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SHORT REPORT

Health and agrochemical use experiences of agricultural workers with high serum cholinesterase levels in Northeastern Thailand

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ABSTRACT

In developing countries, agrochemicals are frequently used, resulting in direct and indirect chemical exposure as well as a variety of health concerns. Although agrochemical safety education is essential to promoting protective behavior among agricultural workers, there is a gap in the body of evidence concerning experience with agrochemical use and practice, which is critical for developing and improving educational interventions, so they are more effective and acceptable to the workers' culture and lifestyle. This phenomenology study included twenty agricultural workers with high serum cholinesterase levels in two Thai rural communities. Data from semi-structured interviews were transcribed verbatim and analyzed by using Colaizzi's 7-step data analysis, which is mentioned in the data analysis part. Five themes and three subthemes emerged in relation to agrochemical use and health: (i) long-term chemical exposure; (ii) no need to be concerned about health after chemical exposure; (iii) insufficient chemical protection knowledge and practices; (iv) difficulties in adhering to the agrochemical exposure prevention regimen; and (v) government policy and the growth of the organic products market are important components of chemical use reduction. Based on the findings, the workers lacked awareness regarding protective behaviors, because they did not notice any abnormal changes in their health. We, therefore, recommend that they undergo annual checkups for monitoring their SChE levels, which should be provided by the local government. In addition, agrochemical use is influenced by socioeconomic and political factors. Thus, a health education program for agricultural workers should involve a multidimensional and community-engaged training program that would promote the safe handling of chemicals through contextually appropriate interventions.

Key words:
agrochemicals; exposure; experience; farmer health; Thailand; qualitative research

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INTRODUCTION

Global market integration has made agrochemicals an integral part of farming all over the world, especially in developing countries. This is because they are less expensive, more effective, and more convenient. In recent years, preventing and improving the safety behaviors associated with agrochemical use among agricultural workers has become a global health issue. This is because unintentional, acute pesticide poisoning is estimated to affect 385 million people annually, accounting for 44 percent of the world's population, which may lead to around 11,000 fatalities every year.[1] Exposure to agricultural pesticides has been a serious public health concern in developing countries like Thailand.[1] According to the Bureau of Occupational and Environmental Diseases, the trend of pesticide poisoning rates (per 100,000 people) declined from 22.72 to 13.14 between 2017 and 2019.[2] However, by the middle of 2022, the Thai Ministry of Public Health stated that pesticides had already harmed 2,159 Thai agricultural workers (12.36 per 100,000 people), and northeastern Thailand has been indicated as the most afflicted by the hazardous effects of pesticides among Thailand's regions.[3,4] In fact, since the NHSO report did not cover self-employed agricultural workers who are not regulated by Thai labor laws, the number of cases may be higher than reported.[5]

Many educational interventions have been developed to improve the knowledge and practice of Thai agricultural workers for decades, as most evidence indicates that improving knowledge can lead to changing behavior when using agrochemicals.[6-10] In fact, the Thai workers in a study typically described themselves as good pesticide users who administered pesticides in the proper manner, but their blood cholinesterase levels were found to be high.[11] Some researchers explain this situation by proposing that understanding health issues and health literacy is not enough to change the behaviors of agricultural workers since they generally fail to recognize the need to protect themselves and use protective practices, even when they have high levels of knowledge.[12,13] Consequently, most educational interventions did not result in sustained behavioral changes in agricultural workers.[14,15] Research has found that, rather than being influenced by their level of knowledge, agricultural workers' decisions to use pesticides and other health-related behaviors are influenced by personal, interpersonal, sociocultural, economic, and political factors.[16] This situation is consistent with our preliminary study on agricultural workers in Nakhon Phanom Province, which found that the workers had high levels of knowledge, even those who had abnormal levels of serum cholinesterase (SChE level).[17] Indeed, there is a need to understand agricultural workers' specific work experiences and perspectives, because these experiences provide insight into pesticide exposure and use, as well as how those influences affect workers' ability to protect themselves from workplace hazards.[18] However, in the absence of adequate qualitative knowledge about Thai workers' agrochemical use, implementing educational interventions, particularly those designed to improve Thai farmers' knowledge, attitude, and practice (KAP) regarding pesticide use, which is the most common design,[11,19] may be difficult to result in behavioral changes because the knowledge may not be appropriate to apply in the Thai farmers' context.[20]

In this study, we used a phenomenological approach to understand agrochemical use experiences among farm workers with abnormal SChE levels, which accounted for 77.30 percent of the agricultural workers in two rural communities in Nakhon Phanom Province according to our preliminary study.[17] The province also has a high rate of pesticide-related illnesses among agricultural

workers aged 15 and over with a pesticide poisoning rate of 10.68 per 100,000 people.[21] The findings of the study will serve as a basis for developing and implementing a program to educate Thai agricultural workers about agrochemical use.

METHODS

Participants

According to Nastasi and Schensul, researchers who collect phenomenological research by interviewing key informants or in-depth interviews should include 5–30 participants to consider data sufficiency.[22] Therefore, twenty key informants were recruited from two rural communities of Nakhon Phanom Province, Thailand, to provide valuable information about their health and pesticide use. The inclusion criteria were: 1) being an agricultural worker who has used pesticides for at least one year; and 2) having unsafe or risky serum cholinesterase levels, which are determined by a reactive-paper finger-blood test. Next, we selected the workers with unsafe or risky serum cholinesterase levels participating in the preliminary project in 2021 (academic services to the community of the Boromarajonani College of Nursing Nakhon Phanom in 2020), to receive the blood test, which would provide a wealth of information. We excluded those workers who had safe or normal levels as well as those who refused to participate in the study.

Data Collection

The semi-structured interview questions were developed by the researchers and evaluated for validity by three experts, including two nurse researchers and one epidemiologist. The researchers made changes following suggestions from the experts and used the questions to interview two people who were similar to the study's population. The researchers then changed the interview questions to suit the participants' contexts. All interviews were audiotaped and transcribed verbatim. The researchers also observed and documented the informants' body language and nonverbal cues during the interviews. Each completed transcript was reviewed by each informant to ensure that the data was precise.

Data Analysis

The transcription and translation of the interviews into English were done by a researcher who did not interview the participants. Then the research team checked the quality of the data or translation quality of the interviews. Disagreements between the translator and the interviewers were resolved through clarification with another translator. Twenty interviews were analyzed by using Colaizzi's 7-step data analysis: 1) familiarization; 2) identification of significant statements; 3) meaning formulation; 4) theme clustering; 5) development of an exhaustive description; 6) production of the fundamental structure; and 7) verification of the fundamental structure.[23] A codebook was developed by the researcher team to capture major themes identified across agrochemical usage experiences and health. All data coding was conducted using ATLAS.ti 22. Codes were individually created by the researchers to make this work more rigorous. Before finalizing the codes, any discrepancies were reviewed by the researchers.

Ethical Considerations

This study obtained ethical approval from the Nakhon Phanom University Research Ethics Committee (Reference 47/64).

RESULTS

Participant's Characteristics

The participants were aged between 38 and 79 years, with an average age of 56.08 years and the majority (68%) being females. The participants were rice farmers who had been using chemical fertilizers, weed killers, and pesticides for over 20 years. Among twenty participants, the reactive-paper finger-blood test determined that 64% of the participants had unsafe serum cholinesterase levels and 36% of the participants had risky levels.

Findings on Experience of Agrochemicals Use and Health

Five themes and three subthemes emerged during the analysis of the interview transcripts: (i) long-term chemical exposure; (ii) no need to be concerned about health after chemical exposure; (iii) insufficient chemical protection knowledge and practices; (iv) difficulties in adhering to the agrochemical exposure prevention regimen; and (v) government policy and the growth of the organic products market are important components of chemical use reduction.

Theme 1: Long-term Chemical Exposure

The interviews revealed that the agricultural workers had spent their entire lives on farmland, witnessing the use of agrochemicals since childhood and, therefore, simply following their parents. *"Cultivation culture, as I already said, is inherited,"* remarked a 50-year-old participant, describing his experience with agrochemical use as an inheritance from generation-to-generation. *"Since the dawn of mankind, chemical fertilizers have been employed. This is something I've seen and done my entire life. They really only spread chemical fertilizer; they don't use any other chemicals. " (P8)*

"*Rice farming is done once a year in the traditional manner, with chemicals used 1-2 times per month from November to February. My parents used them a lot, and now that I'm farming, I use them as well (chemicals). I also learned about chemicals through word of mouth and commercials." (P1)*

Some workers believed that pesticide exposure was unavoidable. The participants could be affected by anything they encountered directly or indirectly in their daily lives, even though they did not use it. "*We live in the fields and get involved with them. Even though we don't use it, when we use the water, it flows down our fields*" *(P7).*

A 54-year-old participant describing her experience said, "*I don't know (why she has high serum cholinesterase) because I don't use weed killers and don't buy vegetables from the market. Someone said that it might be from staying in the fields where someone had sprayed weed killers and smelling the chemicals." (P5)*

Theme 2: No Need to be Concerned about Health after Chemical Exposure

Although the participants had high serum cholinesterase levels, half of them had not experienced any abnormalities in their bodies (10 participants), and some of them had experienced only minor symptoms such as itching (6 participants) and irritation (4 participants). They appreciated the knowledge regarding agrochemical use provided by healthcare providers, but they believed that there were no serious problems. A 48-year-old worker stated, *"I'm a little concerned about having residual chemicals in the body. If there's something wrong, I'll just go see a doctor. If something happens, I'll take medication prescribed by my doctor." (P7)*

Subtheme 2.1: Crop Productivity over Health

Amidst uncertainty about the risks and benefits of agrochemicals to farmers, the participants valued having high crop

productivity above all else: "*You have to use it. If you don't use it, the rice will not grow*" *(P7)*; "*You have to use it. If you don't use it, the rice will not grow…*" *(P11)*; "*if you use chemical fertilizers, it improves productivity and earns more money. If not, the income will be lower*" (3 participants).

Even though they know that using chemicals affects their health, they keep using them, because their crop productivity will be increased: *"It's not good, but it is necessary" (P5),* and *"It's not that safe, considering the growth of rice instead. When using this one, the rice comes up very well, so I use it." "Nothing is safe because it's a chemical." (P8)*

Theme 3: Insufficient Chemical Protection Knowledge and Practices

There was an obvious misuse of chemicals by the agricultural workers in this study, including behaviors before, during, and after their use. A participant said they did not have enough information before using the chemicals, stating, *"The shop also did not provide any information, so I just used gloves to sow (chemical fertilizer)*" *(P8).* However, some of them tried to learn by themselves, "*Every time we use chemicals, we have to read the label to determine whether it is a dangerous chemical and how each chemical is stored and destroyed*" *(P5)*; *"There's a label to read and follow*" *(P9)*; and "*Farming means doing it according to the formula, the fertilizer formula" (P10).*

When using chemicals, the participants normally wear normal clothing and cotton gloves to protect themselves from chemical exposure. For instance, "*To sow fertilizer, I just put on normal clothes, gloves, and cover my mouth, but it's not enough*" *(P3)*; "*Oh, I'm going to tell you something. Although I am aware that they (chemicals) can be absorbed into the body, I still do not use them with sufficient caution (P5)*; *and "I just wear a robber's cap and no gloves*" *(P2)*. The participants did not wear personal protective equipment (PPE) while working with chemicals; one participant indicated that she wanted to, but was unable to because, "*I would like to wear better clothing, but I don't have any, so I'm just using what I have*" *(P5)* and "*Someone suggested that I should wear gloves and cover my nose. I did it, but I wore only cotton gloves, so it wasn't enough" (P11).*

After using chemicals, one participant explained, "*I take a shower. I take a shower several times*." However, some of them explained processes such as returning home after work, "*I return home, shower and change clothes,* " (2 participants). One of the participants said, "*Sometimes I eat with the same hands after washing them with water because I don't have soap handy*" *(P5)*. Even when they recognized that they had high serum cholinesterase levels, they did not know what to do. For example, "*I'm doing nothing, even though I know I am in the risk group*" *(P5)* or "*I'm afraid, but let it be [...] I know that what I'm doing is wrong*" *(P9)*; and "*As a risk group, what should we do? There's nothing I can do*" *(P11).*

Theme 4: Difficulties in Adhering to the Agrochemical Exposure Prevention Regimen

Subtheme 4.1: Impractical Advice

The participants also talked about the difficulties in following the safety regimen. Some of them considered the suggestions to be too difficult to follow, or even impossible to do in daily life, "*Well, it's too difficult to clean and eat, so I don't do it*" *(P5)* and "*How do we change our eating behavior (following suggestions) when we always buy vegetables at the market to eat? The only way is to plant them, but we cannot grow all kinds of vegetables*" *(P7)*. As a result, some of them refuse to practice the safety regimen. "*Yes, I know what I should do*," one participant said, "*but it's good like this, so it goes like*

this" *(P8)* and "*I've got it all (information), now I just need to practice*" *(P3).*

Subtheme 4.2: Insufficient Support

The participants required both private and government sector support to increase their sense of empowerment in practicing chemical precautions. As the participants stated, "*There are services by the District Agricultural Extension Office, but they do not cover everything, because there are so many communities,*" *(P12)* and "*Previously, knowledge was provided by the primary hospital, but it was not enough. After that, the government and the media took the major part*" *(P8)*.

Even after they received information, some participants misunderstood the chemical effects: "*The primary health care unit also provides excellent treatment for us, but I would like the agency to handle some details, because some people still believe that the chemicals will not get into their skin, so just washing their hands will protect them*" *(P3)*. With a sense that knowledge is power, the participants reported a need for education; *"there should have been public training regarding the dangers of chemicals provided by a private or government-run organization" (P5).*

Theme 5: Government Policy and the Growth of the Organic Products Market are Important Components of Chemical Use Reduction

There are 3 key elements to reducing the use of agrochemicals in the community studied. First, the policies of the central government regarding the sale of certain chemicals need to be considered. When people cannot buy chemicals, they do not use them, "*Most of them (people in the area) don't use them (chemicals). Nowadays, it is already less popular,*" *(P9)* and "*Because stores can't sell certain chemicals, they're becoming less popular. It's now against the law*" *(P15)*. Conversations with the participants led some to conclude that the drop in agrochemical use is due to people becoming more aware of chemical toxicity after receiving training from the government, "*The government and the media have promoted avoiding the use of chemicals,*" *(P7)* and "*There are places where fewer chemicals are used, because there are people who come to give knowledge, such as the District Agricultural Extension Office and the primary health care unit" (P9)*.

In addition, the local government showed direct influence on the farming processes in the community, such as in the following statement, "*Neem (a local tree whose seed and leaves are normally used as pesticides) is used to water rice plants to reduce insects and reduce the use of chemicals, which is learned from village wisdom,*" *(P10)* and "*Community leaders recommend growing their own vegetables, especially local vegetables, to reduce the use of chemicals*" *(P15)*.

Aside from government policies, the rise of the organic product market based on customer preferences and costs has also contributed to changing farmer behaviors regarding the use of agrochemicals. According to a participant, *"One reason for stopping pesticide use is that merchants normally come and buy the bulk of the products. When merchants find our products are contaminated with chemicals, they may not buy all of our products for a long time until the residual chemicals have dissipated" (P12).*

DISCUSSION

Abnormal SChE levels are caused by exposure to cholinesterase inhibitors, including organophosphate (OP) and carbamate (CM) insecticides. Despite the fact that most adverse effects of agrochemicals are related to depression of SChE, those adverse effects may not appear right away, depending on factors like agrochemical toxicity, dosages, and

exposure times. Research suggests that abnormal SChE levels are related to many symptoms, including acute symptoms such as headaches, dizziness, and fatigue or weakness;[24] chronic symptoms such as blurred vision;[25] and biochemical changes in the human body, such as red blood cell and white blood cell counts, serum calcium, and lipid profile levels.[26,27] However, the abnormal levels of SChE can recover to normal levels over time.[25] For the reasons mentioned earlier, the farm workers in this study expressed no need to worry about their health following chemical exposure, even after they were found to have abnormal SChE levels. In fact, the farm workers with abnormal SChE levels in this study had long been exposed to agrochemicals and were familiar with them, so they may think they could develop tolerance to some pesticide-related symptoms.[28] Research suggests that improving PPE use in this population as a preventive intervention could potentially reduce the adverse effects from pesticide exposure.[25,26,29] However, because the farm workers in this study were unaware of the possibility of agrochemical poisoning, the workers were not concerned about using PPE while handling agrochemicals.

In terms of personal protective equipment, the priority was to minimize skin, mouth, nose, and eye exposure, including rubber gloves, body coverings, aprons, goggles, face shields, respirators, and boots when handling pesticide products.[30] Personal protection equipment is also necessary for early access to pesticide-treated areas to prevent contact with anything chemically contaminated such as plants, soil, or water. However, the most commonly reported available PPE were dust masks, fabric gloves, long sleeve shirts, long pants, and rubber boots, all of which are acceptable for slightly toxic chemicals, but not enough to prevent aerosol spray.[31] Apart from the quality of PPE, some participants used only one kind of protection. For example, some used only gloves to sow chemical fertilizer. The use of relatively inexpensive PPE suggests that the farmers' choice of PPE was driven by cost-cutting considerations.[32,33] The workers might have chosen PPE out of discomfort associated with hot and humid weather caused by tropical conditions.[34] Interestingly, several studies have documented farm workers' improper use of PPE,[32, 34-38] but other unsafe behaviors, such as reusing, disposing of, washing, and storing pesticide containers, have only been observed in developing countries.[32,35,38]

As mentioned earlier, knowledge, attitude, and practice (KAP) interventions have been widely recognized as effective interventions to improve safe pesticide use for decades. In contrast, a recent study found a linear KAP relationship only for households with low knowledge scores, but not for households with high knowledge scores as a consequence of context-specific socioeconomic factors. Furthermore, knowledge can explain the practice of households by about 37%.[39] Another study found knowledge to be able to explain only 22% of the variance observed in the safe use of pesticides.[40] It follows that, even if farmers are highly aware of the need for personal protection during pesticide spray applications, there is still a possibility that they will not use personal protection.[14] The findings of these studies are comparable to those of Yuantari et al., who found that Indonesian farmers had a good understanding of pesticide effects on their health, but did not apply their knowledge in practice.[41] An explanation by a study from South Africa suggests that, despite farm workers' awareness of exposure risks, unsafe behaviors might continue to be influenced by sociocultural contexts, harmful perceptions, and working conditions.[42] In this study, despite having been educated about the negative effects of agrochemical use, the farm workers perceived agrochemicals as having fewer

adverse health effects and more benefits, which led to their considering further use of agrochemicals. For example, many participants stated that they knew chemicals were bad for health, but they had to rely on them to produce more crop products, which means gaining more money. This reveals a big gap between knowledge and safe practice, especially among developing countries.[40] Our study also shows that farm workers have become accustomed to not practicing safe behavior while using agrochemicals because of impractical guidelines and insufficient support. To avoid this challenge, a self-prevention program should consider contexts, such as available information, political economy, culture, personal characteristics, and the environment, all of which are factors that shape and greatly constrain the participants' positions and perceived feasibility of practice. Therefore, multidimensional interventions[32,44] and community engagement interventions[41, 44-47] have recently become necessary to promote healthy farming practices among farm workers in developing countries.

In addition, our findings support the notion that government policy and the growth of the organic products market are important factors in reducing chemical use among Thai farm workers. This finding is in agreement with researchers from China who found that improving subjective norms alone was not enough to motivate farm workers to adopt preventive behaviors, but improving social norms along with law-regulating policies was effective to motivate them.[42] It was also suggested in a Kuwaiti study that the government needs to give greater priority to enforcing existing pesticide laws and regulations at the retail and farm levels through surveillance and monitoring.[38] It can be concluded that external forces, such as retailers, government policies, commercials, and markets, are found to be very important, particularly in developing countries where the consumption of agrochemicals is always on the rise due to the fact that agricultural workers prioritize economic profit over health.[33,43,48] Another possible recommendation is that it would also be helpful for developing countries to consider the increasing demand for healthy food. The researchers recommend promoting organic farming, in which agrochemicals are restricted.[49] This will protect the environment and have a greater economic impact on these countries, since it may lead to fewer agrochemical imports and increased value of crop products.[49,50] Finally, enforcement of existing pesticide laws and regulations should receive better attention through health surveillance and monitoring. Farm workers and their families, for example, who are exposed to agrochemicals, should have annual SChE level checkups with a primary care unit, which may increase their awareness of their health status and agrochemical use behavior.

RECOMMENDATIONS

The findings of this study will be relevant in furthering knowledge about how to construct effective interventions for agricultural workers in Thailand, particularly in the northeast. Since northeastern farmers can only grow rice once a year in the rainy season, they expect more products with a small investment, which causes them to overlook their health. To make these people aware of their health, follow up on their SChE levels should be a priority. Furthermore, in order to have a greater impact on pesticide use behaviors, nurses should collaborate with individuals in the target population and community leaders. This will enable them to provide sufficient information and support for farmers and to develop policies on increased crop products with reduced agrochemical use. Finally, safe behaviors and barriers to practicing or adhering to safe behaviors regarding pesticide use among Thai farm workers should be investigated

further, because they appear to be significant factors for this group of people.

STUDY LIMITATIONS

The limitation of this study was the lack of a variety of participants, because nearly all were rice farmers. Thus, the results could not be extended to other types of agricultural workers, such as farmers of a variety of other crops, despite the fact that they are from the same part of Thailand as the study participants. In order to conduct a more thorough study, a diverse group of local farmers should be involved.

AUTHOR CONTRIBUTIONS

The study design and conceptualization were developed by OK. Data collection was conducted by OK, AP, CD, PK, and CM. Data analysis was completed by OK, ST, and AP. ST and OK developed the original draft of the manuscript. Before submitting the manuscript, all authors evaluated and approved it.

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