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Knowledge, attitude, and practice of pesticide use by vegetable growers in Bangladesh: a health literacy perspective in relation to non-communicable diseases

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Pesticides are widely used by vegetable growers in Bangladesh, however the health consequences of these chemicals in relation to non-communicable diseases (NCDs) is largely unknown. NCDs have emerged as a major health concern in recent decades and cause deaths, chronic illnesses, and psychosomatic suffering for people worldwide. In Bangladesh, a lack of health literacy among other reasons contributes to the occurrence and prevalence of NCDs. This study interprets and evaluates the status of key health literacy forming components, such as knowledge, attitude, and practices (KAP) of vegetable growers with respect to the use of pesticides. The study was carried out in six districts of Bangladesh. A multistage sampling procedure was used to obtain a survey sample of 334 farmers who grow vegetables and use pesticides. The results revealed that the level of knowledge of the farmers is poor. They are also not very aware of the relationship between pesticide use and potential vulnerability to NCDs. Such knowledge, along with attitude and practices developed through long-held beliefs and perceptions are not helpful for the safe and appropriate use and application of pesticides. To redress such KAP situations among vegetable growers, we posit that policy actors and stakeholders across public health and agricultural sectors, and developmental agencies must strive to improve health literacy in terms of KAP. Large-scale programmatic interventions in the knowledge, attitude, and practices of vegetable growers through training, education, or mass promotion could enhance their literacy and diminish the unabated use of pesticides.

KEYWORDS

pesticide use, vegetables growers, KAP, health literacy, non-communicable diseases

1. Introduction

Pesticides have become an integral part of modern agriculture as they are used for protecting and boosting crop and vegetable production (Oerke, 2006; Verger and Boobis, 2013). However, their utilization is not without consequences for the farmers or growers as these chemicals have adverse impacts on human health as well as the environment (Grung et al., 2015; John and Shaike, 2015; Lerro et al., 2015). The users or applicators of pesticides are exposed to the chemicals while mixing, loading, or applying these or through contact with treated crops (Damalas and Eleftherohorinos, 2011; Remoundou et al., 2014). Although no strong direct link has been established, many studies suggest that pesticide exposure is associated with health effects such as cancers and birth defects (Cha et al., 2014; Cremonese et al., 2014; Markel et al., 2015). In addition to health effects, it is now claimed that many

more non-communicable diseases (NCDs) are occurring in people due to their exposure to pesticides (Dang et al., 2017; Kumar et al., 2020; Calista et al., 2022). Though pesticides are used to fight various pests and diseases in crops, in humans, the chemicals cause both acute and delayed health effects. In particular, exposed users suffer from simple skin and eye irritation to more severe chronic diseases, including cancers, Parkinson's, Alzheimer's, multiple sclerosis, diabetes, aging, and cardiovascular and chronic kidney diseases (Dhouib I. B. et al., 2016; Van Maele-Fabry et al., 2017).

Agricultural farm workers are most exposed to pesticides (Wahab et al., 2016) as they come into contact with highly hazardous chemical compounds, such as carbosulfan, diazinon, carbofuran, heptachlor, endrin, and DDT (Robinson et al., 2007; Zamir et al., 2009; Ali et al., 2014; Shammi et al., 2017). Awang et al. (2011) found that 72% of farmers in Malaysia showed symptoms of poisoning when handling pesticides. Tey et al. (2014) mention that many vegetables are produced with intensive pesticide use, particularly in developing countries. For example, vegetable growers in Bangladesh use a large amount of pesticides throughout the whole production process for many vegetable species (Dasgupta et al., 2005).

The link between NCDs and pesticide exposure is well established by several studies (see for example, Abdollahi et al., 2004; De Souza et al., 2011; and Mostafalou and Abdollahi, 2012). A key finding is that contact with pesticides through long-term exposure harms human life and disturbs the function of different body organs such as the nervous, endocrine, immune, reproductive, renal, cardiovascular, and respiratory systems (Mostafalou and Abdollahi, 2013).

Many studies argue that exposure to pesticides and the occurrence of NCDs are outcomes of there being a low level of health literacy (HL) among the users or applicators (e.g., Rootman and Gordon-El-Bihbety, 2008; Bloom et al., 2011; Vamos and Rootman, 2013). This argument reinforces findings that a good degree of health literacy among people results in a better health situation; more importantly, it is considered a critical factor in managing NCDs (e.g., Schillinger et al., 2002; Johnston et al., 2006; Nutbeam, 2017; Dias et al., 2021). Similar evidence to this argument was outlined by Gazmararian et al. (2003) and Paasche-Orlow et al. (2005) who found that the knowledge specific to NCDs is reciprocated with health literacy as interventions toward improved literacy level were proven effective in reducing health hazards due to NCDs.

The importance of HL in influencing the general health conditions of individuals is immense and necessary for living a healthy life (Hope et al., 2004; Schwartzberg et al., 2007). HL enhances the cognitive and social skills of people, enabling them to seek out health information and concepts to make informed choices, reduce health risks, and increase their quality of life (Zarcadoolas et al., 2006; Sorensen et al., 2012). HL is becoming increasingly significant not only for health promotion but also for understanding NCDs (Vamos and Rootman, 2013). As there is a linkage between NCD occurrence and pesticide use, the spectrum of HL calls for further understanding of NCD–pesticide relations and their consequences on public health (Dang et al., 2017; Almeida et al., 2019; Philippe et al., 2021). NCDs are chronic; the most common and predominant kinds are cardiovascular diseases, cancers, respiratory diseases, and diabetes. They are the result of a combination of genetic, physiological, environmental, and behavioral factors and cause most deaths worldwide every year (Bloom et al., 2011). World Health Organization (WHO) (2022) estimated that NCDs kill 41 million (m) people each year, equivalent to 71% of all deaths globally. Cardiovascular diseases account for most NCD deaths, or 17.9 m people annually, followed by cancers (9.0 m), respiratory diseases (3.9m), and diabetes (1.6 m).

In an evaluation of the agricultural sector in Bangladesh, Mahjabin (2021) concluded that the whole sector is affected by incorrect application processes and that many users use lacking protective measures when applying pesticides that eventually contribute to NCD occurrences. Similarly, Rahman and Debnath (2015) asserted that illiteracy and lack of awareness are the root causes (among others) of excessive use of chemical fertilizers and pesticides in Bangladesh. Mustafa et al. (2021) found NCD vulnerabilities in rural people in Bangladesh. Riaz et al. (2020) suggest that interventions are essential to combat the rising burden of NCDs in Bangladesh, considering the high prevalence of behavioral, physical, and biochemical risk factors and the high-risk population group lacking adequate health literacy.

Against such a background, the objective of this study was twofold: i) to determine and categorize the level of health literacy in terms of KAP among the vegetable growers in Bangladesh with respect to pesticide use and ii) to understand and analyze potential NCD risks due to poor KAP-HL and NCD awareness among growers. In this study, we used "farmers" and "growers" interchangeably, and KAP stands for knowledge, attitude, and practice, which we consider to be the key health literacy-forming components (Koohpayeh et al., 2021) of the vegetable growers. Therefore, we drew on the theory of KAP and conceptualized a model that denotes KAP–HL linkages and their progression and outcome for NCD awareness. The remaining sections of the article are organized as follows: an illustration of a conceived model followed, by a description of the study's context and significance. Then, we describe the methods, including the study area, and inquiries to assess farmers' KAP, followed by the results section that presents the extent of knowledge, attitude, and practice among the research participants and their awareness of pesticide–NCD relationship. Finally, the discussion and conclusion sections evaluate the study findings with a key focus on the importance of enhanced KAP as part of the health literacy of vegetable growers.

1.1. Conceptual considerations: KAP model

Drawing on the KAP model, Adigun et al. (2010) argue that a low level of knowledge and a lack of self-protective attitude lead to the widespread use of pesticides. Goldner et al. (2010) also had a similar view, asserting that a low level of KAP is responsible for the careless use of pesticides. Thus, the degree of exposure of farmers to pesticides is largely related to their knowledge, attitude, or practice. Ngowi et al. (2002) recorded grossly improper pesticide-use practices due to farmers' low level of knowledge about the toxicity of pesticides. The attitude of farmers, ignoring pesticide handling guidelines on container labels, was recorded by Devi (2009). Fan et al. (2015) found that the inadequate

protective behavior of vegetable farmers is the result of their distrust of authorities. Thus, misconstrued perceptions (Hashemi and Damalas, 2010; Hashemi et al., 2012), lack of knowledge (Lekei et al., 2014; Akter et al., 2018), disregard for or absence of regulation (Khan et al., 2015; Akter et al., 2018), and a low level of education (Lekei et al., 2014) among vegetable growers were described as some of the main causes for improper practices in pesticide application.

It is important to understand the HL of vegetable farmers in terms of KAP and the degree of their awareness of the consequence of exposure to pesticides, i.e., susceptibility to NCD in the long run. The KAP model has been widely used to examine the transmission of knowledge, attitudes, and practices in areas, such as health, pain management, nutrition, accident prevention, and amoral health (see, e.g., Smyth et al., 2007; Alzghoul and Abdullah, 2015; Wan et al., 2016; Liu et al., 2018). Although various researchers have proposed different existing theoretical models of the knowledge–attitude–practice relationship, the most frequently applied ordering of the KAP variables is the cognitive model (Valente et al., 1998). This theoretical model "argues that individuals first learn about a practice, then develop a positive attitude toward it, and after passing through these stages, engage in the behavior" (p. 368).

Knowledge is the understanding of information, which is the conscious and non-symbolic perception of meaning (Wessman, 2007). The KAP model argues that knowledge positively influences an individual's attitude and attitude, which in turn influences practices or behavior. In this study, the attitude was used to mean "a complex mental state involving beliefs, feelings, values, and dispositions to act in certain ways" (Sharif and Al-Malki, 2010; p. 55). Essentially, it refers to the habitual behaviors of vegetable growers toward the practice of pesticide use.

In Figure 1 (pesticide–KAP–NCD linkages: progression and outcome model), we show that better health literacy and KAP are closely linked and are instrumental in raising individual awareness of NCDs. With this conceptual model, to address the research objectives, we hypothesize that "there is a mutually reinforcing relationship between health literacy and the KAP components, and a better level of KAP leads to enhanced NCD awareness and a better health situation for people engaged in vegetable production."

1.2. Pesticides, vegetable production, and NCDs in Bangladesh

In Bangladesh, there is widespread and unabated use of agricultural pesticides, such as insecticides, fungicides, and herbicides (Schreinemachers et al., 2016). The country experienced a 5-fold increase in pesticide use between 1990 and 2010 (Pretty and Bharucha, 2015). The application of the chemicals is particularly high in vegetables (Akter et al., 2018). For example, Bentley et al. (2009) and Rashid et al. (2023) found that eggplant farmers had a propensity to spray pesticides in the field almost every day. Many studies have documented the health and environmental risks associated with high levels of synthetic pesticide use in Bangladesh among rice farmers and smallholders (see Rahaman et al., 2018; Ali et al., 2020). Because of the presence of heavy pesticide chemicals, some countries have restricted the import of vegetables from Bangladesh (Mert et al., 2022).

Traditionally, over 60 local and exotic vegetable varieties are cultivated on 470,414 ha of plantation land in Bangladesh, with a 2.8% yearly growth rate (BBS, 2010). Over time, pesticides have received policy incentives from the government for increased crop and vegetable production. In 1974, pesticides were provided for free to encourage market-driven vegetable production from subsistence production. After 1974, ~50% of commonly used pesticides enjoyed a high subsidy until 2000 (Amin and Basu, 2004). Consequently, the country experienced a sharp growth in the use of pesticides—for instance, from 7,350 metric tons in 1992 to 45,172 metric tons in 2010 (Hasan et al., 2014).

At present, ~84 pesticide active ingredients belonging to 242 trade names of numerous chemical groups, such as organochlorine compounds, organophosphates (including all evaluated ones), carbamates, pyrethroids, neonicotinoids, heterocyclic pesticides, nitro compounds, and amides, have been registered in Bangladesh and are routinely used in agriculture and household applications (Chowdhury et al., 2012). An estimated 35% of the crop-producing area is sprayed with organophosphorus pesticides (OPPs) for a variety of crop protection purposes (Chowdhury et al., 2012). Approximately half of the farmers (over 47%) used more pesticides

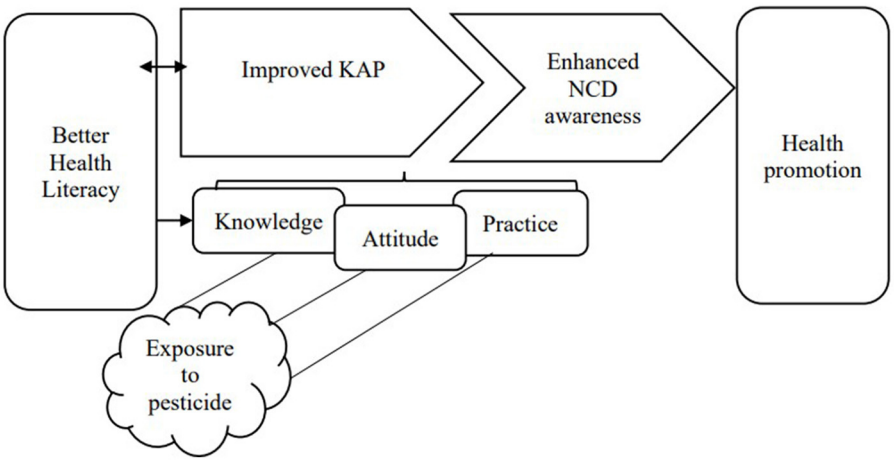

FIGURE 1
Pesticide-KAP-NCD linkages: progression and outcome model.

than required to protect their crops, and the intensity of pesticide use in vegetable cultivation was higher than that in other countries (Dasgupta et al., 2005). Moreover, farmers often sprayed hazardous pesticides up to five or six times in one cropping season when only two applications were necessary (Baig et al., 2009). This rapid increase in the consumption of pesticides raises alarm about its potential impact on farmers' health as well as on the environment, particularly pesticide poisoning due to the widespread use of banned pesticides in Bangladesh.

Dinham and Malik (2003) and Akter et al. (2018) suggest that vegetable growers experience both direct and indirect exposure to pesticides. Direct exposures are mainly occupational, are believed to be associated with the development of cardiovascular diseases among farm workers, and increase the general risk of cancer (Burrows and Edwards, 2002; Alavanja et al., 2013; Sekhotha et al., 2016). The consequences of indirect exposure remain largely unaccounted for. The agricultural system in Bangladesh is being diversified from the most traditional way of three-season crop production to higher-value crops, such as vegetables and fruits (Shammi et al., 2020). This diversification of crops, along with intensive farming practices, calls for pesticide requirements by the farmers (Hasan et al., 2014).

There is an increasing trend in vegetable production among farmers in Bangladesh. The country is ranked as the 15th largest vegetable producer in the world and third in South Asia [Food and Agriculture Organization (FAO), 2018]. Most vegetable producers undertake the intensive application of pesticides to control insects and pests, often without taking into account safety measures, i.e., without wearing masks, gloves, or proper clothes (Akter et al., 2018). Many farmers even blow air from their mouths through the spraying pipe to clear it (Rahaman et al., 2018). Thus, pesticides enter the human body through different organs during and after such application practices.

To date, there has been little advanced literature on pesticide use by vegetable growers published, particularly concerning their vulnerability to NCDs. This research contributes by linking pesticide–NCD interaction in vegetable growers in the public health knowledge domain. The widespread use of pesticides combined with limited or poor health literacy among some growers makes both the exposed human environment and the local ecosystem vulnerable to chemical toxicity. It is, therefore, crucial to understand the factors that lead to the overuse or misuse of pesticides. The process of assessing the KAP of vegetable growers is an important first step to further understanding of this subject.

2. Materials and methods

This research was carried out from January to June 2019 in partnership with the developmental NGO the Center for Natural Resources Studies (CNRS). The research method involved a survey based on multistage, geographically clustered, probability-based sampling of households (HHs). We selected one of the ongoing intervention project sites at CNRS for our survey. The project, entitled "Reducing Dietary Risk Associated with Non-Communicable Diseases (RDRNCD)," was implemented in 14 districts in Bangladesh during 2015–2019. To obtain data on knowledge, attitude, and practices (KAP) in relation to pesticide use and NCDs, we drew 6 districts randomly out of those 14, which are as follows: Sherpur, Jamalpur, Pabna, Khulan, Satkhira, and Munshiganj (Figure 2). The selection criteria to draw KAP sub-samples were age, number of years in farming practices, areas of land in vegetable production, and user or sprayer of pesticide.

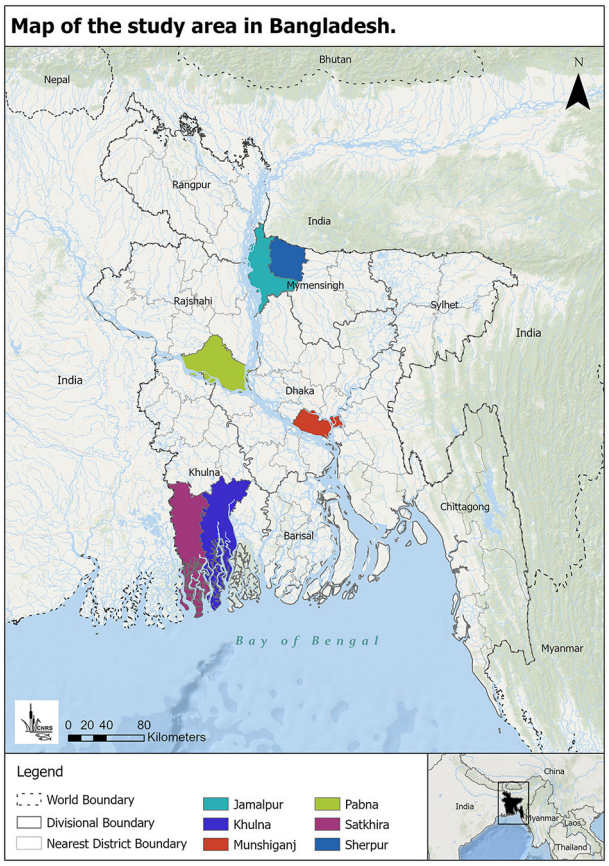

FIGURE 2
Map of the study area in Bangladesh.

We obtained a sample size of 330 with a 95% confidence interval and a 5% margin of error. We procured data from 334 households. The study used *union* as the primary sampling unit (PSU). A *union* is the smallest geographic tier with a precise and defined area in rural areas: each union consists of several villages. Even though the smallest geographic unit was *mauza* or *ward* in Bangladesh, the study avoided considering these because *mauza* may be populated or depopulated and they can be devoid of vegetable cultivation or pesticide use. Thus, in the secondary stage, the study selected 16 unions from those 6 districts, following a simple random sampling procedure.

The questionnaire was administered by enumerators employed by the partner NGO, CNRS, and no proxy interview was allowed. The sampling unit in each stage of selection refers to the entities that were selected for the survey. In this survey, the ultimate sampling units were the household and one individual residing within the selected household. Households (HH) in this survey

were defined, following BBS (2010), as "a dwelling in which persons either related or unrelated living together and taking food from the same kitchen."

A sample of eligible KAP respondents (334) was drawn from within the RDRNCD project's target population of those six districts—with one individual vegetable grower selected per household from a total number of HH (3123). The KAP field survey chose a minimum of 10 and a maximum of 30 households/farmers from each *union* to obtain the optimum representative samples. All interviews were administered verbally in Bengali, and the responses were written on the questionnaire by the enumerators. The survey questionnaire was developed based on author's experience and a review of past studies (Akter et al., 2018; Begum et al., 2019). Inquiry statements were designed based on the three KAP components, i.e., knowledge, attitude, and practice, in relation to pesticide use in vegetable production. The questions under each component dealt with a specific aspect (which we call "criterion" in our findings). Thus, five criteria were explored with the same number of (5) questions to procure data on the status of "knowledge" about pesticide use. Similarly, five "attitude" and six "practice" related criteria were explored. Table 1 summarizes those inquiry statements:

The survey questionnaire was pretested by interviewing 10 farmers in a different district (Sylhet) who were not included in the study. Feedback from the pre-testing was considered to ensure further clarity and appropriateness by editing the questionnaire accordingly. A standardized code plan was used by the interviewers to code the Bengali answers for data entry in English. The aggregated data from the interviewers were sent to the FTP server and then transposed to an analyzable raw data format to be read by SPSS software for analysis. Then, the data analysis technique used descriptive statistics in terms of percentage and content analysis to present the survey data using simple graphs and charts.

TABLE 1 Inquiry statements to explore the knowledge, attitude, and practice of vegetable growers (partially adopted and modified from Shammi et al., 2020).

Knowledge
I can read and understand which chemical pesticide is harmful for health
I am certain that all pesticide increase production of vegetables
I know about right amount of pesticide to be applied to a given vegetable field
There is no health problem with consumption of pesticides applied vegetables
I know other alternative to pesticide to grow vegetables
Attitude
It is possible for me to grow vegetables without pesticides (i.e., abandoning it)
I should use less pesticides in future
I want to follow right and safe procedures of using pesticides
I would like to use organic pesticides instead of chemical ones
I am interested to learn from television and radio programs regarding pesticide use
Practice
I consider air direction, keep kids and family members away while applying pesticides
I sell or eat vegetables immediately or within short period after pesticide applications
I cover my face and hands while using pesticides
I have increased the amount and frequency of pesticide application in my field more than those of last year
I heard about ideal amount that should be used but I apply more than that quantity
I always use pesticides for vegetable production and will continue to do so
NCD awareness
I know what non-communicable diseases (NCDs) are
I understand the relations between pesticide use and NCDs

3. Results

3.1. Knowledge of pesticides and their use

The study results revealed the status of knowledge of growers in terms of their understanding, beliefs, ideas, ignorance, and the depth and quality of this information in relation to the use of pesticides. The extent of agreement, disagreement, and indecisiveness (neutral) of the respondents based on these criteria is illustrated in Figure 3.

We found the lack of understanding in relation to harmful chemical identification among the respondents alarming. This is because more than half of the growers did not know which pesticides could harm their health. Approximately 70% believed that pesticide use "is a must" for high vegetable productivity, while <50% of them knew about the right mix and quantity of pesticides that should be applied to their vegetable fields or gardens. In total, ~70% of respondents were unaware of the health problems caused by the consumption of pesticide-laden vegetables. Interestingly, despite being users of chemical pesticides, approximately one-third of the respondents knew about alternative pest control mechanisms.

3.2. Attitudes to pesticide use

The results on attitude-related issues such as farmers' willingness to abandon pesticides, reduce or replace them (with a view to phasing them out gradually), comply with safer methods of application, adopt organic variants, and learn about their use, indicate mixed scenarios. The results of these attitude-related criteria are shown in Figure 4.

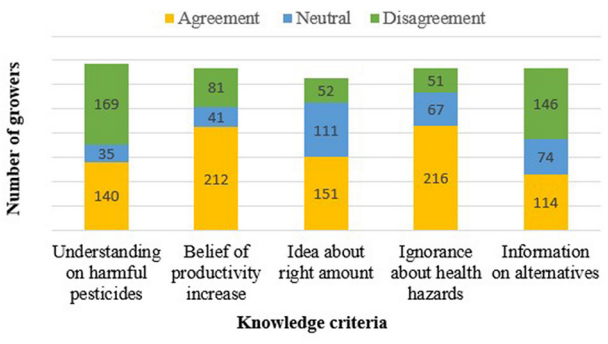

FIGURE 3
Distribution of knowledge and perception of the growers about pesticide-use ($n = 334$).

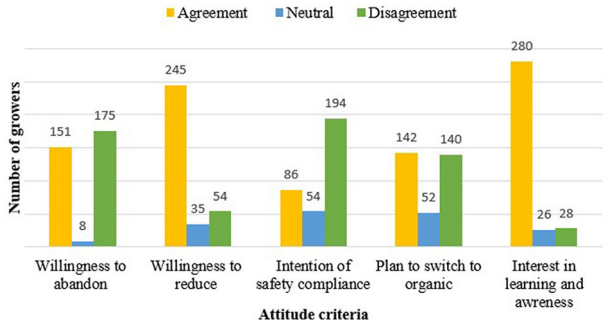

FIGURE 4
Distribution of growers' attitude toward pesticide-use ($n = 334$).

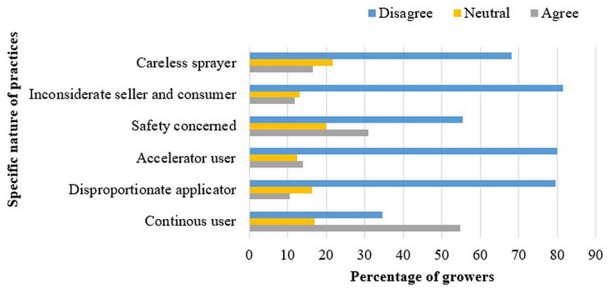

FIGURE 5
Distribution of growers by practice criteria ($n = 334$).

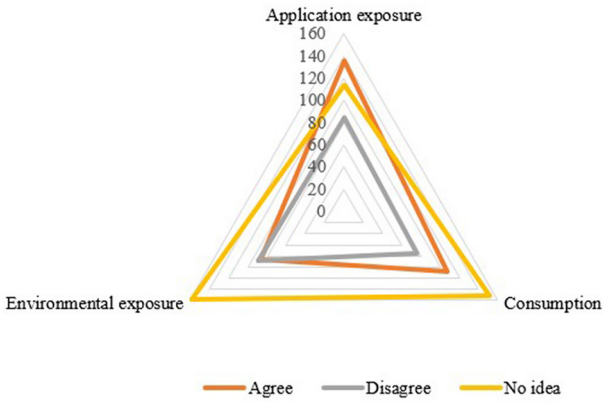

FIGURE 6
Knowledge and awareness spectrum on pesticide exposures and NCD linkage.

More than 50% of the respondents were not willing to abandon pesticide use, as they thought it is impossible to produce vegetables without their application. An overwhelming majority of the respondents (73%), however, thought that they should reduce the extent and quantity of pesticide use. With regard to compliance with safety procedures, only ∼26% of the respondents intended to switch to a safer mode of application, while 16% were unsure, leaving 58% still intending to continue with "business as usual." The number of respondents who were willing to adopt organic pesticides in the future and those who were not willing to do so were almost evenly distributed. Optimistically, the majority of the respondents (∼84%) expressed their interest in learning about pesticide use and gaining awareness of the health risks involved through mass media, e.g., radio and television programs.

3.3. Pesticide application practices

The practices pertaining to pesticide use by vegetable growers were encapsulated by the survey results on their use and especially the application of pesticides. The distribution of the respondents' opinions (whether they agreed, disagreed, or were neutral) by pesticide-use practice criteria is illustrated in Figure 5. Concerning how careful the growers are when applying the pesticide in the field or garden, results showed that only 16% of the growers were adequately careful and took the necessary precautions while spraying pesticides, and ∼68% of them were not careful enough.

We inquired about the selling and consumption behaviors of the growers after applying the pesticides, i.e., whether they were considerate to save their or other people's health from the probable harmful effects of freshly spread pesticides. In total, 82% of them abstained from applying pesticides right before selling the vegetables to the market. In the case of self-consumption, the application generally ceased a few days before picking vegetables. With regard to safety practices, while spraying the pesticides, 56% of the respondents reported that they did not cover themselves with the necessary safety gear.

Some growers were found to be accelerating the use of pesticides. Approximately 14% of the respondents increased the frequency of applications over the previous year. Regarding the standard mix or the right proportion of pesticide quantity, it was found that ∼10% of them emphasized more quantity and 16% were unsure about the proportion of their mix. When asked about the continuation of such practices, 55% of the growers expressed that they would continue using pesticides as a precaution against pest attacks.

3.4. Awareness of pesticide–NCD relations

Overall, the respondents were not adequately aware of the relationship between pesticides and NCDs, though they were familiar with cardiovascular and respiratory diseases, cancers, and diabetes. Many respondents had a poor understanding of the degree of NCD-related danger from direct exposure to pesticides created through application (i.e., handling and spray). The distribution of responses on the awareness spectrum is illustrated in Figure 6.

As previously mentioned, ∼40% of the growers were aware that handling such pesticides is harmful and can cause NCDs. On the question of pesticide-laden vegetable consumption, 32% reported that they understand that such NCDs can occur to them due to the consumption of pesticides applied to unsafe vegetables. Regarding environmental exposure, 26% opined that their children

or other people living within or nearby the pesticide-applied area can develop NCDs.

A notable finding of this study is that most respondents (∼60%) were not aware that exposure to pesticides through handling, air, water, or consumption might cause NCDs in them. The spectrum of unawareness and poor knowledge is seen to be much wider (see Figure 6) than those who "agree" or "disagree" with the questions concerning the key reasons for pesticide–NCD linkages. An overwhelming majority of the respondents have "no idea" whether NCD occurrence has any link with exposure to pesticides. Notably, a considerable proportion of the respondents did not believe ("disagree") that pesticide exposure could cause NCDs in the long run.

4. Discussion

Pesticides are regarded as a solution to the pest concerns of farmers. This study aimed to understand the potential risk of NCDs associated with such solutions. The existing literature does not sufficiently explain why pest management approaches have become a major public health concern and how they should be addressed. It is, indeed, a complex task to determine the health consequences of specific low-level, long-term exposure to the vast array of pesticides used by vegetable growers. There are arguments that many pesticides are beneficial for farmers as well as for the environment (see, e.g., Cooper and Dobson, 2007). Nevertheless, the negative effects of pesticide residue, agricultural safety, and the resulting environmental and health problems from pesticide application are acknowledged widely in the literature, and increasingly, they are considered a major threat to public health (Özkara et al., 2016; Gomes et al., 2020; Tudi et al., 2021). This threat is exacerbated when growers or applicators have poor health literacy in terms of the effects of pesticides, i.e., the diseases (non-communicable) they can cause to humans.

Our study focused on the reasons why pesticide-induced health issues are latent threats and found that the overall health literacy of pesticide users is poor. The results of this study indicate that the knowledge, attitude, practice, and awareness of vegetable growers about the use of and exposure to pesticides and consequential health hazards is dismal. Pesticide users' ability to read and identify harmful chemicals and understand the appropriate application procedure is crucial. The level of knowledge of pesticide use among farmers is vital for providing sound strategies to reduce environmental and human health risks.

Earlier studies (such as Ibitayo, 2006; Recena et al., 2006) indicate that most educated farmers or growers can read and understand the pesticide labels and apply the products correctly, while less educated farmers often fail to follow the prescribed guidelines. Lack of education has been associated with poisonings, exposure risks, and high mortality rates in many rural areas of developing countries (Zyoud et al., 2010; Mokhele, 2011; Remoundou et al., 2014). Although this study did not cover education as an inquiry criterion, we found that the majority of the vegetable growers in this study were unaware of the prescribed guidelines and harmful effects of pesticide use. In addition, a large proportion of them had no idea about the right mix or proportions that should be applied to a given field. Such ignorance is further aggravated as most of them (approximately two-thirds) are unaware of harmless or organic alternatives to pesticides.

Enhancing knowledge through education and training might not be enough to mitigate potential pesticide-related disease risks (Feola et al., 2012). Some studies have shown that growers possessing adequate knowledge of pesticide-related symptoms continue to engage in risky practices (Yassin et al., 2002; Recena et al., 2006; Kachaiyaphum et al., 2010; Darçin and Darçin, 2017). The knowledge of the growers is intertwined with and sourced from their perceptions and beliefs about pesticides. The majority of vegetable growers (∼70%) in our study had a preconceived notion that pesticides increase productivity. In addition, they perceived that there was no problem with consuming pesticide-laden vegetables.

Poor knowledge and an inappropriate attitude are creating improper practices—in the form of increased pesticide use in terms of frequency and dosages. The consequences of this mean lower crop protection and increased human and environmental loads. There is evidence that suggests that farmers' perceptions of their abilities to tolerate pesticide risk after several exposures also resulted in poor pesticide application practices (Arcury et al., 2002; Cabrera and Leckie, 2009; Kim et al., 2017). The attitude of the growers studied here is alarming, as most of them were not willing to abandon pesticide use at all and thought that they were following the appropriate application procedure.

Most growers were careless because they did not consider air direction or pesticide uptake through the air while spraying pesticides, nor were they concerned about the exposure of their family members to pesticides. Such carelessness meant that most of them chose not to wear protective gear—an unsafe practice in pesticide application. This unconcerned behavior also led to unethical practices, as found in the present study, which revealed that most of the growers sell products to the market immediately after the application of pesticides. In addition, as outlined in this study and evident in another by Sharma et al. (2019), with increasing rates of use, most users act as an "accelerator" for pesticides entering the environment. These users could be termed "disproportionate applicators" due to their indiscriminate and out-of-proportion mixing practices.

The studied population, in general, was aware of NCDs; however, their knowledge was limited as to how repeated exposure to pesticides can make them vulnerable to NCDs. It is well known by now that pesticides are associated with both acute and delayed health effects in exposed humans (Dhouib I. et al., 2016). Occupational exposures to pesticides are associated with the development of a number of NCDs (Gangemi et al., 2016) as is long-term non-occupational exposure (Palaniswamy et al., 2021). As revealed by this study, low levels of knowledge, a nonchalant attitude, and inappropriate practices of pesticide use and exposure among vegetable growers mean that they are likely to have an increased risk of NCD.

5. Conclusion

This study indicates that the health literacy of vegetable growers in Bangladesh including their knowledge of non-communicable diseases is alarming because their knowledge, attitude, and practices, i.e., KAP levels on the use of pesticides in vegetable production and its NCD-related consequences is very limited. Such KAP by the producers is ingrained in their long-held beliefs and perceptions. Based on these findings, policy interventions in terms of raising awareness through training and education of the primary users and applicators of pesticides is imperative in redressing this situation. Knowledge-related interventions might lead to improved attitudes and practices among vegetable growers. A significant degree of change in attitude and a renewed mindset among the growers about pesticides and their use is needed to safeguard public health. As a considerable fraction of the growers were willing to learn about the proper application procedure, learning-oriented interventions (similar to programs such as the Stewardship program by the Bangladesh Crop Protection Association and pesticide application technology training by Syngenta) would be an effective approach to enhancing the state of their KAP.

Despite interventions, pesticides with potential toxicity for human health will continue to be used by growers with the insistence of many policymakers to ensure high productivity and address food security issues. This is a challenging situation for Bangladesh, a country with more than 165 million people, of whom ~21% live below the poverty line (Sarker et al., 2021), meaning a reconciliatory approach is required. Policy stakeholders across the agricultural, food, health, developmental, and other public sectors should work together to curb and decrease pesticide-induced NCD conditions and to enhance future public health policy and education in Bangladesh. The key focus of such approaches must be to achieve balanced growth between agricultural production and the protection of public safety and health.

The scope of this study was limited, as it was not poised to determine the occurrence of non-communicable diseases (NCDs) among the respondents. Rather, it gathered empirical evidence on the state of their knowledge as potential victims of pesticide exposure and NCDs. Unsafe pesticide use practices are a national phenomenon in Bangladesh. However, we think that other than national-level regulations, developmental interventions, and community-based approaches could bring about the desired results. There are groups and communities across Bangladesh that have already started organic and green production practices devoid of pesticides.

Bangladesh is one of the signatories of the UN sustainable development goals (SDGs). To achieve the 2030 SDG targets, the country needs to reduce the present high number of NCD-related deaths. Tackling NCDs through a reduction in human exposure to hazardous environmental and occupational risks is essential to achieving the SDGs: most notably, SDG 3 on health. In parallel, to address SDG 7 on energy, SDG 8 on decent work and economicgrowth, and SDG 12 on consumption and production and, thereby, chemicals and waste, well-coordinated intersectoral policies and programs should be developed and successfully implemented. In addition, Bangladesh ratified the Kunming-Montreal Global Biodiversity Framework 2022. As outlined in Target 7, the framework calls for us to effectively reduce the risk of pesticides on biodiversity by at least half by 2030 (Obura et al., 2023). Therefore, we suggest further research on community-based interventions to promote safe pesticide use or the promotion of organic alternative pesticides, should be undertaken to protect both the health of the growers and local biodiversity.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

AS structured the paper in consultation with AI and MR. AS completed the draft paper and then the AI and MR had their views, inputs, and suggestions for the completion of it. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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