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Exposure to pesticide as a risk factor for depression: A population-based longitudinal study in Korea

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ABSTRACT

Background: Exposure to pesticides is associated with mental disorders, including depression, especially among occupationally exposed populations, such as farmers. The results of experimental studies ascribed the negative effects of pesticides on mental health to their neurotoxic and endocrine-disrupting activities.
Purpose: This study aimed to investigate the association between the risk of depression and high- or low-level exposure to pesticides in a rural population.
Methods: This longitudinal study was performed in 2005–2008 (baseline) and 2008–2012 (follow-up) to evaluate the risk of depression among 2151 Korean adults. A standardized questionnaire was used to obtain information on depression upon self-reported exposure to pesticide based on the Center for Epidemiologic Studies Depression Scale. Logistic regression analysis was performed to evaluate the association between pesticide exposure and depression. We adjusted the data for age, cigarette smoking status, current alcohol use, monthly income, educational level, marriage status, and religion.
Results: Among the individuals who reported depression, the number of participants who used pesticides was significantly higher than that who did not (N = 61 [7.2%] vs. N = 54 [4.2%], $P = 0.003$). A positive association was noted between >20-year period of pesticide use and depression (odds ratio [OR], 2.35; 95% confidence interval [CI], 1.41–3.88). Individuals who reported depression showed greater odds of being exposed to higher pesticide concentrations (OR, 2.33; 95% CI, 1.40–3.88) and experiencing pesticide poisoning (OR, 5.83; 95% CI, 1.80–18.86) than those who did not.
Conclusion: Exposure to pesticides at a high concentration was found to be associated with depressive symptoms among Korean adults.

1. Introduction

Major depressive disorder (MDD) is one of the most common psychiatric problems worldwide (Joo and Roh, 2016; Williams et al., 2007). The World Health Organization estimates depression as the fourth leading cause of the global burden of disease (Ustun et al., 2004), and 10%–20% of the global population is suffering from this disease (Riolo et al., 2005). Depression results in serious social, occupational, and physical disorders: around 10–15% of depressive individuals perpetrate suicide (Joo and Roh, 2016). Studies also suggest that depression is more widespread in older age groups than in their younger counterparts (Joo and Roh, 2016; Koenig et al., 1992). According to the 2015 Korean Statistical Information Service, 33% of people aged ≥65 years suffer from depressive symptoms (26.1% for men vs. 38.1% for women) in Korea. Furthermore, depression scores among older adults in suburban areas are higher than among those in urban areas (Joo and Roh, 2016).

Although controversy still exists with regard to the chemical types, intensity, and forms of exposure in relation to the risk factors for neuropsychological problems, pesticide exposure has been shown to be associated with psychiatric disorders among farm

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workers (Faria et al., 2014). It has also been linked to depression among older adults (Joo and Roh, 2016). Most pesticides are considered to contain pyrethroids and organophosphates (OPs) (Kim et al., 2015). The association between OP pesticides, which are the most universally used pesticides and insecticides in the world and utilized for a variety of agricultural and domestic purposes (Mackenzie Ross et al., 2010), and psychiatric problems have long been examined (Bagchi et al., 1995; Paul et al., 2016). The immediate effects of high-level exposure to OPs have been well demonstrated, which involve inhibition of the enzyme acetylcholinesterase, causing changes in the peripheral, autonomic, and central nervous system functions (cholinergic crisis) (Mackenzie Ross et al., 2010). Meanwhile, pyrethroids are synthetic pesticides usually utilized to control insect pests in agricultural and residential settings worldwide (Kaneko, 2011; Morgan, 2012). Moreover, pyrethroid-based pesticides are known to lead to neurotoxicity.

Experimental evidence has demonstrated that pesticides elicit effects on neural systems that are known to underlie depression (Weisskopf et al., 2013). However, studies on the association between pesticide-induced neurotoxicity and depression are lacking in Korea. Therefore, we aimed to outline in this study the association between pesticide exposure and depression among Korean agricultural workers exposed to a wide variety of pesticides.

2. Materials and methods

2.1. Study population

This study was conducted using the data of the participants from the Korea Farmers Cohort study, which was originally undertaken to investigate the association between pesticide exposure and depression. The participants in the study were recruited among the residents of the Wonju and Pyengchang areas, Gangwon-do Province, Republic of Korea, who were farmers or agribusinessmans. This study was approved by the Institutional Review Board of Wonju Christian Hospital. All participants provided written informed consent prior to their inclusion in this study. To recruit participants for the survey, the follow-up steps of the survey were explained in village offices and community health centers in the areas where the survey will be conducted. We contacted the participants face-to-face, not through email or phone. The survey was also promoted among the community leaders and farmers during leadership meetings and to the Rural Development Administration of Korea, and volunteers registered to participate in the survey.

The baseline survey was conducted from November 2005 to January 2008 and included 3162 adults. We excluded 431 participants who had depression scores >21 points at the baseline (Lee et al., 2011) because they had severe depressive symptom based on the Center for Epidemiologic Studies Depression Scale (CES-D) and 598 participants who had incomplete data at the follow-up survey (April 2008–August 2012). Thus, 2151 participants were included in the final sample.

2.2. Questionnaire

We investigated the data collected via a standardized modified questionnaire developed by the Agricultural Health Study (Dosemeci et al., 2002) to obtain information on history of pesticide poisoning and clinical information during the baseline and follow-up surveys conducted from November 2005 to January 2008 and April 2008 to August 2012, respectively. The general demographic characteristics of the participants were obtained through the questionnaire, such as age, gender, educational level, marital status, and income. Educational level was categorized based on whether or not the respondent finished primary school. The population was classified based on their age into three groups: <69, 70–79, and >80 years. Based on alcohol consumption, the individuals were categorized as either current drinker or not. Lastly, based on cigarette-smoking status, the individuals were divided into never, past, or current user groups. We categorized participants who have depression using CES-D, which is a short self-report scale designed to estimate depressive symptomatology in the common population (Radloff, 1991; Siddaway et al., 2017). The fact that the CES-D includes a mixture of negatively (e.g., "I felt sad" or "I thought my life had been a failure") and positively (e.g., "I felt happy" or "I enjoyed life") worded items prompted the proposal that this scale could be reconceptualized as a depression/well-being continuum (Joseph, 2007; Siddaway et al., 2017). Whether a person would have to give all the negatively worded items (e.g., "I felt sad") the lowest possible score ("rarely or none of the time") and all of the positively worded items (e.g., "I enjoyed life") the highest possible score ("most or all of the time") for a score of zero to occur on the CES-D was disputed. For such a person, stating that they have merely indicated an absence of depressive experiences would be confusing; such an individual has also clearly revealed the presence of well-being (Siddaway et al., 2017).

2.3. Pesticide exposure index

Exposure to pesticides can occur while transporting, mixing, and applying pesticide chemicals. Factors influencing exposure levels thereto include activity type (e.g., mixing), application method (e.g., hand spraying and speed sprayer), personal protective equipment (PPE) use (e.g., gloves, face shields, and boots), and personal work habits and hygiene (e.g., taking a bath after pesticide use). We investigated the intensity levels and cumulative exposure index (CEI) levels of pesticide use. Intensity levels were calculated using the following equation: intensity level = (mixing status + application method + equipment repair status) × PPE. Meanwhile, CEI levels were calculated as follows: CEI = intensity level × spraying year × spraying days per year (Dosemeci et al., 2002; Lee et al., 2017).

Individual pesticides were initially examined in broad categories. For example, questionnaire items were "Have you ever applied pesticide?", "Have you applied pesticide in person?", " How many years have you applied?", "How many days per year have you applied?", "How many hours per day have you applied?", "Taking PPEs when mixing pesticide." (Dosemeci et al., 2002; Lee et al., 2017). Information on the history of pesticide poisoning was obtained by asking the individual. Use of any pesticide was calculated by multiplying the number of years of use by the number of days per year of use. Those with history of pesticide poisoning were considered as a separate category, regardless of the number of lifetime days of use. Thus, pesticide exposure was analyzed based on the following categories: low-level cumulative exposure, high-level cumulative exposure, and history of pesticide poisoning.

2.4. Depression and covariate assessment

Short-Form Geriatric Depression Scale (SGDS) was utilized in the follow-up survey to estimate the presence of depression, which was defined as a score of ≥8 during the follow-up survey. Participants who were suspected to have a major depressive disorder at the baseline were excluded from analysis. All participants were also asked about the use of home-gardening pesticides.

2.5. Statistical methods

To analyze the association between pesticide exposure and depression, we counted the numbers and percentiles of