farming or a specific occupation-based population would not allow conclusions regarding the population in general. However, comparing pig farmers with the population in general instead of a more specific control group probably underestimates their work-related risks. The control group from the working age general population included disabled and retired subjects, obviously granting the pig farmers a relatively better state of general health. On the other hand, work-related respiratory symptoms among controls were probably underestimated for the same reason. The control subjects were more often retired or unemployed than the pig farmers; farmers in general have a higher retiring age than other working populations. The high level of unemployment in the control group reflects the general economic and employment situation in Finland during the great economic depression in the 1990s. One way to diminish these differences would have been to restrict the participation of controls only to active workers. However, this would have denied a comparison of symptom patterns between pig farmers and the general population.

The groups of pig farmers and controls differed in the following respects: gender, smoking habits and atopy. The aim of this study was to include both males and females. However, the difference in gender distribution was apparent when selecting the study populations. By including not only the registered owners (mainly males) of the farms but also other active workers on the farms, it was possible to partly correct gender distribution. The male dominance in the study group of pig farmers reflects the gender distribution of Finnish farmers in general. In 1995, 37% and in 1999, 28% of Finnish farmers were women (Finfood 2005). In this study, 29% of the pig farmers were women.

There was a marked difference in smoking habits between the pig farmers and the control subjects. Pig farmers smoked less (11%) and control subjects more (30%) than the population in general (22%) in 1996 (Statistics Finland 2002). The proportion of daily smokers according to Statistics Finland includes subjects over 15 years of age and only those who had smoked at the time of inquiry. Thus the differences in age group and criteria of current smoking partly explain the higher proportion of daily smokers in our control group. Further, socio-economic status explains the high prevalence of current smoking among controls. Nearly half of the control subjects were workers, indicating low educational levels, and the level of unemployment was high (16%). In most countries, smoking is more prevalent among lower-educated groups. In a comparison study of 12 European countries, Cavelaars and co-workers (2000) found large differences in the prevalence of smoking between socio-economic groups, especially in northern European countries including Finland. In Finland the difference was seen in the 20-44 year age group, where smoking rates were higher among lower-educated subjects. However, among farmers, this phenomenon seems not to be true. In the present study, the educational level of the pig farmers was primary school for over half (57%) of them. Despite that, they smoked less than the population in general. The low prevalence of current smoking among pig farmers is comparable with that of Finnish farmers with asthma (Iivonen 2001). A significantly lower prevalence of smoking among farmers than among control subjects was also found in the survey of Farming and Occupational Health in Finland in 1992 (Tammilehto et al. 1994). Similar results of farmers having lower smoking rates than non-farming controls in the same area have been reported from the Netherlands among pig farmers (Vogelzang et al. 1999a), from France among pig and dairy farmers (Choudat et al. 1994, Dalphin et al. 1998) and from Canada among swine, dairy and grain farmers (Cormier et al. 1991, Senthilsevan et al. 1997). Dutch pig farmers smoked less than controls (6.8 and 9.1 pack-yrs, respectively) despite the over-representation of lower or middle professional education among pig farmers compared to controls (Vogelzang et al. 1999a).

The pig farmers had less self-reported atopy than the control subjects. This might be explained by recent findings that a farm environment during childhood (Braun-Fahrländer et al. 1999, Riedler et al. 2000, von Ehrenstein et al. 2000, Kilpeläinen 2001, Pekkanen et al. 2001) and animal husbandry in adulthood (Koskela et al. 2003) are associated with less atopic disorders in later age. This association is thought to occur by endotoxin and other bacterial wall components enhancing the maturation of T-helper (Th) cells to Th1-type cells instead of Th2-type cells, thus downregulating immunoglobulin E responses (von Mutius et al. 2000). Further, changing processes in the structure of Finnish farming may be for other than only economic reasons. Farmers with atopic disorders may leave farming more easily than farmers without health-related problems.

The main differences between the pig farmers and the controls in the questionnaire study (gender, smoking and atopy) were controlled by statistical modelling.

The control subjects for the pig farmers with lung function measurements were matched by grouping gender, age and smoking history defined as pack years. The group matching was successful, since pig farmers and controls were similar in these respects. Further, the groups were similar with respect to atopy and respiratory symptoms (one or more), although the pig farmers had more chronic bronchitis.

7.2. Representativeness of the study populations

The response rates in the questionnaire study (68% for pig farmers and 62% for controls) were higher than in most postal questionnaire studies published in medical journals (below 60%) (Asch et al. 1997) but lower than in two recent Finnish population studies on respiratory symptoms and disease (73% and 84%) (Hedman et al. 1999, Kotaniemi et al. 2001a). Further, the response rate was lower than in two earlier Finnish farmer studies. In a large postal survey conducted in 1979 as a part of the Farmers' Occupational Health Programme, 84% of the farmers to whom the inquiry was sent filled in and returned the questionnaire (Terho et al. 1987d). As a part of the "Farmers' asthma" program, Hanhela and Iivonen (1993) sent a questionnaire to 407 farmers with occupational asthma, of whom 87% replied. However, Peltola (2000) had a response rate of 59% in his farmer enquiry, which was a part of his study about pluriactivity of farm families in Finland.

Common reasons for non-response are that the study questionnaire is sent to a wrong address and a feeling of lack of personal benefit from responding (Bakke et al. 1990), lack of interest in the study or a negative attitude to the health care system (Tibbling 1965, Janzon et al. 1986). In the present study, a wrong mailing address is not likely to explain non-response, since only three questionnaires were returned because of unknown address. In the control group, lack of interest or personal benefit is the most probable reason for not answering. Information of the study given in advance in local journals and at farmers' meetings would have increased the interest in the study and thus may have resulted in higher response rates. Unfortunately this was not done when preparing this study. A low response rate in a questionnaire study may increase risks of random error (lack of precision) and systematic error (selection bias) (Rothman et al. 1998, Sjöström et al. 1999).

Kotaniemi et al. (2001b) has assessed the effect of a non-response bias on results in their previous large postal questionnaire study. They found the percentage of men, current smokers and self-employed men to be higher in the non-response group than in the original study. Accordingly, in the present study the proportion of men was significantly higher among non-respondent controls than in the group of respondent control subjects. The groups were similar in age, while in the study of Kotaniemi, non-responding persons were younger than those who responded to their original study. The proportion of non-responders in the group of pig farmers could be explained by the same reasons Kotaniemi et al. (2001b) presumed: self-employed men are too busy to answer. In addition, at the time of the questionnaire study, Finnish farmers faced increasing paper work and training in their free time due to the transition period to the EU, which may have further decreased interest in postal surveys.

The responding and non-responding pig farmers were alike in gender and age. The main features of the farms (main farm operation, number of pigs) of non-responders did not differ from those who did. Further, during the two-year period, changes in the main features of the farms and production were similar; thus the reason for non-responses was not due to forthcoming changes in production, discontinuing pig husbandry or retirement. In the view of pig husbandry, the responding pig farmers well represented the whole source population of pig farmers.

Kotaniemi et al. (2001b) found that a non-response bias did not significantly affect the results regarding respiratory diseases or symptoms. Only current smoking was underestimated by the original study. In a Norwegian postal survey on airborne occupational exposure and respiratory disorders, Bakke et al. (1990) found that smokers were late responders and subjects with respiratory disorders tended to be early respondents. However, the estimated prevalence of exposures and respiratory disorders, as well as the associations between them, were only slightly changed when initial respondents (63%) were compared to all respondents (90% after two reminders). Hedman (2000) found a tendency that those having a respiratory diagnosis or symptoms were more likely to respond earlier than those without diagnosis or symptoms. He adjusted the prevalence for non-response using the method proposed by Drane (1991). The largest bias in observed versus non-response-adjusted prevalences was for doctor-diagnosed asthma (21.4%); for allergic rhinitis it was 11.6% but for doctor-diagnosed COPD only 3.7% (Hedman 2000).

Fifty-five per cent of pig farmers participating in the questionnaire study were willing to participate in the study including farm visits. The pig farmers participating in farm visits were similar to those who refused with respect to gender, duration of current work and smoking history. The pig farmers with farm visits were approximately two years younger than those without farm visits, and their farms were larger. However they did not differ with respect to respiratory symptoms. Thus, pig farmers with farm visits represented well the whole group of pig farmers.

For the second measurements, 93% of the pig farmers and 87% of the control subjects with the first measurements participated. The losses for the second measurements were regarded as small and therefore were not analysed further.

In conclusion, a selection bias in the questionnaire study is possible because of the moderate response rates. Among the control group the evidence of the selection bias is the gender difference between responding and non-responding controls. A higher response rate would have resulted in a higher proportion of men in the control group and thus diminished the gender difference between the groups. There were no obvious differences among the responding and non-responding farmers or in the features of there farms. However, the moderate response rate in this study might overestimate the prevalence of respiratory symptoms in both groups, presuming that those with health problems respond better.

7.3. Study questionnaire

The Tuohilampi questionnaire includes items based on several different international questionnaires, which have been validated in several studies (Toren et al 1993). The questionnaire used in this study was an applied version of the Tuohilampi questionnaire. However, the study questionnaire included several identical question sets with the final version of Tuohilampi questionnaire. In the present study, the main questions about symptoms were followed by questions about their regularity and duration. Lebowitz and Burrows (1976) found it advantageous to obtain information concerning qualification of associated syndromes independently of the presence or absence of the symptom.

The repeatability of the study questionnaire and the agreement of subjective symptoms with clinically defined diseases were evaluated before the questionnaire study. The repeatability of the questionnaire was good and within a range similar to those of other questionnaires (Burney et al. 1989, Toren et al. 1993). As shown by earlier studies (Lebowitz and Burrows 1976, Samet 1978), factual questions (smoking, atopy) had a higher repeatability than those concerning the perception of symptoms. The real variation in respiratory symptoms affects subjects' responses concerning current symptoms but may also make it more difficult to recall symptom histories.

The sensitivity of symptom-based definitions for identifying clinical asthma or chronic bronchitis with the use of questionnaire proved to be good for screening. The main asthma questions, those including the terms "shortness of breath or wheezing" and "attacks of shortness of breath or wheezing" had the best sensitivity in identifying clinical asthma. This finding agrees with previous results (Bennett et al. 1988). The low sensitivity of WHO criteria for clinical chronic bronchitis with "no" answers to asthma questions reflects the difficulty in distinguishing asthma from chronic bronchitis. The questionnaire definitions for asthma and chronic bronchitis did not separate clinically-defined asthma from chronic bronchitis because patients having either of them reported many similar symptoms. This finding was expected from other studies with similar data (Dodge and Burrows 1980, Dodge et al. 1986, Rijcken et al. 1991). Chronic respiratory diseases have many similarities in symptoms, especially in older age groups, and it is especially difficult to distinguish asthma from chronic bronchitis (Dodge and Burrows 1980, Dodge et al. 1986, Rijcken et al. 1991). This is also the main reason for the low specificity of the questions or question groups used to identify asthma or chronic bronchitis (Toren et al. 1993). In addition, these two diseases may occur simultaneously in same subject.

The population in the validation study of the questionnaire was selected from persons referred to a pulmonary clinic because of respiratory symptoms, and thus there were not "healthy" subjects. Lack of "healthy" subjects may have affected the results with respect to the validity of the questionnaire, especially concerning questions on earlier physician-diagnosed diseases. Kilpeläinen and co-workers (2001) have validated questions on asthma, allergic rhinitis, and conjunctivitis used in the Tuohilampi questionnaire in relation to current disease. They found that diagnosis-based questions had good specificity and positive predictive values (PPV), and symptom-based questions had the highest sensitivity among young adult populations. Hedman (2000) found that Tuohilampi questions concerning asthmatic symptoms and physician-diagnosed asthma showed strong associations with bronchial hyperresponsiveness among subjects with a mean age similar to our study and control subjects. In the questionnaire used in the present study, questions about asthma and allergic disorders were the same as in the Tuohilampi questionnaire. Thus, the results of studies by Kilpeläinen and co-workers (2001) and Hedman (2000) contribute to the validity of the present questionnaire with respect to questions about asthma and allergic disorders.

Misclassification following possible measurement bias due to the imperfect questionnaire is similar in both studied groups and thus nondifferential, which attenuates the associations between exposure and outcome. Thus the observed differences between the groups should be true.

To conclude, the present questionnaire was found to be repeatable and sensitive enough for screening of chronic respiratory symptoms. However, different respiratory diseases could not be further defined with the use of the questionnaire.

7.4. Study nurses and spirometric lung function measurements

The farm visits and lung function measurements were done by three specially trained nurses. Employing more than one study nurse for the lung function measurements may cause measurement bias and weaken the comparability of the results. However, all the nurses were trained by the same laboratory nurse to perform the lung function measurements. The testing protocol was similar throughout the study. In addition, the comparability of the flow-volume spirometer measurements supervised by the nurses was tested before starting farm visits and no major differences in the results were found. The only possible nurse effect was found in the results of MEF_{50}, but this was not significant. The smallest differences were seen in values of FEV_1 and FEV_1/FVC, which were used to describe the main results. All the nurses measured both the farmers and the controls; the measurement bias due to nurse effect would be similar in pig farmers and controls and thus nondifferential.

The spirometer used in this study is made for lung function testing both in clinical and research work; its size was suitable for fieldwork and used interchangeable disposable pneumotachographs. Each manufactured batch of pneumotachographs had its own calibration database. Volume calibration was performed according to the manufacturer's instructions at the start of each measurement session. Measurement bias is less with a spirometer having interchangeable pneumotachographs than with two different spirometers with fixed pneumotachographs. Spirometric measurements were performed according to ATS protocol. Similar equipment and protocol was used for all individuals and for both first and second measurements.

The nurses were not aware of the results of the questionnaire study but during the farm visits they interviewed the study subjects about their respiratory symptoms. Further, it was not possible to blind the nurses to pig farmers and controls during the spirometric measurements. The observer bias caused by these factors is presumed to be minimal because of the careful training of the nurses and the strict protocol for spirometric measurements.

Thus, irrespective of more than one study nurse, the findings and results during the farm visits and spirometric measurements can be assessed as reliable.

7.5. Chronic and work-related respiratory symptoms

Pig farmers in the Satakunta area had twice as much chronic bronchitis compared with the general population in the same area. This is notable, taking into account the significantly lower prevalence of smoking among pig farmers compared to controls. In the multiple logistic regression analysis, pig farming was found to associate independently with chronic bronchitis. The excess prevalence of chronic bronchitis in pig farmers is in concordance with other studies (Vohlonen et al. 1987, Tammilehto et al. 1994, Iversen et al. 1988, Cormier et al. 1991, Monso et al. 2003). Earlier, Tammilehto et al. (1994) found that Finnish farmers had chronic bronchitis 1.5 times as frequently than non-farming control subjects. In Danish farmers, a 1.5-fold risk for chronic bronchitis was also found among pig farmers in relation to dairy farmers or farmers without livestock (Iversen et al. 1988). In accordance with the present results, Canadian pig farmers had an odds ratio of 2.0 (1.2-3.4) for the prevalence of chronic bronchitis in relation to non-farming neighbourhood controls (Cormier et al. 1991).

In the present study, the prevalence of chronic bronchitis in pig farmers (16%) and in controls (9%) was higher than in the survey of Farming and Occupational Health in Finland in 1992 (8% and 7%, respectively; Tammilehto et al. 1994), or among Finnish farmers (8%) in the study of Vohlonen et al. (1987) which used the criteria of WHO for chronic bronchitis. In both earlier Finnish studies, the prevalence of chronic bronchitis among pig farmers was higher than among farmers as a whole (13% and 11%, respectively). Prevalences close to the present data were found in Canadian swine confinement workers (17.5%) and their non-farming controls (12%, Cormier et al. 1991). However, higher prevalences than those mentioned above for chronic bronchitis among pig farmers have been reported from Sweden (34%, Wilhelmsson et al. 1989), Denmark (24%, Iversen and Pedersen 1990) and Canada (25% for chronic phlegm, Donham et al. 1990).

The present study shows no excess of asthma or asthmatic symptoms among pig farmers compared with the population in general. The results are comparable with other studies in Finland (Tammilehto et al. 1994) and elsewhere (Donham 1993, Vogelzang et al. 1999a). However, Iversen et al. (1988) found that pig farming had a stronger risk for asthma (OR 2.0) than for chronic bronchitis (OR 1.5) and asthma-like symptoms were more closely related to pig farming than symptoms of chronic bronchitis (Iversen and Pedersen 1990). In the present study, the prevalence of physician-diagnosed asthma among pig farmers (3%) and controls (3%) was lower than that of self-reported asthma among Finnish farmers (4%) and controls (5%) in the earlier study of Tammilehto and co-workers (1994). Furthermore, the prevalences in the present study are lower than Hedman (2000) reported in his study among adults in southern Finland (4%). In addition, the prevalence of shortness of breath with wheezing is lower among pig farmers (8%) and controls (9%) in the Satakunta area than among adults in the Päijät-Häme area (13%, Hedman 2000). The finding of Hedman (2000) is supported by the results of the Finnish national asthma programme, which found regional differences in asthma prevalence (Astmaohjelma 1994-

2004, 1999). Further, there seems to be regional differences in asthma severity (Aalto et al. 1999). However, the prevalence of asthma among pig farmers in the Satakunta area is comparable with that of European farmers (3%, Monso et al. 2003).

Pig farmers complained more often of work-related symptoms than control subjects. This difference might be explained by lesser working experience among the controls. However, the difference was significant also in the case of respiratory symptoms which worsened at work, which excluded unemployed control subjects from the analysis. Thus, there is a real difference associated with working environment, in concordance with several other studies showing a high prevalence (24%-87%) of work-related symptoms in pig farmers (Donham et al. 1989, 1990, Heederick et al. 1991, Choudat et al. 1994, Radon et al. 2002a). Furthermore, when interviewed by the nurses during farm visits, the majority of pig farmers reported one or more work-related symptoms during the preceding year. The symptom pattern of pig farmers in the Satakunta area was similar to that of Dutch and French pig farmers (Heederick et al. 1991, Choudat et al. 1994). Symptoms such as cough, phlegm and complaints of the nose were common. In the European Farmers' Project, work-related symptoms in pig farmers were related to an asthma-like syndrome (symptoms were mainly shortness of breath, cough without phlegm or wheezing, Radon et al. 2002a).

In the present study, only a few farmers reported symptoms possibly related to ODTS or farmer's lung. The prevalence of ODTS was lower than in previous studies of Finnish farmers (Husman et al. 1990, Tammilehto et al. 1994), although even in those studies ODTS was less common in pig farmers than in dairy or crop farmers. It is probable that work practices and ventilation systems have improved in this respect. Further, the criteria of ODTS used in the present study are stricter than in previous Finnish studies.

7.5.1. Effect of smoking

Smoking is by far the most obvious etiologic factor for chronic bronchitis. In the present study, smoking did not appear to be clearly associated with chronic bronchitis in the study population as a whole. The sizes of the study populations and thus the numbers of smokers were probably too small for the analysis. Current smoking did explain chronic cough, shortness of breath in adult age, and nearly significantly chronic phlegm. A smoking history of 16 pack-years or more was significantly related to chronic cough and chronic phlegm but not chronic bronchitis as defined in this study. However, the prevalence of chronic bronchitis increased with pack-years, although the number of smokers in different categories of pack-years was too small to allow for more detailed analysis. The effect of smoking was not analysed separately in the groups, but in the control group the prevalence of chronic bronchitis increased from 8% in never-smokers to 28% in subjects smoking 16 pack-years or more. This increase in symptom prevalence with increasing pack-years was not seen in pig farmers, in whom the symptoms varied from 21% to 30%. Among the pig farmers, even non-smokers had an excess of chronic bronchitis related to their occupation. Further, the amount of inhaled smoke by given quantity of cigarettes may be smaller in farmers than controls. It is probable that farmers smoke more in the open air than average smokers, thus inhaling less environmental smoke. Dalphin et al. (1989) found a similar difference in smoking effect between farmers and controls. In their study, the effect of smoking on chronic bronchitis was much more evident in the matched administrative control group than in the group of farmers.

7.5.2. Effect of other host factors

Besides pig farming, age and atopy had significant associations with chronic bronchitis. Age and atopy had a significant effect on asthmatic symptoms as well.

The significant effect of age on the occurrence of chronic bronchitis (OR 1.03, 95% CI 1.01-1.06) was of the same magnitude as in a cross-sectional study of Melbostad et al. (1997) among Norwegian farmers. The odds ratio of age as a continuous variable was 1.01 (95% CI 1.004-1.02, Melbostad et al. 1997). Dalphin et al. (1989) found the effect of dairy farming on chronic bronchitis significant in farmers aged 40 years and over (OR 3.2, 95% CI 1.3-7.9) but not in those younger. Furthermore, Iversen et al. (1988) found a marked increase in respiratory symptoms with age (>50 years versus ≤50 years). In their study, the odds ratio for chronic bronchitis of those over 50 years of age was 2.5 (95% CI 1.8-3.6). Age reflects the number of years in farming occupations and thus cumulative exposure (Dalphin et al. 1989, Melbostad et al. 1997). It is common that farmers have been raised on farms and worked in farming since their youth. This was not analysed separately in the present study but was likely, knowing that Finnish farming is generally passed on to the next generation in families. Furthermore, the significantly longer duration of current work among pig farmers than the controls refers to pig farmers starting their working lives earlier than the population in general.

In the present study, atopy had a significant effect on chronic bronchitis (OR 1.6, 95% CI 1.0-2.7), in concordance with the previous findings of Terho (1990) and Terho et al. (1987a, 1995), who have shown atopy to be an independent risk factor for chronic bronchitis among farmers and in the general population. This relates to the theory of Dutch researchers, who have regarded asthma and chronic bronchitis as two aspects of the same underlying mechanisms, i.e. the “Dutch hypothesis” (Orie et al. 1961). It is also possible that some subjects with atopy and symptoms of chronic bronchitis have mild asthma without its symptoms of shortness of breath or wheezing. These asthmatics are not distinguishable from subjects with chronic bronchitis merely by using a symptom questionnaire.

7.5.3. Effect of pig farming

In the present study, pig farming had an independent association with chronic bronchitis. In pig farmers, the prevalence of chronic bronchitis was related with daily working time in pig houses and was significantly higher with six hours or more. A cumulative working time of at least 20 years also significantly increased the prevalence of chronic bronchitis compared with a working history of nine years or less.

Previous results concerning the length of exposure and farming characteristics are partly conflicting. In a small study from Iowa, Donham et al. (1984a) found a significant association between working years and chronic wheezing but not with other chronic symptoms. Supporting the present results, Donham et al. (1989) found that frequency of respiratory symptoms among Swedish pig farmers was related to the number of years and daily time spent working in swine confinement buildings. In another study of Swedish pig farmers, a significant association was found between the number of reported respiratory symptoms and accumulated exposure (time spent in the pig house) during one year (Wilhelmsson et al. 1989). Canadian pig farmers exposed more than three hours daily had a higher incidence of chronic bronchitis than workers with shorter exposures (Cormier et al. 1991). However, in that study the number of years was not associated with chronic bronchitis. Furthermore, in a recent large study of European farmers, a significant dose-response relationship between work-related respiratory symptoms and two or more hours' daily work inside animal houses was established for pig farmers (Radon et al. 2002a). In a large study of Dutch pig farmers, Vogelzang et al. (1996) did not find any association between chronic respiratory symptoms and the number of years in pig farming. The time worked in pig houses per week (>40 hours) was significant in a univariate analysis, but not in a multivariate model where the significant farm characteristics were corrected for each other.

In the present study, no associations were found between chronic symptoms and main farming characteristics. Those farmers using exclusively mechanical feeding systems had fewer chronic respiratory symptoms than those using other types of feeding, but this difference did not reach statistical significance. Accordingly to the present results, as well as those from the studies of Wilhelmsson et al. (1989) and Vogelzang et al. (1996), the type of swine production was not related to respiratory symptoms. In contrast to the present results, Vogelzang et al. (1996) found that Dutch pig farmers using mechanical feeding systems had an increased prevalence of chronic respiratory symptoms compared to farmers using manual feeding. Dutch farmers used wet feeding in their mechanical feeding systems. The authors explained the results by the higher exposure to endotoxin associated with wet feeding. The result of the present study, however, is plausible because mechanical feeding requires less personal attention by the farmer during the feeding period and is associated with a lower exposure (Attwood et al. 1987). In the present study, mechanical feeding included both wet and dry systems. The proportion of exclusively wet mechanical feeding systems was too small for separate analysis. Vogelzang and coworkers (1996) found a significantly increased risk of chronic respiratory symptoms among farmers who used wood shavings as bedding, used disinfectants or employed natural ventilation in confinement buildings. In the present study, the type of ventilation system had no association with respiratory symptoms in a nonadjusted analysis. The majority of the farms had mechanical ventilation; thus the proportion of farms having only natural ventilation was probably too small to show any associations. Associations between bedding material or the use of disinfectants with chronic symptoms were not analyzed in the present study.

In the present study, chronic symptoms were investigated by a cross-sectional questionnaire study and thus the true temporal relationship of pig farming and the symptoms is not possible to assess. Questionnaire data about the total duration of symptoms in addition to the duration of working history would have given information of the time order of exposure and symptoms. However, it is hardly possible that subjects with chronic bronchitis would start pig farming in a higher proportion than those without the symptom. Thus it is plausible that symptom excess has appeared during working years. In addition there was evidence of exposure-response relationship (symptom prevalence increasing with increasing daily exposure time and with increasing working years) which suggests that pig farming is a true risk factor for symptoms of chronic bronchitis.

7.5.4. Across-shift changes in respiratory symptoms

In the present study, one-fourth of pig farmers had one or more symptoms during or immediately after the work shift. This is markedly less than their reported work-related symptoms during the preceding year. During the farm visit, the average duration of work was 1.2 hours (range 0.5-3 hours), significantly less than the reported usual length of the work shift (mean 4.5 hours, range 0-11 hours). For measurements of across-shift changes, working shifts were planned to include normal daily work tasks (e.g. feeding, delivering bedding material, removing manure) and not tasks which farmers performed once or twice a week or less frequently. The working tasks most often related to symptoms during the past year included jobs which the farmers did not perform during the farm visit (e.g. cleaning the swine house, drying or transporting grain). Thus, the working shifts during the farm visits did not represent the most harmful activities with respect to work-related symptoms.

7.6. Spirometric lung function

The baseline spirometric lung function of pig farmers and controls was within Finnish reference values. The proportion of subjects with obstructive lung function was similar in the groups. Among the pig farmers, the mean values for VC (4.95 L, 98% of predicted), FVC (4.81 L, 99%) and FEV_1 (3.78 L, 95%) were significantly better than among the control subjects. Better VC, FVC and FEV_1 but similar FEV% suggest that pig farmers have better lung volumes than the controls.

Comparing the results reported from studies in different countries is difficult because of differences in age and smoking habits of the study populations, varying selection criteria for control groups, different control values for spirometry, and varying criteria of abnormal lung function. This is also true of the present data. The control subjects in the present study represented the general population of the Satakunta area, including farmers (6%) and industrial workers. In other studies of respiratory symptoms and lung function of pig farmers, the control groups have consisted of other farmers or non-farming controls.

The present results stand in contrast to findings by Dosman et al. (1988), who found that male swine producers in Saskatchewan had significantly lower, smoking-pack-years-adjusted, values for FEV_1 and FVC than nonfarming rural male controls (95% versus 104% and 97% versus 107% of predicted, respectively). The FEV_1/FVC ratio (FEV%) was modestly higher in swine producers than in controls (98% versus 97%, respectively). A greater percentage of swine producers in Saskatchewan had FEV_1 and FVC below 85% of predicted (about 18% and 15%, respectively) than control subjects (about 7% and 4%), which is in contrast to the present findings. The results of Dosman et al. (1988) were suggestive of restrictive or mixed disease in swine producers, while the present results suggest restrictive decrement of lung function in the controls. In a later study of swine confinement workers in Saskatchewan, Senthilselvan et al. (1997a) found similar values of unadjusted FEV_1 in the swine confinement workers and nonfarming control subjects, despite the fact that swine confinement workers were younger and had smoked less than the controls. They found evidence that both restrictive and obstructive lung function impairment occurs among farmers. In a study of a sample of Dutch pig farmers, Brouwer et al. (1986) found a significant prevalence of abnormal values in farmers compared to those determined by the European Community for Coal and Steel (12% for FEV_1, 17% for MEF_{50} and 11% for MEF_{25}). The prevalence of abnormal values for FVC (3%) was not significant. Iversen et al. (1989)—after extrapolation of his results to the total population of farmers—suggested that 10% of farmers had an FEV_1 below the 95% confidence limit of predicted values. In contrast to the present data, French dairy farmers had lower FEV_1/VC and FEF_{25-75}% values than nonfarming controls, suggesting obstructive decrement of lung function in farmers (Dalphin et al. 1989). In a later study, significant differences in lung function between dairy farmers and nonexposed controls were found only for FEV_1/VC values (96% versus 99%) (Dalphin et al. 1998). In that study, 21% of dairy farmers and 14% of control subjects (not significant) had FEV_1/VC below 90%. Bronchial obstruction was rarely reversible. The definition for obstruction in the present study was stricter (FEV_1/FVC <88%); thus direct comparisons are difficult to make. In a cross-sectional study of Choudat et al. (1994), accordingly to the present data the mean baseline FEV_1 and FVC were normal according to European control values in French pig and dairy farmers and in non-farming controls, who were not exposed to air contaminants.

In the present study, the prevalence of obstructive lung function (12%, FEV_1/FVC <88%) among the controls was higher than in a survey of a Norwegian general population sample aged 18-73 years (Bakke et al. 1991b) and lower than among a random sample of subjects 45 years of age or older living in Northern Sweden (Lundbäck et al. 2003). In the Norwegian study, 12% had FEV_1 <80% of predicted values and 6% had FEV_1/FVC <0.7; in Northern Sweden the respective prevalences were 14.1% and 14.3%. However, differences in age distribution, smoking habits and criteria of lung function abnormalities may explain the differences in results. In the present study, the definition of obstruction was less strict than in the other studies, and among the control subjects there were fewer lifetime non-smokers (45%) than in Norway (57%) but slightly more than in Sweden (40%). Furthermore, the Swedish population was older than in the present study.

As mentioned before, the group of pig farmers was selected already at the beginning of the study due to the rapid structural change in Finnish farming. An additional health-based selection would explain the lung function results in the present study. This is discussed later.

7.6.1. Effect of smoking

In the present study, the effect of smoking on spirometric lung function, as on chronic bronchitis, was somewhat conflicting. Among the controls the effect of smoking, defined by smoking history (non-smokers, ex-smokers, current smokers) and by pack-years in two classes, was as expected and comparable with previous findings (Burrows et al. 1977, Mastrangelo et al. 2003, Lundbäck et al. 2003, Trupin et al. 2003). However, the effect of smoking on spirometric lung function was not seen in pig farmers. This finding is similar to Dalphin et al. (1989), who did not find any influence of smoking in farmers, in terms of either bronchitis or lung function, but only in the control group. However, they later found that smoking (in four classes or as a continuous variable) had an influence on all respiratory function parameters among dairy farmers and controls (Dalphin et al. 1998). The probable explanation for the present results may be the small number of current smokers and the small number of pack-years among pig farmers. Furthermore, risk estimates of COPD across different occupations have been found to differ strikingly in regard to smoking habits (Mastrangelo et al. 2003).

7.6.2. Effect of other host factors

In this study, no difference was found in baseline spirometry between symptomatic and symptomless pig farmers. Age had a negative correlation on spirometric lung function. Pig farmers older than 50 years of age had significantly more distal airway obstruction than younger ones, while atopy seemed to have a weak, insignificant association with distal airway obstruction.

Regarding the association between respiratory symptoms and lung function, highly conflicting results are reported from different centres. The present results fit with the findings of Heederick et al. (1991), who did not find any significant correlation between lung function and chronic respiratory symptoms among Dutch pig farmers. Schwartz et al. (1992) did not find differences in spirometric measures of airflow between symptomatic (work-related symptoms) swine confinement workers compared with different controls without work-related symptoms, although the symptomatic swine confinement workers had significant elevations in residual volume when compared to the controls. Furthermore, Choudat et al. (1994) found no significant differences in baseline lung function between pig farmers, dairy farmers and non-farming controls, despite a higher prevalence of respiratory symptoms in pig farmers. On the contrary, in several other studies among farmers, an association between respiratory symptoms and lung function has been found (Iversen et al. 1989, Iversen and Pedersen 1990, Preller et al. 1995a, Vogelzang et al 1996, 1998a, Melbostad et al. 1997). Symptomatic Danish farmers had lower FEV_1 than symptomless ones (Iversen et al. 1989, Iversen and Pedersen 1990). Preller et al. (1995a) and Vogelzang et al. (1996, 1998a) found significantly lower lung function in Dutch pig farmers with chronic symptoms than in farmers without such symptoms. Melbostad and co-workers (1997) found chronic bronchitis as a risk factor for obstruction in farmers over 50 years of age.

Among the pig farmers, the effect of age on lung function was demonstrated by the higher prevalence of distal airway obstruction in farmers over 50 years of age. The association of age on obstructive lung function impairment in farmers has been found in several previous, cross-sectional studies (Dalphin et al. 1989, Vergnenegre et al. 1995, Melbostad et al. 1997). In French dairy farmers and their matched administrative controls, the difference in degree of bronchial obstruction was greater in the age group 40 years and older (Dalphin et al. 1989). Vergnenegre et al. (1995) found the risk of distal airway obstruction to be two-fold in French agricultural workers over 50 years of age compared with younger ones. In Norwegian farmers, the risk of airway obstruction was observed mainly in farmers more than 50 years old (Melbostad et al. 1997). Age reflects cumulative exposure, as discussed earlier with respiratory symptoms. On the other hand, age has been found to be an independent risk factor for airway obstruction and chronic obstructive lung disease (Bakke et al. 1991b, Lundbäck et al. 2003, Mastrangelo et al. 2003). In a Norwegian general population, the risk of obstructive airflow limitation was 9.7-fold higher in subjects 55-73 years of age compared to subjects 18-34 years of age (Bakke et al. 1991b). In a case control study of Mastrangelo et al. (2003), the risk of COPD was 28-fold higher in subjects 55-64 years of age than in subjects <45 years of age. The independent effect of age on lung function could be physiological.

The present results suggest some association between atopy and spirometric lung function impairment. Subjects with atopy and airway obstruction may have untreated or poorly treated asthma. This may be true in the present study. Analysing the reversibility of the obstruction would help to distinguish those with asthma from those with an irreversible obstruction. In the present study, the symptom patterns of pig farmers and the determined association of atopy with chronic bronchitis suggested that obstructions in pig farmers were not due to asthma. The "Dutch hypothesis" should mean that atopy is also a risk factor in developing chronic airway obstruction. Fletcher et al. (1976) did not find any relation between increased bronchial responsiveness or evidence of allergy and accelerated decline in FEV_1. Subsequent studies have shown a positive relation between increased bronchial hyperresponsiveness and accelerated annual decline in FEV_1 in smokers (Connellan et al. 1982, Taylor et al. 1985, Tashkin et al. 1996). According to studies among farming populations, farmers in general (Iversen et al. 1989, Iversen and Pedersen 1990, Choudat et al. 1994, Carvalheiro et al. 1995) and swine confinement workers in particular (Schwartz et al. 1992, Bessette et al. 1993, Iversen and Pedersen 1990) experience increased bronchial reactivity. The role of atopy itself or bronchial hyperreactivity in enhancing the risk of chronic bronchial obstruction has been discussed in only a few studies dealing with farmers' respiratory diseases (Cormier et al. 1991, Dalphin et al. 1998, Vogelzang et al. 1998b, Iversen and Dahl 2000). Cormier et al. (1991) found no association between the presence of a skin allergy and a greater prevalence of respiratory symptoms or lower FEV_1/FVC. Dalphin and co-workers (1998) reached similar conclusions in their study among dairy farmers. Vogelzang et al. (1998b) did not find any statistically significant association between mild bronchial responsiveness or atopic sensitisation and longitudinal changes in lung function. These results were supported by the follow-up study of Iversen and Dahl (2000), where differences in bronchial reactivity did not explain the observed accelerated decline in FEV_1 in pig farmers compared to dairy farmers. It has been suggested that the increased bronchial responsiveness of smokers and farmers differs from that associated with asthma (Pride 1986, Sundblad et al. 2002). Hyperresponsiveness may be a consequence of airway narrowing and not an effect of smoking itself (Pride 1986).

7.6.3. Effect of pig farming

According to the present results, daily working time in a swinery or working years in pig farming had no association with baseline spirometric lung function. However, during the follow up there was a weak, insignificant association between an increased risk of lung function impairment and daily working time. The present results are comparable with the findings of Bongers et al. (1987) and Choudat et al. (1994), who found no significant correlation between duration of exposure and pulmonary function. However, opposite results have also been reported. Iversen and Pedersen (1990) found that the number of years in pig farming was negatively associated with FEV_1. In an earlier study, Iversen et al. (1989) found this association only in symptomatic farmers. Lower FEV_1 with increasing numbers of working years has been also found among pig farmers in Netherlands (Vogelzang et al. 1996) and in Germany (Radon et al. 2002a). In concordance, Mastrangelo et al. (2003) showed a positive association between exposure length and COPD risk in farmers and in other occupations, indicating a dose-response relationship. Conflicting results from different studies may have several explanations. The length of cumulative exposure defined by working years is dependent on daily working time, which may vary largely between farmers (0-11 hours in the present study) and thus between studies. Further, the exposure to chemical and biological substances is dependent on working practices and characteristics of the pig house or pig husbandry, which may differ in farms within a study and between studies. Smoking (Trupin et al. 2003) or other factors external to farming (Melbostad et al. 1997) may have interactive effects on exposure. Thus, there may be several factors that make comparisons between different studies difficult.

Health-based selection may be a possible explanation for the result that working time in a swinery or working years in pig farming had no statistical association with baseline spirometry in this study. It is possible that farmers with abnormal or accelerating lung function have left pig farming before this study begun and thus there has been a selection for pig farmers with spirometric lung function better than average. In the present study, this is further confirmed by the results of the spirometric measurements over two years.

7.6.4. Across-shift changes in spirometric lung function

In the present study, changes in spirometry over the pig farmers' working period were small (mean decline of FEV_1 30 ml, and of FVC 20 ml), and did not differ from the changes observed in control subjects during an interval of two hours. In concordance with the present results, Danish pig farmers and Swiss poultry farmers in a European farmers' project did not have any significant decrease in lung function over a feeding period as a whole (Radon et al. 2001). However, symptomatic farmers had a tendency for lung function decline, and among symptomatic German pig farmers this was significant (Radon et al. 2002a). Small but significant across-shift changes have been found in several studies. In a study of 21 pig farmers, Donham et al. (1984b) found small decrements (-5.8% of predicted value for FEV_1 and –3.3 for FVC) in pulmonary function during a 4-hour work shift in a swine confinement building, but the changes were significant only for smokers. In a larger study (168 swine confinement operators), Schwartz and co-workers (1995) showed that pig farmers had greater declines in lung function parameters during a work shift (lasting 2-4 hours) than neighbourhood control farmers. The yearly cross-shift changes varied from 2.07% to 2.86% of the pre-shift value for FEV_1 and from 1.91% to 2.13% for FVC. Donham et al. (1995) showed that smoking had a positive correlation with a decrease in pulmonary function of swine workers over a work shift. Among the present pig farmers, the number of current smokers was only slightly smaller (11%) than among swine confinement workers (15%) in the study of Schwartz et al. (1995); thus the difference in smoking habits does not seem to be a possible explanation for the present results with very small across-shift declines in pulmonary function. In the present study, the mean duration of the work shift was rather short when compared with studies of Donham et al. (1984b) and Schwartz et al. (1995), and may weaken the possible acute effects of working shifts in the swinery.

7.6.5. Changes in spirometric lung function after a period of two years

In the present study, the pig farmers had an accelerated spirometric lung function decline compared with the control subjects, in concordance with previous results in follow-up studies (Senthilselvan et al. 1997a, Vogelzang et al. 1998a, Iversen and Dahl 2000). Among the pig farmers in the Satakunta area, the mean decline in FEV_1 was 220 ml in two years or approximately 110 ml/year. In controls, the decline was one-fourth of that of pig farmers. The mean decline of FEV_1 in the pig farmers is large compared to continuing smokers (62 ml/year) (Scanlon et al. 2000) and healthy non-smokers (29 ml/year) (Quanjer et al. 1993). The difference between pig farmers and controls is remarkable, taking into account that there were fewer current smokers among pig farmers (11%) than among the controls (26%). The annual decline in FEV_1 of pig farmers in the Satakunta area is greater than reported in recent longer follow-up studies (73 ml) (Vogelzang et al. 1998a, Iversen and Dahl 2000). As with FEV_1, an accelerated decline was also seen in FVC among the pig farmers (155 ml/year) compared to the controls (65 ml/year). Furthermore, this decline is greater than reported for pig farmers in previous studies (62-55 ml/year) (Senthilselvan et al. 1997a, Vogelzang et al. 1998a). In contrast to the present results, Iversen and Dahl (2000) did not find any excessive decrease in FVC in their 7-year follow-up of Danish pig farmers.

The difference in the spirometric lung function decline between the pig farmers and controls is not likely to be due to differential measurement bias. The reasons for this judgement are discussed earlier in the chapter of study nurses and spirometric lung function measurement. The short period between the first and the second measurements in the present study may have produced a bias in the observed change in lung function. The factors affecting the interpretation of lung function measurements (patient- and procedure-related source of variation, Kerstjens et al. 1997), if not controlled, become more pronounced with a shorter follow-up time and only two measurements of lung function. It has been shown that the precision of estimates of annual rate change of pulmonary function increases with an increased number of measurements (Schlesselman et al. 1973). Several studies have shown remarkable discrepancies between estimates of annual decline derived from cross sectional studies and longitudinal findings (van Pelt et al. 1994, Kerstjens et al. 1997). It is not clear whether longitudinal estimates of decline in pulmonary function should be greater than, equal to or smaller than estimates derived from cross-sectional studies (van Pelt et al. 1994). With several measurements, there is a learning effect, which will produce a positive bias on estimates of change. With experience, higher spirometric values are achieved and thus the longitudinally estimated decline may be less steep than it really is (Fletcher et al. 1976, Xu et al. 1995). Irrespective of a possible bias, the present finding of an accelerated decline of spirometric lung function in pig farmers compared with the population in general is evident and comparable with previous results.

It is likely that the decline of spirometric lung function reflects the airway inflammation found in pig farmers (Pedersen et al. 1990, 1996, Palmberg 2002). The decline of FVC, meaning a reduction in lung volume, suggests that inflammation and airways injury may be present not only in bronchial epithelium but also in lung parenchyma, as found with cigarette smoking (Saetta 1999).

It seems that farmers at risk of accelerated decline of spirometric lung function are not found solely by screening for respiratory symptoms. In the present study, the decline of spirometric lung function was not different for farmers with one more chronic respiratory symptoms compared with asymptomatic farmers. This is in concordance with the findings of Vogelzang et al. (1998a). Furthermore, in the present study there was no difference in spirometry decline for farmers with work-related symptoms or not. Iversen and Dahl (2000) found a larger annual decline in FEV_1 and FVC for farmers with work-related asthma-like symptoms, but the differences were not significant. In the present study, the effect of smoking on the decline of spirometric lung function was seen only in the group of controls. Among the pig farmers, the numbers of subjects among the three subgroups classified by smoking status were too small for statistical significance. However, it is plausible to suggest that smoking will aggravate the effect of pig farming on the decline in lung function, knowing the harmful effects of smoking (Lundbäck et al. 2003) and the additive or interactive effect of smoking together with occupational exposures on lung function (Krzyzanowski et al. 1988, Xu et al. 1992, Trupin et al. 2003).

7.7. Protective effect of personal dust respirators

In this study, over half of the pig farmers reported that they used a personal dust respirator. However, during farm visits only one-fourth of farmers used respirators while performing one or more work tasks—a proportion comparable with the results in the questionnaire dealing with the regular use of a respirator in different work tasks. In 1997, one-fifth of the farmers using a dust respirator had filters with the lowest protective capacity, but the at the time of the second evaluation a marked proportion of farmers had changed the filters to better ones, and in 1999 the majority of the respirators had filters with a P2 or P3 category. The first farm visit may have had an intervention effect with respect to respirators.

Farmers having histories of asthmatic or work-related symptoms were most likely to use respirators. This finding is similar to the results of Von Essen et al. (1999), who found strong associations between ODTS history and the use of a respirator while working. However, Zedja et al. (1993b) showed that farmers using a dust mask for preventative purposes had a better respiratory health status than those using it for other reasons or not at all. In the present study, individual reasons for starting the usage of respirators were not examined, be it for pre-existing respiratory symptoms or preventative purposes. Thus the true protective effect of dust respirators for chronic respiratory symptoms cannot be analyzed. However, in the present study, farmers' respiratory symptoms across a work shift increased significantly when they left off the dust respirator, suggesting a protective effect for the respirators, as demonstrated by Dosman et al. (2000).

In the present study, no differences in across-shift changes in spirometric lung function dependent on the use of dust respirators were found. The across-shift changes were small as a whole, possibly due to too short a duration of work shifts. Thus it was likely that the effect of changes in circumstances (the use of a dust respirator) is not detectable.

7.8. Health-based selection bias among pig farmers?

The farmers leaving pig husbandry after the first farm visit had significantly more work-related symptoms during the year before the first farm visit in 1997 and significantly more acute symptoms during the work shift in 1997 than those continuing pig husbandry in 1999. However, the number of cases with chronic bronchitis was similar. Those farmers leaving pig husbandry also had significantly lower baseline lung function than the continuing pig farmers.

As discussed earlier, there have been structural changes in Finnish farming and thus selection before and during this study. It is probable that the phenomenon found in this study—discontinuing pig farmers having lower spirometric lung function than those continuing—has also occurred before the study began. That would explain why pig farmers in the present study had better or similar baseline spirometric values than the control subjects despite an accelerated spirometric decline during the two-year period.

Radon et al. (2002b) found a significantly higher prevalence of chronic bronchitis for the dropouts than for those workers remaining under occupational cohort studies. Despite the abundance of organic and inorganic agents in their working environment, pig farmers and other animal farmers have shown to have an even lower prevalence of asthma and allergies than the population in general (Iversen 1992, Radon et al. 2002a). This could be due to a health-based selection of nonasthmatics for pig farming (Vogelzang et al. 1999a). In the present study, no selection regarding chronic bronchitis was determined among the pig farmers. Differences in numbers of work-related symptoms and lung function, however, suggest that there is a true health-based selection among pig farmers. However, only a few farmers reported health-based reasons for leaving pig husbandry. The main reasons for changing the main farm operation or discontinuing pig farming were economic (47%) and retirement (35%). Economic reasons refer to the structural developments which Finnish farming is undergoing (Niemi and Ahlstedt 2005). Despite of over a third of discontinued farmers being retired, the discontinuing and continuing pig farmers were alike in age. Early retirement before the official retirement age has been possible among Finnish farmers due to farmers' early retirement programmes (Pietola et al. 2003). However, during the past ten years the mean age of Finnish farmers has risen by almost three years partly because of low levels of transferring farms to new entrants (Niemi and Ahlstedt 2005). Health-based selection would be less likely among farmers than other workers for several reasons. As the usual owners (or spouses of the owners) of the farms, farmers have made heavy investments in their operations (Niemi and Ahlstedt 2005) and, on the other hand, often have low levels of education which compel them to continue until health problems arise. Peltola (2000) found that a third of those full-time farmers considering off-farm employment regarded their health as too poor for farm work. However, according to his study, farmers had many obstacles for other employment. More than half of the full-time farmers who had considered off-farm employment considered their occupational skills and training to be deficient for off-farming occupations. Among factors relating to the full-time farms were a willingness to give up farming but lack of alternatives or 'being stuck to the farm' (Peltola 2000). On the other hand, Peltola (2000) also found a strong commitment to farming and living in the countryside among farmers and farm families on pluriactive farms.

Another explanation for the low or normal prevalence of asthma among farmers would be recent findings how farming environments protect against asthma and atopic disorders (Braun-Fahrländer et al. 1999, Riedler et al. 2000, von Ehrenstein et al. 2000, Kilpeläinen 2001, Pekkanen et al. 2001). In concordance with this, the present study's farmers were less atopic than control subjects thus lessening their sensitivity to allergic asthma.

In conclusion, the rapid structural change underway in Finnish farming seems to be the main reason to leave pig husbandry at least according to farmers' reports. However, accelerated spirometric lung function decline and a higher prevalence of work-related symptoms among discontinuing farmers than continuing farmers found in the present study suggest that health-related reasons have an influence on farmers' decisions.

8. Conclusions

The most important conclusions to be drawn are:

1. The questionnaire used in this study is repeatable and sensitive enough for screening of chronic respiratory symptoms. Factual questions (smoking, atopy) had a higher repeatability than those concerning the perception of symptoms. The sensitivity of symptom-based definitions for identifying clinical asthma or chronic bronchitis was satisfactory for screening. The specificity of reporting physician-diagnosed asthma or chronic bronchitis was high. The questionnaire definitions for asthma and chronic bronchitis did not separate clinically-defined asthma from chronic bronchitis.

2. Pig farmers have more cough, phlegm, symptoms of chronic bronchitis and work-related respiratory symptoms than the population in general. The prevalence of symptoms of chronic bronchitis was two-fold among pig farmers compared with the population in general, despite less smoking among pig farmers. The prevalence of asthmatic symptoms among pig farmers was similar to that of the population in general. Pig farmers reported work-related respiratory symptoms nearly three times more often than general population. Among pig farmers, respiratory symptoms worsened at work more than twice as often than among employed controls. Farmers leaving pig husbandry had more work-related symptoms than those who continued.

   In addition to pig farming, atopy and age were associated with symptoms of chronic bronchitis.

3. The baseline spirometric lung function of active pig farmers is normal. The spirometric lung function of pig farmers was slightly better than that of the population in general. However, lung function was within normal limits in both studied groups. The prevalence of abnormal spirometric lung function among pig farmers was similar to that of the controls. There was no significant association between chronic respiratory symptoms and baseline spirometry among pig farmers.

   In the present study, farmers over 50 years of age had more distal airway obstruction in baseline spirometry than younger ones. During the two-year period, age had a significant linear association with the decline of FVC among pig farmers.

4. Among pig farmers, daily working time and working years in pig husbandry were associated with symptoms of chronic bronchitis. Daily working times of six hours or more and working histories of 20 years or more were significantly associated with increasing prevalence of chronic bronchitis. In the present study, the main farming characteristics had no significant associations with chronic respiratory symptoms. There was a suggestive finding that mechanical feeding systems are associated with fewer chronic respiratory symptoms.

Working history in terms of daily working time or working years in pig husbandry does not seem to be associated with baseline lung function among active pig farmers. Short working shifts have no significant effect on lung function. In the present study, the changes in lung function across a working shift were small, and the changes observed in pig farmers did not differ from that of the control population.

5. Pig farmers have an accelerated lung function decline compared with the population in general. The observed declines in forced expiratory volume and forced vital capacity were nearly four times more rapid in the pig farmers than in the controls despite fewer current smokers among pig farmers.

   There is a suggestion of a health-based selection among pig farmers. Those sixteen per cent of pig farmers who left pig husbandry during the two-year period had lower baseline spirometric lung functions and a higher proportion of abnormal lung function values than farmers who continued pig farming. Discontinuing farmers had also more work-related symptoms than continuing pig farmers.

   Pig farmers need to be monitored by regular spirometric measurements to discover those farmers at risk of an accelerated lung function decline.

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11. Appendices

11.1. Appendix 1. Study questionnaire

KYSELY HENGITYSELINOIREIDEN ARVIOIMISEKSI N:o _________

vastauspäivämäärä: ____

vastaajan nimi: ____

syntymäaika: ____________________ **sukupuoli:** 1 mies
2 nainen

lähiosoite: ____

postinumero ja -toimipaikka: ________________________________

puhelinnumero: ____

nykyinen työtehtävä: ______________________________________

nykyinen työpaikka: ______________________________________

OHJEET VASTAAJALLLE

Kysymyksiin vastataan rengastamalla oikean vaihtoehdon numero.
Useita vaihtoehtoja sisältävissä kysymyksissä rengastakaa niiden vaihtoehtojen numerot (yksi tai useampia), jotka sopivat kohdallenne.

Esim: ① mies
2 nainen

Esim: 2 vähemmän kuin kaksi peräkkäistä vuotta
③ kaksi peräkkäistä vuotta tai kauemmin

Joissakin kysymyksissä vastataan kirjoittamalla yksittäiseen ruutuun haluttu luku (esim. vuosien lukumäärä yhden vuoden tarkkuudella).
Mikäli vastauksenne on kieltävä, on tärkeää silti vastata rengastamalla vaihtoehto ”0” (ei).
Muistattehan vastata kaikkiin kysymyksiin!

KYSYMYKSET

1.1. Onko Teillä koskaan ollut pitkään jatkunutta yskää ?

0 ei *(siirtykää kysymykseen 2.1.)*
1 kyllä

1.2. Onko yskää ollut viimeisten 12 kuukauden aikana?

0 ei
1 kyllä

1.3. Onko yskää ollut päivittäin tai lähes päivittäin?

0 ei *(siirtykää kysymykseen 2.1.)*
1 kyllä

1.4. Onko tällaista yskää ollut yhteensä ainakin kolmen kuukauden ajan vuodessa?

0 ei *(siirtykää kysymykseen 2.1.)*
1 kyllä

1.5. Kuinka monena vuotena kysymyksissä 1.3. ja 1.4. kuvattua yskää on ollut?

2 vähemmän kuin kaksi peräkkäistä vuotta
3 kaksi peräkkäistä vuotta tai kauemmin

2.1. Onko Teillä koskaan ollut pitkään jatkunutta limannousua?

0 ei *(siirtykää kysymykseen 3.1. Jos vastasitte kieltävästi myös kysymykseen 1.1., voitte siirtyä kysymykseen 4.1.)*
1 kyllä

2.2. Onko limannousua ollut viimeisten 12 kuukauden aikana?

0 ei
1 kyllä

2.3. Onko limannousua ollut päivittäin tai lähes päivittäin?

0 ei *(siirtykää kysymykseen 3.1.)*
1 kyllä

2.4. Onko tällaista limannousua ollut yhteensä ainakin kolmen kuukauden ajan vuodessa?

0 ei *(siirtykää kysymykseen 3.1.)*
1 kyllä

2.5. Kuinka monena vuotena kysymyksissä 2.3. ja 2.4. kuvattua limannousua on ollut?

2 vähemmän kuin kaksi peräkkäistä vuotta
3 kaksi peräkkäistä vuotta tai kauemmin

3.1. Onko oireita (*yskä ja/tai limannousu*) ollut...

2 ympärivuotisesti *(siirtykää kysymykseen 3.3.)*
3 kausittain tai kausittain pahentuen
4 en osaa sanoa

3.2. Milloin kausittain esiintyviä oireita on yleensä ollut?

2 keväällä
3 kesällä
4 syksyllä
5 talvella
6 lomakaudella
7 työkaudella
8 ei liity vuodenaikoihin tai työ-/lomajaksoihin

3.3. Onko yskään tai limannousuun koskaan liittynyt hengityksen vinkumista?

0 ei *(siirtykää kysymykseen 4.1.)*
1 kyllä

3.4. Onko tällaista yskää tai limannousua ollut...

2 vain hengitystietulehdusten *(esim. flunssan tai keuhkoputkentulehduksen)* yhteydessä
3 muulloinkin kuin hengitystietulehdusten yhteydessä

4.1. Onko Teillä koskaan ollut kohtauksittain esiintyvää hengenahdistusta?
(ei tarkoiteta tavallista hengästymistä)

0 ei *(siirtykää kysymykseen 5.1.)*
1 kyllä

4.2. Milloin hengenahdistuskohtauksia on ollut?

2 ennen kouluikää
3 kouluiässä
4 aikuisena *(yli 18 vuotiaana)*
5 viimeisten 12 kuukauden aikana

4.3. Onko Teillä ollut hengenahdistuskohtauksia, joihin on liittynyt hengityksen vinkumista?

0 ei
1 kyllä

4.4. Onko hengityksenne ollut kohtausten välillä normaalia?

0 ei
1 kyllä

4.5. Oletteko koskaan yöllä herännyt hengenahdistuskohtaukseen tai hengityksen vinkumiseen?

0 ei
1 kyllä

Jos Teillä ei ole mitään edellä kysyttyjä oireita, siirtykää kysymykseen 5.4.

5.1. Mikä tai mitkä seuraavista tekijöistä mielestänne pahentavat oireitanne? *(yskää, limannousua tai hengenahdistusta)*

2 ulkoilman pöly tai käry
3 työpaikan pöly tai käry
4 koti-ilman pöly tai käry
5 tupakansavu
6 tuoksut tai hajut
7 lämmin ilma
8 kylmä ilma
9 ruumiillinen rasitus
10 henkinen rasitus
11 ruoka
12 juomat

5.2. Vaikeutuvatko oireenne *(yskä, limannousu tai hengenahdistus)* **yleensä ...**

2 työviikon tai -jakson alussa
3 työviikon tai -jakson lopussa
4 vapaapäivinä
5 en ole huomannut vaihtelua
6 en ole nyt työsuhteessa *(siirtykää kysymykseen 5.4.)*

5.3. Miten oireenne muuttuvat vuosiloman aikana?

2 pysyvät ennallaan
3 pahenevat
4 lievenevät tai häviävät kokonaan

5.4. Onko Teillä koskaan ollut työstä johtuvia hengityselinoireita?

0 ei
1 kyllä

5.5. Mitä seuraavista oireista on esiintynyt viimeksi kuluneen vuoden aikana toistuvasti?

2 kuivaa yskää
3 kuumetta tai vilunväreitä
4 selkäsärkyä
5 limannousua yskiessä
6 hengenahdistusta
7 hengityksen vinkumista tai pihinää
8 poikkeavaa hengästymistä rasituksessa
9 kurkunpään ärsytystä tai karheutta
10 nuhaa
11 pahoinvointia
12 ei mitään edellä kysytyistä

6.1. Onko Teillä koskaan ollut maitorupea tai taiveihottumaa eli ns. atooppista ihottumaa?

0 ei
1 kyllä

6.2. Onko Teillä koskaan ollut heinänuhaa tai muuta, esimerkiksi siitepölyihin tai eläimiin liittyvää allergista nuhaa?

0 ei
1 kyllä

6.3. Onko Teillä koskaan ollut siitepölyyn tai eläimiin liittyvää allergista silmätulehdusta tai silmien kutinaa?

0 ei
1 kyllä

6.4. Onko Teillä koskaan ollut siitepölyyn tai eläimiin liittyvää hengenahdistusta?

0 ei
1 kyllä

7.1. Oletteko ollut lääkärin hoidossa tai tutkimuksissa hengityselinoireiden takia?

0 ei *(siirtykää kysymykseen 7.4.)*
1 kyllä

7.2. Kuinka monta kertaa olette käynyt hengityselinoireiden takia seuraavien lääkärien vastaanotolla viimeisen vuoden aikana?

2 terveyskeskuslääkäri tai muu yleislääkäri . . . . [ ] kertaa
3 työterveyslääkäri . . . . [ ] kertaa
4 erikoislääkäri . . . . [ ] kertaa

7.3. Kuinka monta kertaa olette ollut hoidossa sairaalan vuodeosastolla hengityselinoireiden takia viimeisen vuoden aikana? . . . . [ ] kertaa

7.4. Kuinka monta kertaa Teillä on ollut seuraavia hengityselintulehduksia viimeisen vuoden aikana?

2 flunssa . . . . [ ] kertaa

3 poskiontelontulehdus . . . . [ ] kertaa

4 keuhkoputkentulehdus . . . . [ ] kertaa

5 keuhkokuume . . . . [ ] kertaa

7.5. Kuinka monta kertaa olette saanut antibioottikuurin hengityselintulehduksen hoidoksi viimeisen vuoden aikana? . . . . . . [ ] kertaa

8.1. Onko lääkäri todennut Teillä jonkun seuraavista pitkäaikaisista hengityselinsairauksista?

2 krooninen keuhkoputkentulehdus eli krooninen bronkiitti

3 keuhkonlaajentuma eli keuhkoemfyseema

4 keuhkoputkien laajentumat eli bronkiektasiat

5 keuhkoastma

6 joku muu, **mikä?** ____________________

7 ei lääkärin toteamia pitkäaikaisia hengityselinsairauksia

8.2. Onko Teillä lääkärin toteama krooninen sydämen vajaatoiminta?

0 ei

1 kyllä

9.1. Oletteko koskaan tupakoinut?

0 ei *(siirtykää kysymykseen 9.8.)*

1 kyllä

9.2. Oletteko koskaan tupakoinut säännöllisesti?
(= lähes joka päivä ainakin yhden vuoden ajan)?

0 ei *(siirtykää kysymykseen 9.8.)*

1 kyllä

9.3. Minkä ikäinen olitte aloittaessanne säännöllisen tupakoinnin? . . . . [ ] vuotias

9.4. Kuinka monta vuotta olette tupakoinut säännöllisesti yhteensä? *(vähentäkää yli 6 kk kestäneet tupakkalakot)* . . . . [ ] vuotta

9.5. Tupakoitteko nykyisin säännöllisesti?

0 ei

1 kyllä

9.6. Koska olette tupakoinut viimeksi?

2 eilen tai tänään

3 2 pv – 1 kk sitten

4 yli 1 kk – puoli vuotta sitten

5 yli puoli vuotta – vuosi sitten

6 yli vuosi sitten, **minä vuonna?** 19________

9.7. Kuinka paljon poltatte nykyisin tai poltitte ennen lopettamistanne keskimäärin päivässä?

2 savukkeita . . . . ☐ kpl
3 piippua . . . . ☐ piipullista
4 sikareita . . . . ☐ kpl

9.8. Tupakoiko joku säännöllisesti kotonanne sisätiloissa silloin, kun olitte lapsi?

0 ei kukaan
2 äiti
3 isä
4 joku muu

9.9. Joudutteko nykyisin oleskelemaan viikottain sisätiloissa, joissa tupakoidaan?

0 ei
2 kotona
3 työpaikalla
4 vapaa-aikana

9.10. Kuinka monta tuntia keskimäärin olette viikottain sisätiloissa, joissa tupakoidaan? . . . . ☐ tuntia

10.1. Mikä on nykyinen työtilanteenne?

2 työssä
3 työtön
4 eläkkeellä
5 opiskelen
6 muusta syystä pois työelämästä

10.2. Kuinka kauan olette ollut tällä hetkellä työttömänä, eläkkeellä tai muusta syystä pois työelämästä? . . . . ☐ vuotta

10.3. Kuinka kauan olette ollut nykyisessä tai sitä vastaavassa työssä? . . . ☐ vuotta

SIKATALOUTEEN LIITTYVÄT LISÄKYSYMYKSET

11.1. Mikä on tilanne tärkein tuotantosuunta? *(korkeintaan kaksi vaihtoehtoa)*

2 sikatalous
3 lypsykarjatalous
4 muu nautakarjatalous
5 kanatalous
6 muu kotieläintalous **Mikä?**______________________________
7 viljanviljely
8 juurikasvienviljely
9 muu kasvinviljely **Mikä?**______________________________
10 metsätalous
11 muu tuotantosuunta **Mikä?**______________________________
12 ei enää varsinaista tuotantoa

11.2. Onko tuotantosuunta vaihtunut sinä aikana kun olette tehnyt maataloustyötä?

0 ei *(siirtykää kysymykseen 12.1.)*

1 kyllä

11.3. Oliko tuotantosuunnan vaihtoon syynä tai osasyynä hengityselinsairaus?

0 ei

1 kyllä

11.4. Mikä tuotantosuuntanne oli ennen nykyistä?

2 sikatalous
3 lypsykarjatalous
4 muu nautakarjatalous
5 kanatalous
6 muu kotieläintalous **Mikä?**______________________________
7 viljanviljely
8 juurikasvienviljely
9 muu kasvinviljely **Mikä?**______________________________
10 metsätalous
11 muu tuotantosuunta **Mikä?**______________________________

12.1. Mitä eläimiä tilanne on?

2 sikoja

3 lypsylehmiä

4 lihanautoja tai muuta nautakarjaa

5 kanoja

6 muuta siipikarjaa

7 lampaita, vuohia

8 hevosia

12.2. Teettekö kotieläinten hoitoon liittyviä töitä?

0 ei *(siirtykää kysymykseen 13.1.)*

1 kyllä

12.3. Mitä kotieläinten hoitoon liittyviä töitä teette päivittäin tai useita kertoja viikossa?

2 rehun jako

3 säilörehun irrotus tai jako

4 heinän tai kuivikkkeiden jako

5 lannanpoisto

6 muuta **Mitä?**____

12.4. Mitä kotieläinten hoitoon liittyviä töitä teette viikottain tai kuukausittain?

2 viljan jauhatus
3 eläinten harjaus tai puhdistus tai karvan leikkaaminen
4 kotieläinrakennuksen puhdistus
5 eläinten punnitus
6 eläinten lastaus myynnin yhteydessä
7 muuta **Mitä?**____________________

13.1. Mikä on sikatalouden tuotantomuoto tilallanne?

2 porsastuotanto
3 lihasikojen kasvatus
4 yhdistelmätuotanto
5 jalostustoiminta

13.2. Minkätyyppinen sikala on?

2 ”karsinasikala”
3 ”pihattosikala”
4 sekä karsina- että pihattosikala **Miten siat on jaettu näiden kesken?** __________

____

13.3. Kuinka paljon tilallanne on sikoja? *(viimeisen vuoden aikana keskimäärin kerrallaan)*

2 emakoita . . . . ☐ kpl
3 porsaita *(alle 3 kk:n ikäiset porsaat)* . . . . ☐ kpl
4 lihasikoja *(yli 3 kk:n ikäiset siat)* . . . . ☐ kpl
5 karjuja . . . . ☐ kpl

13.4. Mikä on sikalan lattiapinta-ala? *(ilman varastotiloja)* . . . . ☐ m^2

13.5. Mikä on karsinoiden yhteispinta-ala . . . . ☐ m^2

13.6. Kuka hoitaa tilanne päivittäisen sikalatyön? *(yksi tai useampi vaihtoehto)*

2 itse
3 puoliso
4 poika / tytär
5 palkattu työntekijä **Kuinka monta?**____________________
6 joku muu **Kuka?**____________________

13.7. Kuinka monta tuntia keskimäärin päivässä itse työskentelette sikalassa? . . . . ☐ tuntia

13.8. Kuinka monta vuotta olette itse työskennellyt päivittäin tai lähes päivittäin sikalassa? *(tilapäisiä taukoja esim. sairauden takia ei oteta lukuun)* . . . . ☐ vuotta

13.9. Miten sikojen ruokinta on järjestetty? *(yksi tai useampi vaihtoehto; rengastakaa ruokintavaihtoehdon/-ehtojen kohdalta myös kyseisellä tavalla ruokittavat siat)*

2 rehun jako vaunusta käsin: a) emakot b) porsaat c) lihasiat d) muut siat

3 rehun jako vaunusta koneellisesti: a) emakot b) porsaat c) lihasiat d) muut siat

4 kuivaruokinta täysin koneellisesti: a) emakot b) porsaat c) lihasiat d) muut siat

5 liemiruokinta koneellisesti: a) emakot b) porsaat c) lihasiat d) muut siat

6 muu **Mikä?**____

13.10. Minkälaista rehua sikalassa käytetään? *(yksi tai useampi vaihtoehto)*

2 jauhorehu

3 rakeistettu rehu

4 tuoresäilötty viljarehu

5 liemiruokinta

6 muu rehu **Mikä?**____

13.11. Lisätäänkö viljarehuun öljyä?

0 ei

1 kyllä

13.12. Täytetäänkö rehuvaunu eläintilassa?

0 ei

1 kyllä

13.13. Mitä kuiviketta sikalassa käytetään?

0 ei kuiviketta

2 sahanpuru

3 kutterinpuru

4 olki

5 turve

6 muuta **Mitä?**____

13.14. Minkälainen lannanpoistojärjestelmä sikalassa on? *(yksi tai useampi vaihtoehto; rengastakaa lannanpoistojärjestelmän kohdalta myös kyseiseen menetelmään liittyvät siat)*

2 lietelantamenetelmä: a) emakot b) porsaat c) lihasiat d) muut siat

3 kuivalanta, lannanpoisto käsin: a) emakot b) porsaat c) lihasiat d) muut siat

4 kuivalanta, lannanpoisto koneellisesti a) emakot b) porsaat c) lihasiat d) muut siat

5 kuivikepohjainen pihatto (=”purupohjasikala”): a) emakot b) porsaat c) lihasiat d) muut siat

6 muu **Mikä?**____

13.15. Kostutetaanko eläintilan ilmaa vesi- tai öljysumutuksin?

0 ei

1 kyllä

14.1. Kuivataanko tilallanne rehuviljaa?

0 ei *(siirtykää kysymykseen 15.1.)*

1 kyllä

14.2. Miten kuivaatte rehuviljanne?

2 lämminilmakuivurilla

3 kylmäilmakuivurilla

4 molemmat käytössä

15.1. Säilötäänkö tilallanne rehuviljaa?

0 ei

1 kyllä

16.1. Käytetäänkö tilallanne kuivaheinää?

0 ei *(siirtykää kysymykseen 17.1.)*

1 kyllä

16.2. Miten heinä varastoidaan?

2 irtoheinänä

3 pienpaaleissa

4 suur- eli pyöröpaaleissa

5 muu menetelmä

0 ei varastoida

16.3. Lisäkuivataanko varastoheinää latokuivurilla?

0 ei

1 kyllä

17.1. Käytetäänkö tilallanne kuivattua olkea?

0 ei *(siirtykää kysymykseen 18.1.)*

1 kyllä

17.2. Miten olki varastoidaan?

2 irto-olkena

3 pienpaaleissa

4 suur- eli pyöröpaaleissa

5 muu menetelmä

0 ei varastoida

17.3. Lisäkuivataanko varastoitua olkea latokuivurilla?

0 ei

1 kyllä

18.1. Käytetäänkö tilallanne kotitarvemyllyä?

0 ei *(siirtykää kysymykseen 19.1.)*

1 kyllä

18.2. Minkälainen mylly on?

2 täysin automaattisesti toimiva

3 vaatii vierellä oloa käytön aikana

19.1. Käytättekö hengityksensuojaimia?

0 ei *(siirtykää kysymykseen 20.1.)*

1 kyllä

19.2. Missä töissä käytätte lähes aina hengityksensuojainta?

2 ruokinta–aikana

3 viljan jauhatuksessa

4 tuotantorakennusten kausipuhdistuksessa

5 eläinten punnituksessa

6 viljasiilon puhdistuksessa

7 muussa työssä **Missä?**____

0 ei säännöllisesti missään työssä

19.3. Minkätyyppistä hengityksensuojainta käytätte?

2 kertakäyttöinen

3 puolinaamari

4 kokonaamari

5 moottoroitu

6 muu **Mikä?**____

19.4. Minkälainen suodatin hengityssuojaimessanne on?

0 ei luokiteltua suodatinta

2 pölysuodatin, luokka P1

3 pölysuodatin, luokka P2

4 pölysuodatin, luokka P3

5 kaasusuodatin, luokka A (orgaaniset kaasut)

6 kaasusuodatin, luokka B (epäorgaaniset kaasut)

7 kaasusuodatin, luokka E (rikkidioksidi)

8 kaasusuodatin, luokka K (ammoniakki)

9 en tiedä

20.1. Onko tuotantorakennuksessa koneellinen ilmanvaihtolaitteisto?

0 ei *(siirtykää kysymykseen 21.1.)*

1 kyllä

2 kyllä, mutta vain osassa **Missä osassa?**___________________________

20.2. Minä vuonna ilmanvaihtolaitteisto on hankittu? 19__________

20.3. Missä ilmanpoisto sijaitsee? *(yksi tai useampi vaihtoehto)*

2 katossa

3 lattian alla olevien poistokanavien tai lattiakanavien päässä

4 seinällä

5 muualla **Missä?**

21.1. Mikä on peruskoulutuksenne?

2 enintään kansakoulu

3 peruskoulu

4 keskikoulu

5 ylioppilastutkinto

22.2. Minkälainen maatalousalan ammattikoulutus Teillä on?

0 ei maatalousalan ammattikoulutusta

2 ammattikurssi tai kursseja (kesto alle 1 vuosi)

3 ammatillinen koulu (kesto 1–3 vuotta)

4 ammatillinen opisto (3–5 vuotta)

5 korkeakoulu

6 muu **Mikä?**____

22.4. Onko Teillä muuta kuin maatalouteen liittyvää koulutusta?

0 ei

1 kyllä **Minkälaista?**_____________________________________

Kiitos vaivannäöstänne!

11.2. Appendix 2. Questionnaire and observation form for nurses at farm visits

TILAKÄYNNIN OIRE- JA HAVAINTOLOMAKE N:O ____________

päiväys: ____

tutkitun nimi: ____

syntymäaika: ___________________________ **sukupuoli:** 1 mies 2 nainen

VIIMEISEN VUODEN OIREET *(hoitaja haastattelee)*

1.1. Onko teillä ollut yskää viimeisten 12 kuukauden aikana? *(yskimistä, yskittämistä)*

1 kyllä 0 ei *(siirry 2.1.)*

1.2. Onko yskää ollut...

2 päivittäin tai lähes päivittäin
3 viikoittain tai lähes joka viikko *(siirry 2.1.)*
4 kuukausittain tai lähes joka kuukausi *(siirry 2.1.)*
5 jaksoittain *(jos jaksoittain, jakson aikana päivittäin vai viikoittain?)*
6 satunnaisesti

1.3. Onko yskää ollut yhteensä ainakin kolmen kuukauden ajan?

1 kyllä 0 ei *(siirry 2.1.)*

1.4. Onko tällaista yskää ollut... *(päivittäistä tai lähes päivittäistä, kolme kk/v)*

2 vähemmän kuin kaksi peräkkäistä vuotta
3 kaksi peräkkäistä vuotta tai kauemmin

2.1. Onko teillä ollut limannousua viimeisten 12 kuukauden aikana? *(hengitysteistä, nousee suuhun asti)*

1 kyllä 0 ei *(siirry 3.1)*

2.2. Onko limannousua ollut...

2 päivittäin tai lähes päivittäin
3 viikoittain tai lähes joka viikko *(siirry 3.1)*
4 kuukausittain tai lähes joka kuukausi *(siirry 3.1)*
5 jaksoittain *(jos jaksoittain, jakson aikana päivittäin vai viikoittain?)*
6 satunnaisesti

2.3. Onko limannousua ollut yhteensä ainakin kolmen kuukauden ajan?

1 kyllä 0 ei *(siirry 3.1)*

2.4. Onko tällaista limannousua ollut... *(päivittäistä tai lähes päivittäistä, kolme kk/v)*

2 vähemmän kuin kaksi peräkkäistä vuotta
3 kaksi peräkkäistä vuotta tai kauemmin

3.1. Milloin <u>jaksoittain</u> esiintyviä oireita *(yskä ja/tai limannousu)* **on yleensä ollut?** *(kysy vain niiltä, joilla oireilu jaksottaista)*

2 keväällä
3 kesällä
4 syksyllä
5 talvella
6 lomakaudella
7 työkaudella
8 ei liity vuodenaikoihin tai työ-/lomajaksoihin

3.2. Mihin vuorokaudenaikaan yskä tai limannousu yleensä esiintyy? *(kysy kaikilta, joilla on oireita)*

2 aamuisin
3 päivisin
4 iltaisin
5 öisin
6 ei eroa vuorokauden ajoilla

3.3. Onko yskään tai limannousuun koskaan liittynyt hengityksen vinkumista?

1 kyllä 0 ei *(siirry 4.1.)*

3.4. Onko tällaista yskää tai limannousua ollut...*(sellaista, johon liittyy hengityksen vinkumista)*

2 vain hengitystietulehdusten *(esim. flunssan tai keuhkoputkentulehduksen)* yhteydessä
3 muulloinkin kuin hengitystietulehdusten yhteydessä

4.1. Onko teillä ollut kohtauksittain esiintyvää hengenahdistusta <u>viimeisten 12 kuukauden aikana</u>? *(ei tarkoiteta tavallista hengästymistä; kohtauksittain = tilapäinen, ohimenevä oireilu)*

1 kyllä 0 ei *(siirry 5.1.)*

4.2. Kuinka usein hengenahdistuskohtauksia on ollut?

2 päivittäin tai lähes päivittäin
3 viikoittain tai lähes joka viikko
4 kuukausittain tai lähes joka kuukausi
5 jaksoittain *(jos jaksoittain, jakson aikana päivittäin vai viikoittain?) (kysy 4.3. ja 4.4.)*
6 satunnaisesti

4.3. Onko teillä ollut hengenahdistuskohtauksia, joihin on liittynyt hengityksen vinkumista?

1 kyllä 0 ei

4.4. Onko hengityksenne ollut ahdistuskohtausten välillä normaalia?

1 kyllä 0 ei

4.5. Oletteko koskaan yöllä herännyt hengenahdistukseen tai hengityksen vinkumiseen?

1 kyllä 0 ei

Jos tutkittavalla ei mitään edellä kysytyistä oireista (yskä, limannousu tai hengenahdistus), siirry 6.1.

5.1. Vaikeutuvatko oireenne *(yskä, limannousu tai hengenahdistus)* **yleensä ...**

2 työviikon tai -jakson alussa
3 työviikon tai -jakson lopussa
4 vapaapäivinä
5 ei ole huomannut vaihtelua
6 ei osaa sanoa

5.2. Miten oireenne muuttuvat vuosiloman aikana?

2 pysyvät ennallaan
3 pahenevat
4 lievenevät tai häviävät kokonaan
5 ei lomia tai vapaapäiviä

6.1. Mitä oireita tai vaivoja teillä on esiintynyt työtehtäviin liittyen viimeksi kuluneen vuoden aikana? *(alkaa tai pahenee tietyn työn tai työvaiheen aikana tai sen jälkeen)*

2 kuivaa yskää
3 limannousua
4 kuumetta tai vilunväreitä
5 lihassärkyjä
6 nivelvaivoja
7 päänsärkyä
8 väsymystä
9 hengenahdistusta
10 hengityksen vinkumista tai pihinää
11 poikkeavaa hengästymistä rasituksessa
12 kurkunpään ärsytystä tai karheutta *vastaamisen jälkeen kysy vielä:*
13 nuhaa **Onko esiintynyt mitään muita oireita?**
14 pahoinvointia
15 muita oireita **Mitä?**____

6.2. Mihin työtehtäviin oireet ovat liittyneet?

2 rehuviljan käsittely sisätiloissa (jauhatus, siirto, ruokinta)
3 kuivittaminen
4 oljen siirto tai silppuaminen
5 heinän käsittely sisätiloissa
6 lannan poisto
7 purupohjan kääntö
8 sikalan siivous
9 eläinten puhdistus tai harjaus
10 eläinten punnitus tai mittaus
11 eläinten siirrot
12 eläinten siirrot ja lastaus myynnin yhteydessä
13 viljan puinti
14 viljan kuivaus tai siirto
15 vilja- tai heinävaraston tai kuivureiden siivous
16 säilörehun käsittely *(hapolla käsitelty rehu tai vilja)*
17 polttohakkeen käsittely
18 muu maataloustyö **Mikä?**____

6.3. Ovatko oireet yleensä alkaneet...

2 korkeintaan puoli tuntia työtehtävän alkamisesta tai työtilaan saapumisesta
3 myöhemmin kuin puolen tunnin kuluttua

6.4. Kuinka kauan oireet ovat tavallisesti kestäneet?

2 alle vuorokauden
3 1-3 vuorokautta
4 yli 3 vuorokautta

SIKALA *(haastatellen ja havainnoiden)*

7.1. Peruskorjaus-/rakentamisvuosi 19_____

7.2. Ilmanvaihtolaitteiston hankinta tai uusimisvuosi 19______

8.1. Tuotantomuoto

2 porsastuotanto
3 lihasikojen kasvatus
4 yhdistelmätuotanto
5 jalostustoiminta

8.2. Sikalatyyppi

2 ”karsinasikala”
3 ”pihattosikala”
4 sekä karsina- että pihattosikala **Miten siat on jaettu näiden kesken?** _________
____

8.3. Sikojen määrä tällä hetkellä

2 emakoita ___kpl
3 porsaita *(alle 3 kk:n ikäiset porsaat)* ikä____kk ________kpl
4 lihasikoja *(yli 3 kk:n ikäiset siat)* ikä____kk ________kpl
5 karjuja ________kpl

8.4. Sikalan lattiapinta-ala *(ilman varastotiloja)* ________m^2

8.5. Karsinoiden yhteispinta-ala ________m^2

8.6. Pihaton / purupohjasikalan koko *(jos vain osa sikalasta pihattona)* _____m^2

8.7. Sikojen määrä pihatossa / purupohjaosastossa ________kpl

9.1. Sikojen ruokinta *(yksi tai useampi vaihtoehto; rengasta ruokintavaihtoehdon/ -ehtojen kohdalta myös kyseisellä tavalla ruokittavat siat)*

2 rehun jako vaunusta/ämpäristä käsin: a) emakot b) porsaat c) lihasiat d) muut siat
3 rehun jako vaunusta koneellisesti: a) emakot b) porsaat c) lihasiat d) muut siat
4 kuivaruokinta täysin koneellisesti: a) emakot b) porsaat c) lihasiat d) muut siat
5 liemiruokinta koneellisesti: a) emakot b) porsaat c) lihasiat d) muut siat
6 muu **Mikä?**____

9.2. Sikojen rehu *(yksi tai useampi vaihtoehto)*

2 jauhorehu
3 rakeistettu rehu
4 tuoresäilötty viljarehu
5 liemiruokinta
6 muu rehu *(tiivisteet ym.)* **Mikä?**_______________________________

9.3. Lisätäänkö viljarehuun öljyä?

1 kyllä 0 ei

10.1. Kuivike

0 ei kuiviketta
2 sahanpuru
3 kutterinpuru
4 olki
5 turve
6 muuta **Mitä?**____

10.2. Sikalan lannanpoistojärjestelmä *(yksi tai useampi vaihtoehto; rengasta lannanpoistojärjestelmän kohdalta myös kyseiseen menetelmään liittyvät siat)*

2 lietelantamenetelmä: a) emakot b) porsaat c) lihasiat d) muut siat
3 kuivalanta, lannanpoisto käsin: a) emakot b) porsaat c) lihasiat d) muut siat
4 kuivalanta, lannanpoisto koneellisesti a) emakot b) porsaat c) lihasiat d) muut siat
5 kuivikepohjainen pihatto
(=”purupohjasikala”): a) emakot b) porsaat c) lihasiat d) muut siat
6 muu **Mikä?**____

11.1. Sikalan ilmanvaihto

2 painovoimainen
3 koneellinen
4 koneellinen vain osassa sikalaa **Missä osassa?**____________________________

11.2. Ilmanvaihtojärjestelmän poistoaukot

2 katossa
3 lattian alla olevien poistokanavien tai lattiakanavien päässä
4 seinällä
5 muualla **Missä?**____

11.3. Tuloilman lämmitys

1 kyllä 0 ei

11.4. Pintojen kosteus *(kokonaan kostea tai märkä)*

2 katto
3 seinät
4 ikkunat

12. Sikalan pöly, joka näkyy tavallisessa valaistuksessa *(ei vain kirkkaassa auringon valossa)*

12.1. ruokinta-aika:	**12.2. viljan jauhatus:**
0 ei	0 ei
2 koko ajan	2 koko ajan
3 puolet työajasta	3 puolet työajasta
4 vähemmän	4 vähemmän

13.1. Sikalan lämpöolot

2 lämpötila _______ ^oC 3 kosteus ______%

13.2. Sikalan kaasut

2 CO_2 ______ cm^3 / m^3 3 NH_3 ______ cm^3 / m^3

14.1. lisähuomioita ____

____

TYÖVAIHEET *(kirjataan sikalassa tehdyn työn mukaisesti)*

15.1. Kotieläinten hoitoon liittyvät työt **16.1. Hengityksensuojain käytössä:**

2	ruokintavaunun/-ämpärien täyttö	___
3	rehun jako vaunusta tai ämpäristä käsin	___
4	koneellisen ruokinnan tarkkailu	___
5	säilörehun irrotus tai jako	___
6	heinän tai kuivikkeiden jako	___
7	lannanpoisto täysin käsin	___
8	lannanpoisto käsin vain karsinoista	___
9	purupohjan kääntö	___
10	eläinten harjaus tai puhdistus tai karvan leikkaaminen	___
11	kotieläinrakennuksen puhdistus tai siivous harjaten	___
12	eläinten punnitus tai mittaus	___
13	eläinten lääkitys	___
14	porsitus	___
15	astutus	___
16	eläinten siirto karsinasta toiseen	___
17	eläinten lastaus myynnin yhteydessä	___
18	rehun jauhatus vaatien myllyn vierellä oloa	___
19	muuta **Mitä?**____	

15.2. Ruokintavaunun tai -ämpärien täyttö

2 lattialta lapioiden
3 avoimeen vaunuun/ämpäriin suoraan siilosta
4 siilosta koteloituun tai katettuun vaunuun
5 laarista/säkistä kuupalla (ämpärillä) avoimeen vaunuun/ämpäriin
6 säkistä kaataen ämpäriin/vaunuun

15.3. Ruokintavaunun/-ämpärien täyttö eläintilassa

1 kyllä 0 ei

16.2. Hengityksensuojain

2 kertakäyttöinen
3 puolinaamari
4 kokonaamari
5 moottoroitu
6 muu **Mikä?**____________________ ______________________________________

16.3. Hengityssuojaimen suodatin

0 ei luokiteltua suodatinta
2 pölysuodatin, luokka P1
3 pölysuodatin, luokka P2
4 pölysuodatin, luokka P3
5 kaasusuodatin, luokka A (orgaaniset kaasut)
6 kaasusuodatin, luokka B (epäorgaaniset kaasut)
7 kaasusuodatin, luokka E (rikkidioksidi)
8 kaasusuodatin, luokka K (ammoniakki)

17.1. Sikalatyön kesto ____tuntia

TYÖHÖN LIITTYVÄT VÄLITTÖMÄT OIREET *(kysytään työjakson jälkeen)*

18.1. Mitä oireita tai vaivoja teillä oli tänään sikalatyössä tai on juuri nyt?

2 kuivaa yskää
3 limannousua
4 kuumetta tai vilunväreitä
5 lihassärkyjä
6 nivelvaivoja
7 päänsärkyä
8 väsymystä
9 pahoinvointia
10 hengenahdistusta
11 hengityksen vinkumista tai pihinää
12 poikkeavaa hengästymistä rasituksessa
13 kurkunpään ärsytystä tai karheutta,
14 nuhaa
15 silmien kirvelyä, punoitusta tai kyynelvuotoa
16 ihon kutinaa tai punoitusta
17 huimausta
18 muita oireita

vastaamisen jälkeen kysy vielä:
Onko/oliko mitään muita oireita?

Mitä?____

18.2. Missä työvaiheessa oireenne alkoivat tai mihin työvaiheeseen ne mielestänne liittyvät?

2 rehun jako
3 säilörehun irrotus tai jako
4 heinän tai kuivikkeiden jako
5 lannanpoisto
6 purupohjan kääntö
7 eläinten harjaus tai puhdistus tai karvan leikkaaminen
8 kotieläinrakennuksen puhdistus tai siivous
9 eläinten punnitus tai mittaus
10 eläinten lääkitys
11 porsitus
12 astutus
13 eläinten siirto karsinasta toiseen
14 eläinten lastaus myynnin yhteydessä
15 rehun jauhatus
16 muu **Mikä?**____

SPIROMETRIA

vasta-aiheet: kuumeinen hengitystieinfektio, tuore sydäninfarkti, oireinen koronaaritauti (nitroja päivittäin), oireita aiheuttava rytmihäiriö, lepohengenahdistus lääketauot: 3 vrk muut antihistamiinit, paitsi Atarax 5 vrk, Tavegyl 5 vrk, Zyrtec 5 vrk, Hismanal 8 viikkoa. Yskänlääkkeet 3 vrk, Efedrin 12 t

Astmalääkitys: **tänä aamuna otettu:** *(ruksaa)*

Spirometriaan liittyviä huomautuksia *(ko-operaatio, puhallustekniikka ym.)*

Yleisiä huomioita, kommentteja