KNOWLEDGE OF THE EFFECT OF PESTICIDE USE IN VEGETABLES AND FRUITS ON HEALTH AND ENVIRONMENT AMONG CONSUMERS: A DESCRIPTIVE CROSS-SECTIONAL STUDY

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ABSTRACT

According to the WHO, pesticides are chemical compounds that are used to kill pests, including insects, rodents, fungi, and unwanted plants (weeds) or it is any substance, or mixture of substances of chemical or biological ingredients intended for repelling, destroying, or controlling any pest, or regulating plant growth. Persistent organic pollutants circulate globally as a set of toxic chemicals that are persistent in the environment and can last for several years before breaking down. This study aims to find out the knowledge of consumers on effects of pesticide used in vegetables and fruits on health and environment. A descriptive cross-sectional study was conducted among visitors of patients, students, and staff at tertiary center after getting ethical approval from Institutional Review Committee. Individuals who know effects of pesticides on health were included in the study and those who did not give consent for study were excluded. Convenience sampling method was used. Out of 324 participants, 146 (45.10%) of participants reside in urban areas, followed by semi-urban 107 (33.0%) and rural 71 (21.90%). Organophosphates are the most common pesticides used on fruits and vegetables, 167 (51.54%). The risk of pesticide residues to health was known by 295 (91.0%) of respondents. According to the majority, 291 (89.80%) pesticides used are bad for the environment, and only 33 (10.20%) think that pesticide use is not bad for the environment. This descriptive cross-sectional study concludes diverse levels of knowledge among consumers regarding the effect of pesticide use in vegetables and fruits, as well as knowledge level influenced by education, income, and geographic location. There is an urgent need for accessible, clear communication through labelling and public education to bridge these gaps and to promote sustainable consumer practice.

KEYWORDS

Knowledge, pesticide, persistent organic pollutants

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INTRODUCTION

According to the WHO, pesticides are chemical compounds that are used to kill pests, including insects, rodents, fungi, and unwanted plants (weeds).[1] Pesticide is defined as any substance, or mixture of substances, of chemical or biological ingredients intended for repelling, destroying, or controlling any pest, or regulating plant growth.[2] There are over 1000 different pesticides that are used around the world, and in public health, they are used to kill vectors of disease.[1] Many pesticides have been shown to cause adverse effects on non-target organisms, amongst which one is persistent organic pollutants (POPs). POPs are man-made, hazardous, lipophilic nature chemicals that not only threaten human health but also affect the planet's ecosystems, causing potentially biodiversity loss.[2-4]

POPs circulate globally as a set of toxic chemicals that are persistent in the environment and can last for several years before breaking down. Also, chemicals released in one part of the world can be deposited at far distances from their original source through a repeated process of evaporation and deposition.[3] Twelve highly persistent and toxic chemicals, according to are aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, and toxaphen, additionally carcinogenic polycyclic aromatic hydrocarbons (PAHs) and certain brominated flame-retardants, tributyltin (TBT), etc. have been added.[4]

The uncontrolled use of pesticides on fruits and vegetables may result in increased residue levels of pesticides above the maximum residue limits (MRLs) that might be toxic to human health.[5] The improper use and/or disposal of agrochemicals and industrial chemicals, elevated temperatures and combustion processes due to POPs, and their highly toxic and exposure can take place through diet, environmental exposure, or accidents. Regarding the danger of pesticides and its residues in fruits and vegetables are not known by most of the consumers.[6] This study aims to find out the knowledge of consumers on the effects of pesticide use in vegetables and fruits on health and the environment.

MATERIALS AND METHODS

A descriptive cross-sectional study was conducted from 6th Nov 2023 till 6th June 2024 among the visitors of patients, students and staff at Nepalgunj Medical College Teaching Hospital, Nepalgunj, Banke, Nepal, after obtaining ethical approval from the Institutional Review Committee (Ref. No.: 22/080-081). Individuals who know the effects of pesticides on health were included in the study and those who did not give consent for the study were excluded. A convenience sampling method was used. The sample size was calculated using the following formula:

$n = Z^2 \times p \times q/e^2$
$= 1.96^2 \times 0.68 \times 0.32/0.05^2$
$= 324$

Where,
n= minimum required sample size
Z= 1.96 at 95% confidence interval
p= prevalence taken from similar study conducted in the past, 68%[7]
q= 1-p
e= margin of error, 5%

A semi-structured open-ended questionnaire was prepared based on multiple literature review about the knowledge of pesticides and its hazards on human and environment with some modifications according to the local context.[1-3,5-11] The questionnaire was divided into four parts, with five questions on demographic information, ten on knowledge of consumer about the pesticide use in vegetables and fruits, five on effect of pesticide use on health and five on effect of pesticide use on environment. After the IRC approval from the institute the questionnaire was pretested among adults living in Nepalgunj area and the validity and reliability was tested. After a revised questionnaire was prepared, the face to face interview was conducted among 324 participants with their consent.

Data was collected and entered into on Microsoft Excel and statistical analysis was performed using SPSS-17. Descriptive statistical tools like frequency, percentage were used to express the results. The point estimate was calculated at a confidence interval of 95.0%.

RESULTS

Out of 334 participants, 146 (45.10%) of participants reside in urban areas, followed by semi-urban 107 (33.0%) and rural 71 (21.90%). A higher number, i.e., 218 (67.30%) of male respondents were there, and females were fewer in frequency 106 (32.70%). Less than half i.e.151 (46.60%)of them have completed secondary or high school, followed by 90 (27.80%) university, 44 (13.60%) illiterate, and 39 (12.0%) were primarily educated. Married

respondents were more than half, 184 (56.80%), followed by 121 (37.30%) single, and 19 (5.90%) divorced. Professionally, 114 (35.20%) were employees, 111 (34.30%) were students, 65 (20.10%) were without any profession, and 34 (10.50%) were doctors.

General knowledge of consumers about the pesticide use in vegetables and fruits: A majority 126 (38.90%) of respondent purchased their fruits and vegetables from the bazar followed by 110 (34.0%) fruits and vegetables shops, 54 (16.70%) supermarkets, and 34 (10.50%) from the street. Selection criteria for the purchase of fruits and vegetables mainly depend on their freshness, 248 (76.50%) (Fig. 1).

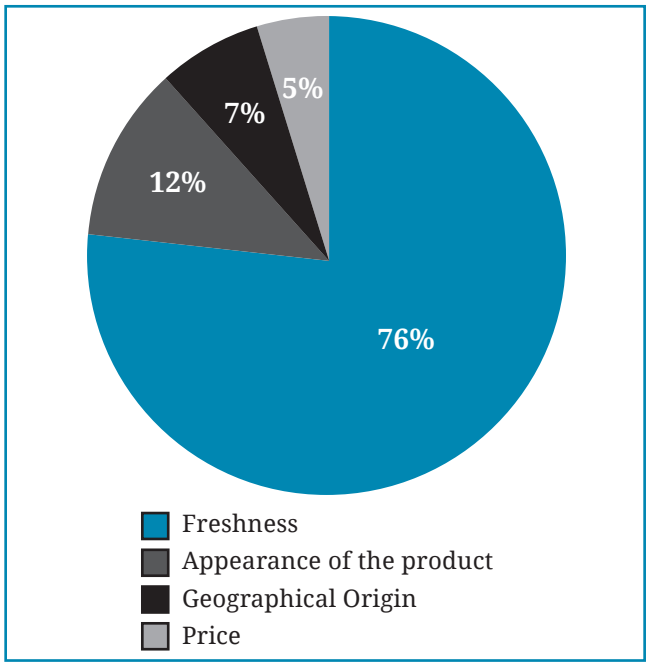

Fig. 1: Selection criteria for their fruits and vegetables (n=324)

More than half, 197 (60.8%) of participants buy these foods (fruits and vegetables) every week, followed by once per month 69 (21.3%) put them in their refrigerator, and 58 (17.9%) who buy them every day. The most consumed fruits were apple, 198 (61.1%), and banana. Among vegetables most consumed were potatoes, cauliflower, and tomatoes, 253 (78.1%) in their home. However, fewer participant takes seasonal fruits, 126 (38.9%), and 71 (21.9%) vegetables. Vegetables are taken twice a day by the majority, 202 (62.4%), and 122 (37.7%) consume vegetables sometimes one time and non-vegetarians one time and sometimes twice a day. Regarding fruits, a higher number of 155 (47.8%) people take once or twice a month, followed by once or twice a week, 99 (30.5%), and 70 (21.6%) once or twice in every three to four months. Almost all 300 (92.6%) participants knew about organic foods, while 34 (10.5%) were not aware of it. If they get to purchase organic fruits and vegetables in greater numbers, 202 (62.4%) of them would like to purchase if it's available; however, 122 (37.6%) don't prefer organic foods because they're costly. About half 167 (51.5%) of them believed pesticides are poisonous depicted below (Fig. 2). Organophosphates are the most common pesticides used on fruits and vegetables, 167 (51.5%) shown in (Table 1).

Table 1: Common pesticides used in fruits and vegetables as per the respondent (n= 324)

Pesticides used on fruits and vegetables	n (%)
Organophosphates	167 (51.5)
Malathion	45 (13.9)
Urea	41 (12.7)
DDT	37 (11.4)
Do not know	26 (8.0)
BHC	8 (2.5)

Less than half 156 (48.2%) of them were aware about name of pesticide which has low cost and long term effects on health and environment due to which it is banned in Nepal that includes DDT 11 (76.3%) followed by 36 (23.7%) benzene hexachloride however, 168 (51.9%) majority can not remember the name.

Effect of pesticide use on health: Overall all participants knew the risks of pesticide residues on their health. However, the sever risk of pesticide residues to health was known by 295 (91.0%) of respondents (includes both acute and chronic effect on health) and 29 (8.9%) respondents although they were aware of pesticides effect, were unaware that pesticides residues can cause severe health risks.

Table 2: The effects of pesticide use on health (n= 324)

Effect of pesticides on health	n (%)
Acute effects include allergy, skin rashes, eye irritation, and nausea, acute gastroenteritis	112 (34.6)
Chronic effects such as cancer, reproductive problems, **delay** in mental and physical development, **effect** on the immune system, and neurological damage	212 (65.4)

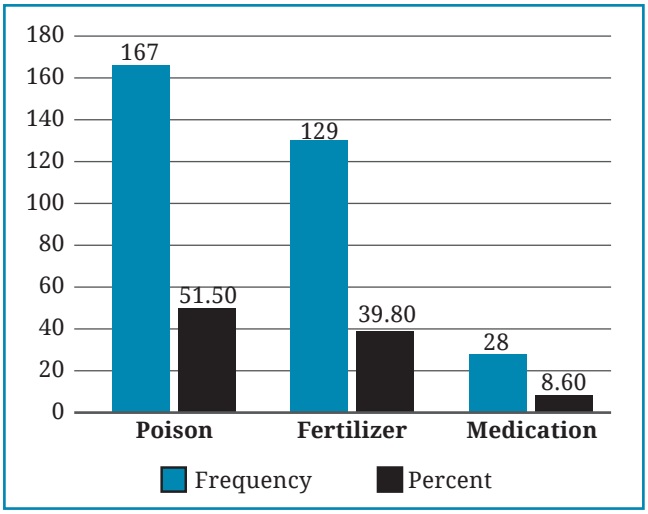

Fig. 2: Participant's views on pesticides (n= 334).

A majority 236 (72.8%) of respondents reported that they did not suffer from any chronic disease or an allergy after consuming fruits and vegetables; however, 50 (15.8%) were not sure, and 37 (11.5%) people agreed they did suffer, especially from respiratory disease, allergies, and GI upset. According to the respondent, the effect of pesticides on their health could be various; however, majority, 212 (65.4%), answered that there will be a chronic effect (Table 2). According to the respondent effect of pesticide on children's health could be more acute infection 188 (58.0) or chronic (Table 3).

Table 3: The effect of pesticide use on children's health (n= 324)

Effect of pesticide on children's health	n (%)
Acute effects such as respiratory tract infection, allergies, gastrointestinal upset (GI upset)	188 (58.0)
Chronic effect such as delay development, growth hormonal impairment, growth retardation and cancer	136 (42.0)

Effects of pesticide use on the environment: Almost all 288 (88.9%) believed pesticides contaminate surface and ground water as well as soil, and only a few answered 36 (11.1%) that it does not contaminate. Similarly, a greater number of them agree that pesticides contaminate air and non-target vegetation, as more than half 201 (62.0%) respondents said yes, while 123 (38.0%) responded no, it does not. Likewise, the majority, 258 (79.6%) of them believed there are long-term effects on the sustainability of farming practices because of pesticide use; however, 66 (20.4%) responded that it does not. Similarly, almost all 314 (96.9%) agreed that pesticide use is not good for the environment; however, very few 10 (3.1%) believed it's good for the environment as it kills unwanted insects in crops. According to the majority, 291 (89.8%) pesticides used are bad for the environment, and only 33 (10.2%) think that pesticide use is not bad for the environment.

DISCUSSION

Most participants, 91.0%, understood the risk of pesticide residues to human health, and an even higher proportion, 96.0%, recognised their negative effect on the environment. These findings point towards a growing public concern and knowledge about food safety, as similar studies have reported similar results in their studies.[5-7] In alignment with our findings similar study from Bangladesh reports that 68.0% consumers responded that they were conscious of health risk due to pesticide residues, and 67.5 % consumers answered that they were conscious about health risk due to residues of chemicals in vegetables, comparable to our result.[7] Similarly, another study conducted in Uganda also demonstrated a substantial proportion of respondents expressing concern over pesticide contamination and its associated health hazards.[5] These similarities in these studies with our findings indicate that consumer awareness is not isolated to Nepal but reflects a wider regional pattern. However, a study from Nepal reports only 35.0% of the consumers responded they didn't have any idea about pesticides residue and its impact on human health which indicates lower level of awareness similar as our finding.[9]

Likewise, the health effect on children such as acute effects like respiratory tract infection, allergies, gastrointestinal upset (GI upset) and chronic effect such as delay development, growth hormonal impairment, growth retardation and cancer. Similarly, in them acute effects such as allergy, skin rashes, eye irritation, and nausea, acute gastroenteritis and chronic effects such as cancer, reproductive problems, delay in mental and physical development, effect on immune system and neurological damage were reported by consumer. This finding is supported by author Shah as she reports people who are exposed to pesticides are at a greater risk to develop various cancers including non-Hodgkin lymphoma (NHL), leukemia, brain tumors, and cancers of the breast, prostate, lung, stomach, colorectal, liver, and the urinary bladder.[10-14]

Similarly, we found the most consumed vegetables were potatoes, cauliflower, and tomatoes as 78.09% ate in their home, it is supported by the system review from Bangladesh as pesticide-contaminated vegetables were cucumber 51.0%, tomato 41.0%, cauliflower 31.0%.[11] The availability of vegetables in all season due to pesticides use could be the reason respondent mostly consumed. Likewise, we found vegetables are taken twice a day by 62.35%, however, fruits are taken only once or twice a month by 47.84% people a study by Penny revel fruit and vegetable consumption was low somehow it is inconsistent with our findings.[15]

We found majority of respondent 38.90% purchased their fruits and vegetables from the bazar followed by 34.0% fruits and vegetables shops, 16.70% supermarkets and 10.50% from the street. However, a mixed method study from Uganda reports 93.3% of the consumers purchased their fruits and vegetables from market vendors and transporters consistent with our finding.[12]

In terms of health outcomes, 72.8% respondents said that they did not suffer from any chronic disease or an allergy after using fruits and vegetables; however, 15.8% were unsure, and 11.5% people reported that they did suffer, especially from respiratory disease, allergies, and GI upset. This perception is consistent with existing study, which reports that long-term exposure to organochlorine and organophosphate pesticides is linked to multiple chronic diseases and developmental impairments.[3]

From an environmental perspective, a strong majority of respondents, 88.9% believed that pesticides contaminate soil and water, while 96.9% agreed they negatively impact the environment. These perceptions are aligning with scientific evidence indicating that pesticides, especially persistent organic pollutants (POPs), are capable of accumulating in the ecosystem, travelling over long distances, causing significant ecological harm and loss of biodiversity.[4]

Interestingly, while a majority, 51.54% identified organophosphates as the most commonly used pesticides, only 48.15% were aware of banned or highly hazardous substances like DDT or BHC. This partial knowledge reflects a gap in public awareness about specific pesticide types and regulatory frameworks. It suggests the need for targeted educational campaigns to promote safer food choices and demand stronger policy enforcement.[2,8] Also, the systemic review from Bangladesh on pesticides in vegetable production reports the most observed pesticide groups used in vegetable production were organophosphorus, pyrethroids, carbamate, organochlorine, nereistoxin analogue group, and neonicotinoids these finding is consistent with our study.[11] Although the effect of organophosphates compounds is known as it works by inhibiting acetylcholinesterase (an enzyme crucial for nerve function) and which is considered a neurotoxicant especially in neurodevelopmental in children we found most of our participant mentioned it as commonly used pesticides.

Another significant finding was the willingness of 62.35% of respondents to buy organic fruits and vegetables if available. This reflects a promising consumer shift toward safer and environmentally friendly alternatives, despite some resistance due to higher prices. This finding supports earlier studies that showed an increasing interest in organic produce among informed consumers.[6]

Despite this considerable awareness, actual change in consumer behaviour remains limited. Only 126 (38.89%) of participants reported consuming seasonal fruits, indicating a potential gap between knowledge and practice. This gap might be influenced by factors like accessibility, affordability or habitual consumption patterns, which were not explored in this study but can be explored in further investigations.

The finding from our studies reports that 88.9% respondents believed pesticides contaminate surface and groundwater as well as soil, along 62.04% agree that pesticides contaminate air and non-target vegetation. Similarly, 79.6% of them believed there is long-term effects on sustainability of farming practices because of pesticide use and 96.9% agreed pesticide use is not good for environment these are in alignment with finding from similar study in Nepal as Gyawali *et al*[2] also mentioned the pesticides do contaminate surface and ground water as well as soil also air and non-target vegetation. Along with it, its use is not good for the environment.[8,15-17] A study reports country where their high pesticides pollution, they witness watersheds such country such as South Africa, China, India, Australia and Argentina as high-concern regions because they have high pesticide pollution risk, bear high biodiversity and suffer from water scarcity. Our finding also reports similar result.[18] Similarly a review from Pakistan also other study supports our finding on environment.[19,20] Although the sample size do includes individuals from different areas as

we recruited patient visitors, students and staff of an institute, the result cannot be generalized for far western region as the sample size is small, so we recommend large sample size.

In conclusion, this descriptive cross-sectional study concludes diverse levels of knowledge among consumers regarding the effect of pesticide use in vegetables and fruits as well as knowledge level influenced by education, income and geographic location. There is an urgent need for accessible, clear communication through labelling and public education to bridge these gaps and to promote sustainable consumer practice.

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