

Assessment of relationship between farmer's syndrome and neurotoxic symptoms in farming couples

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Abstract

The purpose of this study was to evaluate the relationship between farmer's syndrome and neurotoxic symptoms in farming couples. The study was conducted on 348 farmers (174 couples) in Chungnam Province of South Korea. We obtained information on general and agricultural characteristics, farmer's syndrome, and neurotoxic symptoms through face-to-face surveys from 2014 to 2019. The Korean version of the diagnostic standard scale was used for farmer's syndrome, and the Swedish Q16 questionnaire was used for neurotoxic symptoms. Logistic regression analysis was used to identify neurotoxic symptoms affected by farmer's syndrome. The prevalence of 'positive' neurotoxic symptoms was higher in wives (72.4%) than in husbands (56.9%). Compared with husbands with 'negative and probable' farmer's syndrome (reference), husbands with 'positive' farmer's syndrome were more likely to have 'positive' neurotoxic symptoms (odds ratio [OR] = 5.37, 95% confidence interval [CI] = 2.01-14.30). Compared with wives with 'negative and probable' farmer's syndrome (reference), wives with 'positive' farmer's syndrome were more likely to have 'positive' neurotoxic symptoms (OR = 7.07, 95% CI = 2.58-19.38). Therefore, neurotoxic symptoms in both husbands and wives were significantly associated with farmer's syndrome. However, wives had a higher risk of neurotoxic symptoms than husbands. The findings of this study might be useful as important data for establishing and training agricultural safety and health policy.

Keywords: Couple, Farmer, Farmer's syndrome, Husband, Neurotoxic symptoms, Wife

Introduction

Agriculture is one of the longest-running occupations in South Korea [1]. With the expansion of farming scale and the spread of agricultural machinery, agriculture has continued to develop and is very important in terms of national food production [2]. However, according to the Census and the Agriculture, Forestry and Fisheries Survey by Statistics Korea (KOSTAT), the farming population of South Korea is steadily decreasing from 8.7% in 2000 through 6.3% in 2010 to 4.5% in 2018 [3]. In addition, most of the farmers are family-oriented [4], and the health problems of farmers are increasing due to the deterioration of the agricultural workforce such as aging, increasing involvement of women, and changes in agricultural work [5].

It is known that farmers have a lower total mortality rate than general population, while farmers have higher rates of respiratory diseases, skin diseases, musculoskeletal disorders, nervous system disorders, and certain cancers than general population [6,7]. These diseases have not yet been accurately identified [8], but it is reported that various harmful factors such as rural environment and agricultural factors (e.g., different lifestyles from general population, chemicals including pesticides, agricultural machinery use, and agricultural stress) are related [9]. Of these, nervous system diseases are mainly caused by pesticide exposure, and the incidence risk of some central nervous system diseases such as depression, neurobehavioral disorders, and Parkinson's disease may increase due to pesticide exposure [10]. Nerve conduction function has been reduced in farmers and agricultural workers who are professionally exposed to pesticides [11]. Also, it has been reported that neuropsychological and neurobehavioral lesions remain chronic due to pesticide exposure abroad [12].

Farmer's syndrome is a typical mental and physical disability syndrome that appears mainly in farmers [13] and has been widely used as a useful indicator to measure health level of rural residents [14]. Farmer's syndrome is a manifestation of physical fatigue, mental tension, malnutrition, infection, and cold disorders accumulated in the body, and

can cause various diseases such as rheumatism, hypertension, arteriosclerosis, neurosis, and myocardial damage [15]. According to previous studies, it was reported that farmer's syndrome was also highly related to general diseases, and the prevalence was higher in women than in men [16].

While studies on neurotoxic symptoms and related factors of farmer's syndrome have been conducted abroad [17], there is a lack of interest in not only neurotoxic symptoms of farmers but also the relationship between farmer's syndrome which represent previous stage of diseases and chronic neurotoxic symptoms in South Korea. Therefore, the purpose of this study was to identify the prevalence of neurotoxic symptoms in husband and wife who are farmers and to evaluate the difference between couples in the relationship between farmer's syndrome and neurotoxic symptoms. Through this, it is intended to provide basic data to prepare management plan of health effects in farming couples.

Materials and Methods

Study population

We targeted 920 farmers (460 couples) out of a total of 1,723 farmers who live in Chungnam Province, South Korea and participated in the cohort of farmers' pesticide exposure at Dankook University Hospital's Center for Farmers' Safety and Health from 2014 to 2019. Prior to participation in the study, written consent was obtained from the subjects to voluntarily participate with sufficient explanation of the study. The survey was conducted via 1:1 interview of a trained interviewer by visiting the target area. Of these, a total of 348 farmers (174 couples) were included in the analysis, except for 572 farmers (286 couples) who answered incompletely. All subjects were professional farmers, and the average age was 63.4 ± 7.8 years (husband = 65.1 ± 7.4 years; wife = 61.6 ± 7.8 years). This study was approved by the Institutional Review Board of Dankook University Hospital (IRB no. 2014-08-003, 2017-07-001).

Survey

The general and agricultural characteristics of survey included the following: age (<65 years, ≥ 65 years), education level (\leq elementary school, middle school, \geq high school), current smoking (no, yes), current drinking (no, yes), cultivation type (green house, orchard, crop, rice), cultivation scale (<1000 pyeong, 1000-2000 pyeong, ≥ 2000 pyeong; pyeong = 3.3 m²), farming period (<20 years, ≥ 20 years), pesticide spraying period (<20 years, ≥ 20 years), pesticide spraying role (direct spray, spray assistant, both), pesticide spraying method (high pressure hand sprayer, backpack sprayer, speed sprayer, others), frequency of pesticide spraying in the last year (<10 times, 10-20 times, ≥ 20 times), symptoms of acute pesticide poisoning in the last year (no, yes), frequency of farmer's syndrome in the last month (no, sometimes, always), neurotoxic symptoms in usual day (no, yes).

The symptoms of acute pesticide poisoning were defined as the occurrence of one or more of the 21 symptoms within 48 hours after exposure to the pesticide in the last year. The 21 symptoms of acute pesticide poisoning included nausea, vomiting, diarrhea, sore throat, runny nose, dyspnea, headache, dizziness, anxiety, excessive sweating, blurred vision, paresthesia, slurred speech, paralysis, chest pain, syncope, muscle weakness, skin irritation, eye irritation, lacrimation, and fatigue [18].

Farmer's syndrome

The Korean version of the diagnostic criteria scale [19] was used to investigate the incidence of eight symptoms of farmer's syndrome such as shoulder stiffness, low back pain, numb limbs, nocturia, dyspnea, insomnia, dizziness, and abdominal discomfort in the last month. The total score was calculated using zero for 'none', one point for 'sometimes', and two points for 'always'. The results were classified as follows: 'negative and probable' for less than seven points and 'positive' for seven points or more.

Neurotoxic symptoms

For the neurotoxic symptoms, the Swedish Q16 questionnaire was used as the most generalized neurological symptoms questionnaire for chronic exposure of organic solvents abroad, which was verified for validity in a previous study [20]. The Swedish Q16 questionnaire was surveyed for the 16 neurotoxic symptoms in usual day. The details are as follows: 'Are you abnormally tired?', 'Do you have palpitations even when you don't exert yourself?', 'Do you often have a painful tingling in some part of your body?', 'Do you often feel irritated without any particular reason?', 'Do you often feel depressed without any particular reason?', 'Do you have problems with concentrating?', 'Do you have a short memory?', 'Do you perspire without any particular reason?', 'Do you have any problems with buttoning and unbuttoning?', 'Do you generally find it hard to get the meaning from reading newspapers and books?', 'Have your relatives told you that you have a short memory?', 'Do you sometimes feel an oppression in your chest?', 'Do you often have to make notes about what you must remember?', 'Do you often have to go back and check things you have done such as locked the door?', 'Do you have a headache at least once a week?', and 'Are you less interested in sex than what you think is normal?'. The total score was

calculated by using zero for 'no' and one point for 'yes'. The results were classified as follows: 'negative' of less than six points and 'positive' of six points or more.

Statistics

The prevalence of subjects' total and each neurotoxic symptom was indicated by frequency analysis. Chi-square test was used for general and agricultural characteristics and farmer's syndrome according to neurotoxic symptoms of husband and wife. To assess the relationship between farmer's syndrome and neurotoxic symptoms in husband and wife, logistic regression analysis was conducted after correcting for age, education level, drinking, cultivation type and scale, farming period, pesticide spraying period, pesticide spraying method, and frequency of pesticide spraying of this study. These results were shown by odds ratio (OR) and 95% confidence interval (CI). All statistics were performed using Statistical Analysis Software (SPSS version 18.0, SPSS Inc.).

Results

Table 1. Summary on characteristics of subjects

Variable	Husband		Wife		p-value	
	N	%	N	%		
Total	174	50.0	174	50.0		
Age (years)	<65	71	40.8	110	63.2	<0.001
	≥65	103	59.2	64	36.8	
Education	≤Elementary school	70	40.2	101	58.1	<0.001
	Middle school	44	25.3	43	24.7	
	≥High school	60	34.5	30	17.2	
Smoking	No	101	58.0	173	99.4	<0.001
	Yes	73	42.0	1	0.6	
Drinking	No	69	39.7	125	71.8	<0.001
	Yes	105	60.3	49	28.2	
Cultivation type	Green house	59	33.9	61	35.1	0.99
	Orchard	61	35.1	61	35.1	
	Crop	37	21.3	35	20.1	
	Rice	17	9.7	17	9.7	
Cultivation scale (Pyeong ^a)	<1,000	33	18.9	37	21.3	0.49
	1,000-2,000	53	30.5	43	24.7	
	≥2,000	88	50.6	94	54.0	
Farming period (years)	<20	28	16.1	27	15.5	0.99
	≥20	146	83.9	147	84.5	
Pesticide spraying period (years)	<20	27	15.5	37	21.3	0.21
	≥20	147	84.5	137	78.7	
Pesticide spraying role	Direct spray	171	98.3	32	18.4	<0.001
	Spray assistant	1	0.6	133	76.4	
	Both	2	1.1	9	5.2	
Pesticide spraying method	High pressure hand sprayer	63	36.2	65	37.4	0.99
	Backpack sprayer	28	16.1	26	14.9	
	Speed sprayer	64	36.8	63	36.2	
	Others	19	10.9	20	11.5	
Frequency of pesticide spraying (times/year)	<10	35	20.1	42	24.1	0.68
	10-20	88	50.6	84	48.3	
	≥20	51	29.3	48	27.6	
Acute pesticide poisoning	No	155	89.1	151	86.8	0.62
	Yes	19	10.9	23	13.2	
Farmer's syndrome	Negative and probable (<7)	127	73.0	105	60.3	<0.05
	Positive (≥7)	47	27.0	69	39.7	

^aPyeong = 3.3 m²

Neurotoxic symptoms are the period for usual day. Farmer's syndrome is the period for the last month.

General and agricultural characteristics

Table 1 showed general and agricultural characteristics for 348 farmers (174 couples). As a result, over 65 years of age, the number of husbands (59.2%) had significantly higher than that of wives (36.8%) ($p<0.001$). In terms of under elementary school graduation, the number of wives (58.1%) had significantly higher than that of husbands (40.2%) ($p<0.001$). Current smokers were significantly higher in husbands (42.0%) than wives (0.6%) ($p<0.001$). Also, current drinkers were significantly higher in husbands (60.3%) than wives (28.2%) ($p<0.001$). Husbands had the most direct spraying role (98.3%), and wives had the most spraying assistant role (76.4%) in a significant difference ($p<0.001$). In the case of 'positive' farmer's syndrome, the number of wives (39.7%) had significantly higher than that of husbands (27.0%) ($p<0.05$). However, there were no significant difference as both husbands and wives showed similar distributions in cultivation type and scale, farming period, pesticide spraying period, pesticide spraying method, frequency of pesticide spraying, and acute pesticide poisoning.

Prevalence of neurotoxic symptoms

Table 2 showed the prevalence of total and each 16 neurotoxic symptoms for farming couples. The average score of neurotoxic symptoms were 5.8 ± 3.1 points for husbands, and 7.3 ± 3.4 points for wives and there was a significant difference ($p<0.001$). In the case of 'positive' for neurotoxic symptoms, the prevalence in wives (72.4%) was significantly higher than that in husbands (56.9%) ($p<0.01$). The prevalence of each neurotoxic symptom in both husbands and wives was the highest in 'short memory' and all of 16 neurotoxic symptoms showed a higher prevalence in wives than husbands.

Related factors of neurotoxic symptoms

Table 3 and Table 4 showed general and agricultural characteristics and farmer's syndrome according to neurotoxic symptoms of husband and wife, respectively. As a result, husbands with 'positive' neurotoxic symptoms were significantly higher than those 'negative' in the following groups: 46.5% for those with elementary school graduation or lower ($p<0.05$), 68.7% for those with current drinker ($p<0.05$), 29.3% for those with crop cultivation ($p<0.05$), 90.9% for those with farming period over 20 years ($p<0.01$), 91.9% for those with pesticide spraying period over 20 years ($p<0.01$), 43.4% for those who used for high pressure hand sprayer in pesticide spraying method ($p<0.05$), 39.4% for those with 'positive' farmer's syndrome ($p<0.001$). However, the role of direct spraying was very clear at 98.3% in the role of husband's pesticide spraying, so there was no difference in neurotoxic symptoms.

Table 2. Prevalence of neurotoxic symptoms

	Total (N=348)		Husbands (N=174)		Wives (N=174)	
	N	%	N	%	N	%
Total score (mean \pm SD) ^{***}	6.5 \pm 3.3		5.8 \pm 3.1		7.3 \pm 3.4	
Total, positive (≥ 6) ^{**}	225	64.7	99	56.9	126	72.4
Short memory	293	84.2	144	82.8	149	85.6
Poor concentration	239	68.7	111	63.8	128	73.6
Tired	235	67.5	109	62.6	126	72.4
Make notes	220	63.2	105	60.3	115	66.1
Poor sexual desire	215	61.8	103	59.2	112	64.4
Tingling	193	55.5	87	50.0	106	60.9
Perspire	185	53.2	83	47.7	102	58.6
Check door ^{**}	183	52.6	78	44.8	105	60.3
Do not understand [*]	113	32.5	46	26.4	67	38.5
Headache ^{***}	77	22.1	23	13.2	54	31.0
Forgetfulness [*]	72	20.7	28	16.1	44	25.3
Chest tightness [*]	68	19.5	24	13.8	44	25.3
Palpitation ^{**}	64	18.4	20	11.5	44	25.3
Irritated	47	13.5	23	13.2	24	13.8
Depressed [*]	52	14.9	17	9.8	35	20.1
Button	16	4.6	7	4.0	9	5.2

^{*}Standard deviation, ^{*} $p<0.05$, ^{**} $p<0.01$, ^{***} $p<0.001$
 Neurotoxic symptoms are the period for usual day.

Table 3. Summary on characteristics of husbands for neurotoxic symptoms

Variable	Negative (<6)		Positive (≥6)		p-value	
	N	%	N	%		
Age (years)	<65	36	48.0	35	35.4	0.12
	≥65	39	52.0	64	64.6	
Education	≤Elementary school	24	32.0	46	46.5	<0.05
	Middle school	17	22.7	27	27.3	
	≥High school	34	45.3	26	26.2	
Smoking	No	42	56.0	59	59.6	0.65
	Yes	33	44.0	40	40.4	
Drinking	No	38	50.7	31	31.3	<0.05
	Yes	37	49.3	68	68.7	
Cultivation type	Green house	25	33.3	34	34.3	<0.05
	Orchard	33	44.0	28	28.3	
	Crop	8	10.7	29	29.3	
	Rice	9	12.0	8	8.1	
Cultivation scale (Pyeong ^a)	<1,000	11	14.7	22	22.2	0.09
	1,000-2,000	19	25.3	34	34.3	
	≥2,000	45	60.0	43	43.5	
Farming period (years)	<20	19	25.3	9	9.1	<0.01
	≥20	56	74.7	90	90.9	
Pesticide spraying period (years)	<20	19	25.3	8	8.1	<0.01
	≥20	56	74.7	91	91.9	
Pesticide spraying role	Direct spray	74	98.7	97	98.0	-
	Spray assistant	0	0.0	1	1.0	
	Both	1	1.3	1	1.0	
Pesticide spraying method	High pressure hand sprayer	21	28.0	43	43.4	<0.05
	Backpack sprayer	10	13.3	18	18.2	
	Speed sprayer	36	48.0	27	27.3	
	Others	8	10.7	11	11.1	
Frequency of pesticide spraying (times/year)	<10	15	20.0	20	20.2	0.98
	10-20	37	49.3	51	51.5	
	≥20	23	30.7	28	28.3	
Acute pesticide poisoning	No	69	92.0	86	86.9	0.33
	Yes	6	8.0	13	13.1	
Farmer's syndrome	Negative and probable (<7)	67	89.3	60	60.6	<0.001
	Positive (≥7)	8	10.7	39	39.4	

^aPyeong = 3.3m²

Neurotoxic symptoms are the period for usual day. Farmer's syndrome is the period for the last month.

Wives with 'positive' neurotoxic symptoms were significantly higher than those 'negative' in the following groups: 33.3% for those with current drinker ($p<0.05$), 23.8% for those with crop cultivation ($p<0.05$), 41.3% for those who used high pressure hand sprayer in pesticide spraying method ($p<0.01$), 47.6% for those with 'positive' farmer's syndrome ($p<0.001$). However, the role of the pesticide spraying in wives varied from 76.4% of spray assistant, 18.4% of direct spray, to 5.2% of both spray assistant and direct spray, but there was no difference in neurotoxic symptoms.

Relationship between farmer's syndrome and neurotoxic symptoms

In order to evaluate neurotoxic symptoms affected by farmer's syndrome, a logistic regression analysis was performed by adjusting the confounding variables such as age, education, drinking, cultivation type, cultivation scale, farming period, pesticide spraying period, pesticide spraying method, and frequency of pesticide spraying. The results are shown in Table 5 and Table 6. The risk of 'positive' neurotoxic symptoms for husbands compared to 'negative and probable' farmer's syndrome was 5.37 times (95% CI = 2.01-14.30) higher in 'positive' farmer's syndrome. The risk of 'positive' neurotoxic symptoms for wives compared to 'negative and probable' farmer's syndrome was 7.07 times (95% CI = 2.58-19.38) higher in 'positive' farmer's syndrome. In conclusion, both husbands and wives showed a significant association between farmer's

syndrome and neurotoxic symptoms. However, wives had a higher risk of ‘positive’ neurotoxic symptoms than husbands when farmer’s syndrome was ‘positive’.

Table 4. Summary on characteristics of wives for neurotoxic symptoms

Variable	Negative (<6)		Positive (≥6)		p-value	
	N	%	N	%		
Age (years)	<65	29	60.4	81	64.3	0.73
	≥65	19	39.6	45	35.7	
Education	≤Elementary school	25	52.1	76	60.3	0.11
	Middle school	10	20.8	33	26.2	
	≥High school	13	27.1	17	13.5	
Smoking	No	48	100.0	125	99.2	-
	Yes	0	0.0	1	0.8	
Drinking	No	41	85.4	84	66.7	<0.05
	Yes	7	14.6	42	33.3	
Cultivation type	Green house	15	31.3	46	36.5	<0.05
	Orchard	25	52.1	36	28.6	
	Crop	5	10.4	30	23.8	
	Rice	3	6.2	14	11.1	
Cultivation scale (Pyeong ^a)	<1,000	10	20.8	27	21.4	0.50
	1,000-2,000	9	18.8	34	27.0	
	≥2,000	29	60.4	65	51.6	
Farming period (years)	<20	10	20.8	17	13.5	0.25
	≥20	38	79.2	109	86.5	
Pesticide spraying period (years)	<20	12	25.0	25	19.8	0.53
	≥20	36	75.0	101	80.2	
Pesticide spraying role	Direct spray	12	25.0	20	15.9	0.25
	Spray assistant	35	72.9	98	77.8	
	Both	1	2.1	8	6.3	
Pesticide spraying method	High pressure hand sprayer	11	22.9	52	41.3	<0.01
	Backpack sprayer	5	10.4	21	16.7	
	Speed sprayer	28	58.4	37	29.4	
	Others	4	8.3	16	12.6	
Frequency of pesticide spraying (times/year)	<10	8	16.6	34	27.0	0.35
	10-20	26	54.2	58	46.0	
	≥20	14	29.2	34	27.0	
Acute pesticide poisoning	No	41	85.4	110	87.3	0.80
	Yes	7	14.6	16	12.7	
Farmer’s syndrome	Negative and probable (<7)	39	81.3	66	52.4	<0.001
	Positive (≥7)	9	18.8	60	47.6	

^aPyeong = 3.3m²

Neurotoxic symptoms are the period for usual day. Farmer’s syndrome is the period for the last month.

Table 5. Logistic regression analysis of farmer's syndrome and neurotoxic symptoms for husbands

	Crude		Adjusted	
	OR ^a (95% CI ^b)	p-value	OR ^a (95% CI ^b)	p-value
Negative and probable (<7)	1		1	
Positive (≥7)	5.44 (2.36-12.57)	<0.001	5.37 (2.01-14.30)	<0.01

^aOdds ratio; ^bConfidence interval

Neurotoxic symptoms are the period for usual day. Farmer’s syndrome is the period for the last month. Adjusted for age, education level, drinking, cultivation type and scale, farming period, pesticide spraying period, pesticide spraying method, and frequency of pesticide spraying.

Table 6. Logistic regression analysis of farmer's syndrome and neurotoxic symptoms for wives

	Crude		Adjusted	
	OR ^a (95% CI ^b)	<i>p</i> -value	OR ^a (95% CI ^b)	<i>p</i> -value
Negative and probable (<7)	1		1	
Positive (≥7)	3.94 (1.76-8.81)	<0.01	7.07 (2.58-19.38)	<0.001

^aOdds ratio; ^bConfidence interval

Neurotoxic symptoms are the period for usual day. Farmer's syndrome is the period for the last month. Adjusted for age, education level, drinking, cultivation type and scale, farming period, pesticide spraying period, pesticide spraying method, and frequency of pesticide spraying.

Discussion

The results of this study on the usual neurotoxic symptoms of farming couples showed a similar trend to the previous domestic study, as the 'positive' prevalence of wives was significantly higher than that of husbands ($p < 0.01$). According to a study on the effects of pesticide exposure on the central nervous system, the prevalence of six or more neurotoxic symptoms was higher in females (66.7%) than in males (44.4%) [21]. In addition, the score of neurotoxic symptoms in this study was similar to that of previous study abroad. A study in Ethiopia showed that the score of neurotoxic symptoms was 5.3 ± 1.9 points in males spraying pesticides [22], and a study in South Africa reported that the score of neurotoxic symptoms was seven points in females living in agricultural and surrounding areas [23].

In this study, the neurotoxic symptoms of husbands were significantly different in education, drinking, cultivation type, farming period, pesticide spraying period, pesticide spraying method, and farmer's syndrome. In addition, the neurotoxic symptoms of wives were significantly different in drinking, cultivation type, pesticide spraying method, and farmer's syndrome. Alcohol in the drinking factor is known to induce the chemical and structural changes of nerve cells by acting on the central nervous system [24]; it supports this study, in which the association between drinking factor and neurotoxic symptoms was observed in both husbands and wives. Also, the neurotoxic symptoms of both husbands and wives were significantly related to cultivation type and pesticide spraying method. This is very dependent on the couple's workforce because Korea's agriculture consists of couple-centered farm management [25]. Particularly, it is judged that this is the result as farming couples often share each other's lives in a similar living environment [26].

In a previous study of spraying pesticides by men, as the association between cumulative lifetime days of using any pesticide and neurotoxic symptoms was reported [27], it showed similar results to the factors of husband's farming period and pesticide spraying period in this study. This is assumed to have influenced neurotoxic symptoms not only during pesticide spraying period but also farming period, because most of them started farming and pesticide spraying at the same time. In a study of spraying pesticide by men commercially, it has been reported that neurobehavioral symptoms are associated with age and symptoms of acute pesticide poisoning [22]. In this study, the prevalence of acute pesticide poisoning symptoms in husbands was 13.1% when the neurotoxic symptoms were 'positive' and higher than those (8.0%) when the neurotoxic symptoms were 'negative', but there was no significant difference. Besides, a study with female farmers reported that past or present agricultural experience factors are associated with some neurotoxic symptoms [23]. As such, studies on pesticide exposure factors related to neurotoxic symptoms have been partially attempted, but studies comparing by gender are incomplete. So, it is necessary to study concretely for pesticide exposure factors affecting neurotoxic symptoms in farmers.

The prevalence of 'positive' farmer's syndrome in this study was significantly higher in wives than in husbands ($p < 0.05$), and it was consistent with the results of previous studies [28]. In addition, when the farmer's syndrome was 'positive,' the prevalence of neurotoxic symptoms was higher in wives than in husbands. As a result of analyzing the association between farmer's syndrome and neurotoxicity symptoms, the risk of neurotoxicity 'positive' symptoms in both husbands and wives increased significantly when the farmer's syndrome was 'positive'. This study has been supported because it has been suggested that farmer's syndrome, an occupational disease syndrome of agricultural workers, can be regarded as the predecessor of chronic diseases such as hypertension, arteriosclerosis, myocardial disorders, kidney diseases, rheumatoid arthritis, and neurosis [29]. The farmer's syndrome is also associated with the prevalence of other common diseases, so it is reported that people with 'positive' farmer's syndrome were often accompanied by physical and mental illness [30]. However, the risk of 'positive' neurotoxic symptoms was higher in wives than in husbands when the farmer's syndrome was 'positive' in this study. In a study of rural residents across the country, women (13.55 points) had a higher score of farmer's syndrome than men (12.07 points), and the health problem score for nervous system was also higher in women (2.30 points) than men (1.42 points), and there was a significant positive correlation ($p < 0.001$) between the health problems including nervous system and farmer's syndrome [31]. These results are considered to affect not only farmer's syndrome but also neurotoxic symptoms, which is one of the chronic diseases, because most female farmers have a dual role in domestic labor and agriculture [2] and have more labor tasks such as spray assistant, dilution, washing, and re-entry and a lot of working hours [32]. However, farmer's syndrome is a characteristic symptom that occurs frequently in farmers [8]. Therefore, it will be important to clarify the definition and confirm the association with neurotoxicity to female farmers

by identifying the cause of each symptom.

Some limitations of this study are as follows. First, subjects were recruited in Chungnam Province and they were not randomly selected. Second, only 38% of all farming couples are selected and there is a possibility of selection bias, which requires careful interpretation of the results. Third, it is possible that there are factors that have not been investigated in this study or are not yet known about neurotoxic symptoms. Fourth, because a survey method that depends on the subject's memory was used, a recall bias may occur which can be interpreted as underestimation or overestimation. However, this study has significance in that the prevalence of neurotoxic symptoms in domestic farming couples and the relationship between farmer's syndrome and neurotoxic symptoms in farming couples was examined for the first time. It is thought that it will be able to contribute to the prevention of related diseases, focused on farming couples.

Conclusion

For 348 farmers (174 couples) in Chungnam Province in 2014-2019, the relationship between farmer's syndrome and neurotoxic symptoms of husbands and wives was examined respectively. Neurotoxic symptoms in both husbands and wives were significantly associated with farmer's syndrome. Particularly, when farmer's syndrome was 'positive,' the risk of neurotoxic symptoms tended to be higher for wives than for husbands. Therefore, this study might be useful as important data for establishing and training agricultural safety and health policy by comparing the relationship between farmer's syndrome and neurotoxic symptoms of husband and wife farmers.

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Conflict of interest

The authors have no conflicts of interest with material presented in this paper.

CRedit author statement

JC: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Writing - Original draft; SIM: Investigation, Project administration; SR: Supervision, Writing - Review and Editing

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