

Disease Prevalence and Mortality among Agricultural Workers in Korea

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The aim of this paper was to provide an overview of mortality and disease prevalence related to occupational diseases among agricultural workers in Korea. We evaluated the age-standardized mortality rates and the prevalence of chronic diseases and compared them with those of other populations using death registration data from 2004 through 2008 and the 2005 Korean National Health and Nutrition Examination Survey. In addition, we conducted a literature review on published articles examining the health status of farmers in Korea. Agricultural workers have a significantly higher mortality of cancer, tuberculosis, chronic respiratory diseases, liver diseases, suicide, motor and non-motor vehicle accidents. Compared to other populations, farmers have higher prevalence rates of arthritis and intervertebral disc disorders. The literature review revealed a number of work-related diseases among farmers, such as musculoskeletal diseases, pesticide poisoning, infections, and respiratory and neurologic diseases. Korean farmers demonstrate a distinct pattern of mortality and disease prevalence compared to other populations. Although lifestyle factors remain important contributors to those deaths and diseases, our study suggests that occupation is a major determinant as well. Intensive programs such as surveillance systems, therefore, should be developed in order to identify and prevent work-related diseases among agricultural workers in Korea.

Key Words: Agricultural Workers' Diseases; Mortality; Occupations; Prevalence; Republic of Korea

INTRODUCTION

Agriculture is the single largest form of employment in the world and, based on occupational fatality, non-fatal injury, and occupational illness rates, one of the most hazardous of occupations in most countries (1). Farming as a means of employment entails a number of unique characteristics compared to other occupations, such as worker traits and behaviors, setting, and organizational structure. Furthermore, agricultural workers are exposed to a wide range of occupational hazards, such as ergonomic stresses, sunlight, viruses, inorganic dust, pesticides, and other chemicals (2). A number of previous studies have suggested a unique pattern of disease among farmers when compared to other populations (1).

Korea has traditionally been an agricultural country and as of 2008 retained a farm population exceeding 3.1 million however, little interest has been demonstrated in studying health and safety concerns in an agricultural setting. Previous studies reported that agricultural workers in Korea suffer poor working conditions and a variety of work-related diseases (3). However, occupational diseases among agricultural workers are more difficult to quantify than those of other workers, because such

illnesses among the self-employed are rarely identified as occupation-related. Agricultural workers are not included in the special periodic health examinations which are normally provided to industrial workers, and no official program exists to identify occupational diseases among agricultural workers in Korea. Although data from Industrial Accident Compensation Insurance is a key source for investigating occupational diseases covered by the program, the majority of self-employed agricultural workers in Korea have not been included. Most of the scattered available studies on agricultural workers were also focused on specific regions or clinical findings and did not estimate their overall health status.

The purpose of this article, therefore, is to offer an overview of work-related diseases among agricultural workers both by examining overall mortality and disease prevalence and through a literature review.

MATERIALS AND METHODS

Mortality and prevalence data

Mortality data were obtained from death registration data from 2004 to 2008 which are classified by the underlying cause of

death according to the International Classification of Diseases and Related Health Problems, 10th Revision (ICD-10) (4). The death data for the previous five years were pooled to minimize the fluctuation in cases of death.

The prevalence data used was drawn from the 2005 Korean National Health and Nutrition Examination Surveys (KNHANES). The KNHANES was a cross-sectional and nationally representative survey conducted by the Ministry of Health and Welfare, Korea. The survey employed a stratified multistage probability sampling design. The subjects were selected from sampling units predicated by geographical area, gender and age, as determined by household registries (5).

Study population and disease outcomes

The overall number of deaths from 2004 to 2008 was 1,229,423 and the 2005 KNHANES participants totaled 34,145. The occupations of study subjects were categorized according to the standard Korean classification of occupations. The category of farmers included about 4.4% fishery and 0.2% forestry workers (6). We restricted the subjects to those aged 20 or over in order to compare prevalent chronic diseases and mortality across the working-age population. As a result, we investigated a total of 1,207,531 deaths through death certificate data, including 151,919 agricultural workers, and a population of 25,161, including 1,732

agricultural workers, via the KNHANES.

Overall and all causes of specific deaths were analyzed and causes resulting in less than one hundred annual deaths are not presented. Participants in the KNHANES were considered to have a chronic disease if they answered “yes” to both of the interview questions: “Have you ever experienced any chronic diseases?” and “Have you been diagnosed with such a disease by a physician?” Individual chronic diseases were selected based on an a priori interest in farmer’s health and in acquiring a sufficient number of cases.

Statistical analysis

We calculated mortality rate as the number of deaths divided by the sum of persons in each occupation. The mortality rates were directly standardized to 10-yr age groups, using the average age distribution from 2004 to 2008 of the Korean population (6). The annual death rates for each cause of death were calculated per 100,000 population. Standardized mortality ratios (SMRs) were calculated to compare deaths among agricultural workers with mortality patterns in the overall population.

The age-standardized prevalence of chronic diseases per one hundred population with 95% confidence intervals was calculated using the direct adjustment method for the 2005 standard population, with a population breakdown by five-year incre-

Table 1. Age-standardized mortality rates and standardized mortality ratios for overall and major cause-specific deaths among agricultural workers from 2004 to 2008

Causes of death (ICD-10)	Annual average cases	ASR (95% CI)*	SMR (95% CI)
All death (A00-Y98)	30,384	854 (835-873)	108 (107-109)
All cancer (C00-C97)	9,441	230 (223-237)	132 (129-134)
Esophagus (C15)	352	7 (7-9)	192 (173-213)
Stomach (C16)	1,755	42 (39-45)	142 (136-149)
Colorectum (C18-C21)	574	13 (12-15)	92 (85-100)
Liver (C22)	1,574	45 (42-48)	137 (130-144)
Gallbladder (C23)	110	3 (3-3)	110 (90-133)
Pancreas (C25)	516	12 (11-14)	124 (113-135)
Lung (C34)	2,702	59 (57-62)	153 (147-159)
Brain (C71)	108	3 (2-4)	118 (97-143)
Non-Hodgkin's lymphoma (C82-C85)	148	3 (3-4)	114 (96-134)
Leukemia (C91-C95)	147	4 (3-6)	126 (107-148)
Prostate (C61)	108	3 (3-4)	108 (89-131)
Infectious and parasitic diseases (A00-B99) [†]	301	10 (7-12)	104 (92-116)
Tuberculosis (A15-A19)	339	9 (7-10)	116 (104-129)
Diabetes mellitus (E10-E14)	1,027	26 (24-29)	73 (67-77)
Mental and behavioural disorders (F00-F99)	305	10 (8-11)	78 (69-87)
Alzheimer's disease (G30)	108	2 (2-3)	54 (44-65)
Hypertension (I10-I15)	388	9 (8-10)	72 (65-80)
Ischemic heart disease (I20-I25)	1,295	33 (31-36)	77 (73-82)
Cerebrovascular diseases (I60-I69)	3,327	76 (72-79)	89 (86-92)
Pneumonia (J12-J18)	486	10 (9-11)	82 (75-90)
Chronic lower respiratory diseases (J40-J47)	1,229	25 (24-27)	124 (117-131)
Diseases of the liver (K70-K77)	1,150	47 (43-51)	169 (159-179)
Renal failure (N17-N19)	209	6 (4-7)	61 (53-70)
Motor vehicle accidents (V01-V99)	1,695	78 (70-87)	305 (291-320)
Nonmotor vehicle accidents (W00-X59)	786	35 (29-41)	128 (119-137)
Suicide (X60-X69)	944	46 (40-53)	278 (261-297)

*Age-standardized mortality rate per 100,000 population and 95% confidence intervals; [†]Total infectious and parasitic diseases except tuberculosis.

ments from the Statistics Korea (6). For prevalence rates, sampling weights were applied to account for unequal probabilities of selection resulting from the sample design and from non-response, as well as to adjust for post-stratification population totals for the KNHANES. Multiple logistic analyses were conducted while controlling for potential confounding factors to compare prevalence rates of chronic diseases among agricultural workers with those for the total population. Other occupational reference groups (i.e., manual workers and non-manual workers) for odds ratio were also used to avoid health worker effect. Statistical analyses were carried out using Stata 10.0 (StataCorp., College Station, Texas, USA). This study analyzed publicly available data sets and was therefore exempt from institutional review board approval.

RESULTS

Table 1 shows average annual deaths, age-standardized mortality rates, and SMRs by cause of death for agricultural workers versus the total population. During the five-year period from 2004 through 2008, there was an average of 30,384 annual deaths among agricultural workers. The most prevalent causes of death were cancer, motor vehicle accidents, and cerebrovascular diseases. Significantly increased SMRs were observed for total cancers, along with cancer of the esophagus, stomach, liver, pancreas, and lung, as well as leukemia, tuberculosis, chronic lower respiratory diseases, liver diseases, motor vehicle accidents, non-motor vehicle accidents, and suicide. Reduced SMRs were shown for diabetes mellitus, mental disorders, hypertension, ischemic heart disease, cerebrovascular diseases, and renal failure.

Table 2 presents selected lifetime disease prevalence and odds ratios for agricultural workers. The most prevalent diseases were arthritis, hypertension, and intervertebral disc disorders. Compared to the total population, agricultural workers showed a significantly higher risk of arthritis, gastritis and duodenitis, whereas agricultural workers had a lower prevalence of diabetes mellitus, cancer, and cataract/glaucoma. The results were similar when the analyses were repeated comparing agricultural to manual and non-manual workers.

Table 3 summarizes selected major papers published since 2000 on work-related diseases among agricultural workers in Korea which were used to supplement the limited available mortality and morbidity data. The principle health outcomes include musculoskeletal diseases, injury, pesticide poisoning, neurological diseases, respiratory illness, allergy, cancer, infectious diseases and others. Infectious, neurological and respiratory diseases were more frequently reported than other outcomes, and the majority of the studies are cross-sectional or case reports. However, there were few published studies on mental health, temperature-related illnesses, hearing loss, bites, toxic diseases which may relate to agricultural work or studies on fishery and forestry workers.

DISCUSSION

When compared to the total population, agricultural workers were observed to be generally more likely to die from a variety of site-specific chronic diseases such as cancer, as along with chronic respiratory diseases, non-motor vehicle accidents, and suicide. The prevalence of musculoskeletal diseases such as ar-

Table 2. Age-standardized prevalence, and prevalence odd ratios of selected diseases among agricultural workers versus other populations in 2005 Korean National Health and Nutrition Examination Survey

Diseases	Cases	ASP (95% CI)*	OR (95% CI)†	OR (95% CI)‡
Arthritis	560	15.0 (13.5-16.6)	1.4 (1.1-1.7)	1.5 (1.2-2.0)
Osteoporosis	187	3.9 (3.1-4.8)	1.2 (0.9-1.7)	1.5 (1.0-2.3)
Intervertebral disc disorders	226	10.8 (7.8-14.7)	1.2 (0.9-1.6)	1.4 (1.0-2.0)
Diabetes mellitus	122	3.4 (2.7-4.2)	0.4 (0.3-0.6)	0.5 (0.3-0.8)
Gastritis and duodenitis	102	3.6 (2.6-5.1)	1.6 (1.1-2.2)	1.9 (1.3-2.9)
Chronic hepatitis	16	0.5 (0.3-1.1)	0.8 (0.4-1.7)	0.6 (0.3-1.5)
Hypertension	406	11.6 (9.7-13.8)	0.8 (0.6-1.0)	0.9 (0.7-1.1)
Cerebrovascular diseases	37	0.9 (0.6-1.4)	0.7 (0.4-1.2)	1.3 (0.6-2.7)
Ischemic heart disease	56	1.5 (1.1-2.0)	1.0 (0.6-1.6)	1.4 (0.7-2.9)
Asthma	58	1.6 (1.1-2.3)	1.0 (0.7-1.6)	1.0 (0.5-1.6)
Chronic obstructive pulmonary disease	39	0.8 (0.6-1.1)	0.6 (0.3-1.3)	0.5 (0.2-1.1)
Tuberculosis	48	1.3 (0.9-1.8)	0.8 (0.4-1.3)	0.7 (0.4-1.4)
Bronchiectasis	5	0.8 (0.1-4.3)	0.6 (0.1-2.8)	0.6 (0.1-3.4)
Allergic rhinitis	51	7.8 (3.3-17.1)	0.6 (0.3-0.9)	0.6 (0.4-1.0)
Cancer	42	1.0 (0.7-1.4)	0.3 (0.1-0.7)	0.4 (0.1-1.0)
Cataract/glaucoma	173	3.9 (3.3-4.7)	0.6 (0.4-0.9)	0.7 (0.5-1.1)
Atopic dermatitis	120	5.2 (3.3-8.0)	0.9 (0.6-1.3)	0.9 (0.6-1.5)
Injury	104	4.8 (3.5-6.5)	0.8 (0.5-1.2)	0.8 (0.5-1.3)

*Age-standardized prevalence per one hundred population and 95% confidence intervals; †Adjusted for age, education, marriage, smoking, drinking. The reference category was total population; ‡Adjusted for age, education, marriage, smoking, drinking. The reference category was manual and nonmanual workers.

Table 3. Selected published studies since 2000 on the health status of agricultural workers in Korea

Main outcomes	Authors (yr)	Study type (data sources)	Findings	Ref.
Musculoskeletal diseases	Cha et al. (2009)	Cross-sectional (KNHANES)	Arthritis, Intervertebral disc disorders	(7)
	Jeong et al. (2004)	Surveillance data	Carpal tunnel syndrome cases	(8)
Injury	Im et al. (2008)	Cross-sectional (National Health Insurance data)	Prevalence of injury and poisoning	(10)
	Ahn et al. (2004)	Survey (Korea Labor Welfare Corporation data)	Unintentional fatal occupational injury	(9)
Pesticide poisoning	Lee & Cha (2009)	Review	Prevalence of pesticide poisoning	(11)
	Lee et al. (2009)	Cross-sectional (registered death data)	Mortality rates from pesticide-related deaths	(12)
Neurologic diseases	Park et al. (2005)	Case-control (hospital data)	Parkinson's disease	(15)
	Kwon et al. (2004)	Cross-sectional (survey)	Neurologic symptoms	(13)
	Shin et al. (2002)	Case report (hospital data)	Organophosphate induced peripheral polyneuropathy	(14)
Respiratory diseases	Lee & Lim (2008)	Review	Work-related diseases including asthma and pneumonitis	(3)
	Kim & Kim (2002)	Review	Spider-mite allergy and asthma	(18)
	Kwon et al. (2004)	Cross-sectional (survey)	Occupational pollinosis	(19)
	Kim et al. (2008)	Case report	Hypersensitivity pneumonitis	(20)
Infectious diseases	Kim et al. (2008)	Case-control (hospital)	Scrub typhus	(21)
	Min et al. (2005)	Cross-sectional (surveillance report)	Scrub typhus	(22)
	Ahn & Lim (2007)	Survey (Korea Labor Welfare Corporation data)	Occupational diseases including scrub typhus	(23)
	Kim et al. (2006)	Cross-sectional (hospital)	Brucellosis	(24)
	Shin et al. (2003)	Cross-sectional (hospital)	Tetanus	(25)
Cancer	Lee et al. (2008)	Ecologic (registered death data)	Cancer mortality	(26)
	Sull et al. (2002)	Cohort (prospective)	Cancer incidence	(27)

thritis was significantly higher among agricultural workers than among other populations. Although these may have been due to lifestyle or other environmental factors, our findings suggested that such causes of death and chronic diseases may also be closely related with occupational factors. The discrepancy between mortality and prevalence may be explained in part by agricultural worker's tendency to enter into the health care system at a later point and in more advanced stages of diseases than other populations, possibly due to lower incomes and education.

Musculoskeletal diseases such as osteoarthritis, low back pain, and neck and upper limb complaints are among the most prevalent illnesses of agricultural workers. Our analyses based on the 2005 KNHANES revealed significantly increased risks of arthritis and intervertebral disc disorders than the total population and other occupations. Although determining a cause-effect relationship between work and musculoskeletal injuries is difficult, a number of risk factors for musculoskeletal diseases, such as extensive workloads, heavy lifting, and working in stressful postures, are all encountered in agriculture. Among musculoskeletal diseases, agricultural workers demonstrated a higher prevalence of arthritis and intervertebral disc disorders than other occupational groups. Furthermore, this same class of workers showed a higher prevalence changes for intervertebral disc disorders than other occupational classes in analyses of the 1998, 2001, and 2005 KNHANES (7). Another major work-related musculoskeletal disease among agricultural workers is carpal tunnel syndrome. Surveillance data from 2000 to 2003 showed that agricultural workers had the second-highest proportion of work-related carpal tunnel syndrome among all occupations (8).

Injures can be considered the primary occupational health concern in agriculture. Farm machinery such as cultivators, tractors, and combines, along with animal-related injuries are the primary sources of acute injuries. Our results showed a significantly increased SMR for non-motor vehicle accidents, and agricultural (including fishery and forestry) workers were reported to experience the second-highest rates of unintentional fatal injuries (33 per 100,000 workers) from 1998-2001 (9). Based on national health insurance and agricultural and fishery qualification data, the age-adjusted standardized morbidity ratio of total injuries and poisoning was significantly higher among both men (SMR=137) and women (SMR=123) in the agricultural and fishery population than in the general population in 2002 (10).

Pesticide poisoning is a typical occupational disease among agricultural workers. The prevalence of non-fatal pesticide poisoning has been reported to vary from 5.7% to 86.7% among Korean farmers, depending on the study subjects, years studied, and definition of pesticide poisoning (11). A variety of work-related factors such as pesticide usage, pesticide application days, hazardous practices, and poor hygiene are significantly related with pesticide poisoning. Greenhouse farmers have been reported to receive greater exposure to pesticide than ordinary farmers. Mortality rates for pesticide poisoning based on death registration data also significantly increased in Korea from 4.42 to 6.42 per 100,000 during the period of 1996-2005 (12). Although intentional self-poisoning was the primary cause of these deaths, the majority of victims were residing in rural areas, and pesticide exposure itself may have been related to the intentional self-poisoning.

In addition, neurologic diseases such as neurologic symptoms,

depression, organophosphate-induced delayed polyneuropathy, and Parkinson's disease, are all related with agricultural work, especially in terms of pesticide exposure. Long-term occupational exposure to pesticides was seen to increase neurologic symptoms among agricultural workers in a field survey in 2001 (13). Organophosphate-induced delayed polyneuropathy cases were reported among farmers after increased exposures to pesticides (14). It has been reported in a multi-center case-control study in Korea (15) that ever having worked in the agricultural, hunting, and/or forestry sector of industry (OR=1.88) and farmers as an occupation (OR=1.64) are positively associated with Parkinson's disease.

Mental health is another important health issue in agriculture. Korean agricultural workers suffer stress from chronic diseases, economic, and other workplace factors, certain of which may lead to stress-related health disorders such as depression and suicide. Heightened risk of suicide among farmers has been reported from several countries (1). Although mental health status is difficult to quantify and no studies have been reported focusing on agricultural work in Korea, we found a significantly increased SMR for suicide among agricultural workers. Suicide from pesticide ingestion is a prevalent and notorious phenomenon in rural areas in Korea. Among the different occupational groups analyzed through 2000 death registration data, suicide risk is the greatest in agricultural workers (16).

Respiratory illnesses are among the most prominent occupational illness of agricultural workers and may stem from organic/inorganic dusts, microorganisms, mycotoxins, endotoxins, pollens, mites, molds, animal production, and/or pesticides, and other chemicals. These exposures have been demonstrated to give rise to a variety of respiratory disorders such as bronchitis, asthma, and organic dust toxic syndrome (1). In our study, a higher mortality from chronic respiratory diseases was seen in agricultural workers than in the total population. Excessive levels of organic dusts and ammonia have been reported in poultry farms in Korea (17) and respiratory diseases have been frequently reported among farmers (3). A variety of case reports and field studies have shown that many other respiratory diseases or allergies such as occupational asthma in fruit farmers (18), occupational pollinosis induced by radish and Chinese cabbage pollen in horticultures farmers (19), and hypersensitivity pneumonitis from stored hay (20).

A great number of infectious diseases can be transmitted from animals or the environment that may result in occupational diseases in agricultural workers. These include scrub typhus (i.e., tsutsugamushi disease), hemorrhagic fever with renal syndrome, leptospirosis, anthrax, rabies, brucellosis, tetanus, and swine and avian influenza. Among these, scrub typhus has been the most frequently reported in Korea. A case-control study for scrub typhus showed that fruit farming (OR=2.44), gathering chestnuts (OR=2.05), and taking breaks in locations adjacent to agricul-

tural operations (OR=3.06) are all associated with a high risk of developing scrub typhus (21). The majority of scrub typhus patients (67.2%) were revealed to be farmers in an analysis of surveillance data from Gyeongsanbuk-do from 1999 to 2001 (22). Major compensated occupational diseases among agricultural, forestry and fishery workers in Korea as seen in Industrial Accident Compensation Insurance data were infectious disease, skin disease, and intoxication cases (23). Brucellosis (24) and tetanus cases (25) were found most frequently among agricultural workers.

Agricultural workers showed a higher mortality of total cancers as well as most cancer sites except colorectum, compared to other populations. A previous ecologic study demonstrated an increased risk of cancer mortality in rural areas (26), and a cohort study reported an elevated risk for total cancer and digestive cancer among farmers exposed to pesticides in Korea (27). Work-related factors such as exposure to pesticides, organic and inorganic dusts, zoonotic viruses, fertilizers, and nitrates have been suggested as the possible risk factor to explain the increased rate of cancer among agricultural workers (28). From the Agricultural Health Study, a largest prospective cohort study for agricultural workers, the relation between individual pesticides and developing cancer to be discovered (29).

Although not observed in our analysis, skin diseases rank as one of the most common occupational diseases among agricultural workers. Contact dermatitis is the most common type, but they are not often reported as they occur, since sufferers may accept these conditions as a natural occurrence rather than a work-related illness. Green tobacco sickness from tobacco leaves was reported in 2001, and showed 42.5% to 67.0% prevalence in rural areas in Korea (3). Farmer's syndrome, which refers to a combination of eight symptoms of physical and mental impairment observed in farmers, has been frequently surveyed and reported to show a wide range of prevalence, but it is difficult to recognize as an occupational disease due to its subjectivity.

Numerous additional work-related illnesses and injury conditions remain among agricultural workers. These categories of specific conditions include heat and cold-induced illnesses such as heat stroke and frostbite, hearing loss, snake and insect bites, parasitic infection, keratitis, and allergies or toxic reactions from substances used for animals such as antibiotics, immunization products, and hormones (1). Although those diseases occur frequently in agriculture and are occasionally reported as cases, the mortality or KNHANES data may not represent their epidemiology as a result of limited information.

There are certain important limitations to this analysis, such as the cross-sectional nature of the KNHANES data, the potential misclassification of self-reported medical history, a lack of individual information and the validity of death certificates. Job titles are also only a crude approximation of occupational factors, include a wide range of exposures, and would be expected

to contain misclassifications. Although there was no study focused on the accuracy of self-reporting as agricultural workers, a previous reliability study showed 70.3% agreement in the three occupational classes (manual workers, non-manual workers and others) between KNHANES and death certificate data (30). Agricultural work is more likely to be a life-long occupation than are other occupations and a job description as an agricultural worker may be more accurate than in the case of other types of jobs. We were also unable to examine separate risks by detailed occupational groups (i.e., farmers, fishery workers, and forestry workers) due to limitations in the information collected by the KNHANES and death data. However, the population of fishery and forestry workers constituted less than 5% of the agricultural workers group within our data. Therefore, estimates of mortality and disease prevalence would be mainly explained by agricultural workers.

Despite these limitations, this study has shown that agricultural workers have a distinct pattern of mortality and disease prevalence than other populations and that certain of these diseases may be work-related or occupational. These results from limited data sources are not sufficiently comprehensive and would underestimate the actual number of occupational diseases in agriculture. Since no national-level official data are collected focusing on agricultural worker's health, intervention programs such as surveillance systems are required to investigate the impact of distinct aspects of agricultural work and to prevent occupational diseases among agricultural workers in Korea.

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