

Epidemiological Evidence of Pesticide Poisoning Cases in Nanumba-North Municipality, Ghana

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Abstract

The present study deduced the epidemiological evidence of pesticides and health-related cases in Nanumba-North Municipality. The paper retrospectively analyses 257 pesticide-poisoning records from clinics and Bimbilla Hospital to characterise incidence, demographics and outcomes between 2014 and 2024 in Nanumba-North Municipality, Ghana. Herbicides caused 41% of cases, men accounted for 76%, and the overall mortality was 15%. Suicide attempts represented the dominant circumstance (83 cases), highlighting pesticides as an important driver of self-harm in the study area.

Keywords

Poisoning, Epidemiology, Pesticide, Hazardous, Nanumba-North Municipality

1. Introduction

Pesticides are designed to protect humans and animals but must be monitored to protect the environment. Despite the advantages associated with the application of chemical pesticides in agricultural practices, there is an increasingly urgent necessity for epidemiological studies of poisoning among agricultural workers and farmers. Previous studies in Ghana have indicated high levels of pesticide in food and biomonitoring evidence of exposure among agricultural workers. Farmers or workers who come into contact with these potential chemicals can be at risk of its harmful effects. For instance, according to the World Health Organization (WHO),

more than 1000 different pesticides are used globally. It is without a doubt that, the misuse of these potentially toxic chemicals is becoming more apparent, and they can pose a significant risk to humans and the environment in the Nanumba-North Municipality [1]. Similarly, according to [2], a significant issue associated with pesticide use is bio-accumulation, where these chemicals build up in the body over time, especially when exposure is frequent or prolonged.

In some parts of developing countries, more deaths than infectious diseases are caused as a result of pesticide exposure. In the sense that, they are easily accessible by farmers or workers who come into contact with these chemicals, moreover, the use of these potentially toxic chemicals is abysmally regulated and therefore often pernicious, which makes them detrimental to humans and animals. For instance, according to [3], pesticide poisoning constitutes a significant medical emergency with a major burden on health. which accounts for 14% - 20% of global suicides with an estimated 110,000 - 168,000 deaths per annum. Similarly, [4], envisaged that suicide rates increased in areas devoted to agriculture with intensive pesticide consumption. Bimbilla is the capital of the Nanumba North Municipality it lies in the Southeastern part of the Northern Region and lies between latitudes 8.5°N and 9.25°N and longitudes 0.57°E and 0.5°E. However, it shares boundaries with five Districts; Yendi Municipal to the north, Mion District to the northwest, East Gonja District to the west and south-west, Nanumba South District to the south and east, and Zabzugu District to the north-north-east. According to [5], the population of Nanumba North Municipality is 141,584 representing 5.7 percent of the population of the Region 2,479,461. Males constitute 49.4 percent and females represent 50.6 percent of the Municipality. The Municipality has a total land area of 2260.8 sq-Km. The predominant occupation is farming with about 97.7% of the Municipal economically active population (15 years and older) involved in farming staple food crops and cash crops.

In fact, the unreasonable risks of depression and other psychiatric unsoundness have been associated with previous pesticide poisoning. Furthermore, epidemiological evidence of pesticides poisoning cases by farmers in other farming areas in the world has been documented by [6]-[8], and it is enough backing to give cause for similar concerns in the Nanumba-North Municipality.

In Nanumba-North Municipality, the use of pesticides for suicide or criminal purposes has become increasingly alarming. The aim of this study was to provide epidemiological evidence of pesticide health-related cases in the Nanumba-North Municipality of the Northern Region of Ghana.

2. Materials and Methods

The present study is a retrospective analysis of all cases of pesticide poisoning collected at the emergency unit of the Bimbilla Hospital and Clinics over a period of 11 years, from January 2014 to December 2024. The methodology comprised a cross-sectional study designed to accumulate relevant epidemiological evidence of pesticide poisoning within the Nanumba-North Municipality. Data acquisition

was multi-modal: interviews with Municipal hospital personnel, examinations of inpatient records from 2014 to 2024, and consultations with the Municipal Quarantine Officer combined systematic, qualitative, and quantitative techniques to enhance coverage of pesticide-poisoning incidence rates and analysed the types of pesticides most frequently implicated. Hospital records facilitated enumeration of cases with sex, age, and pesticide type, as well as calculations of incidence and prevalence rates. Also, a one-way analysis of variance ($p < 0.05$) was considered to indicate statistical significance. Age was analysed according to the distribution of the International Programme on Chemical Safety (WHO, 2017): child, 5 - 14 years; teenagers, 15 - 19 years; adult, 20 - 74 years; elderly, 75 years of age or older.

3. Results

Pesticide cases involved in poisoning Within the 11-year study period from 2014 to 2024, a total of 257 poisoning cases were received by clinics and the Bimbilla Hospital. Looking closely at pesticide data in **Table 1** and **Figure 2**, the highest number of pesticides poisoning cases was caused by herbicides ($n = 105$), followed by agricultural insecticides ($n = 97$), rodenticides ($n = 41$) and fungicides ($n = 41$). In greater detailed, among the herbicides, the highest poisoning cases recorded were due to atrazine and glyphosate. However, of the different types of agricultural insecticides, the poisoning cases came from DDT which is a typical organochlorine pesticide, however, the other poisoning cases were caused by chlorpyrifos which belongs to the phosphate derivatives and therefore is an organophosphate pesticide.

3.1. Sociodemographic Characteristics

The general patterns of demographic characteristics of patients involved in pesticide poisoning cases are depicted in **Table 1**. The results showed that pesticide poisoning was more prevalent in men ($n = 196$) compared with women ($n = 61$). For distribution among age groups, the highest incidence rate was observed among adults which accounted for 142, followed by teenagers with a total number of 72. Geographical distribution showed that most pesticide poisoning cases were most prevalent in the Bincheratanga ($n = 114$) and Chamba areas ($n = 101$), which are located in the northern and western part of the Municipality. The majority of exposures were acute, with dermal being the predominant route of exposure which accounted for 119 cases, followed by ingestion ($n = 75$), also, inhalation recorded 46 cases, similarly other forms of exposure recorded a total number of 17, respectively. Furthermore, ($n = 131$) cases of the pesticide poisoning were reported to have occurred at home and a limited number of cases were reported to have occurred at academic institutions ($n = 24$). However, ($n = 71$) of occupational induced poisoning cases were reported to have occurred in the agricultural workplace.

3.2. Relative Importance of Types of Pesticide Poisoning

Based on **Table 2**, most of the pesticide poisoning cases occurred with suicides recording the highest type of cases in this category at ($n = 83$). On the other hand,

abortion cases of pesticide poisoning cases accounted for (n = 3) in the Municipality. However, pesticide poisoning cases pertaining to criminal accounted for (n = 1).

Table 1. Demographic characteristics of patients involved in pesticide poisoning in the study area.

Variables	Catchment Areas			Total Number (N)	(%)	p-value	
	Bimbilla-Dankpe	Bincheratanga	Chamba				
Sex	Male	27	89	80	196	76	0.00056
	Female	15	25	21	61	24	
Age group	Children	8	15	12	35	14	0.00056
	Teenagers	11	29	28	68	26	
	Adults	22	65	55	142	55	
	Elderly	1	5	6	12	5	
Workplace	Home	19	59	53	131	51	0.00056
	Workplace	12	32	27	71	28	
	Public	8	12	11	31	12	
	Academic institutions	3	11	10	24	9	
Clinical status	Asymptomatic	32	74	66	172	67	0.00056
	symptomatic	10	40	35	85	33	
Types of pesticides	Herbicide	21	43	41	105	41	0.00056
	Insecticide	18	40	39	97	38	
	Fungicide	1	9	4	14	5	
	Rodenticide	2	22	17	41	16	
Route of exposure	Ingestion	11	33	31	75	29	0.00056
	Inhalation	9	21	16	46	18	
	Dermal	20	50	49	119	46	
	Others	2	10	5	17	7	
Types of Exposure	Acute	32	74	66	172	67	0.00056
	Chronic	10	40	35	85	33	

Table 2. Distribution of the types of pesticides used according to circumstances.

Types of pesticides	Circumstances			Total
	Criminal	Abortion	Suicide attempt	
Herbicides	1	1	50	52
Insecticides	0	1	25	26
Fungicides	0	1	3	4
Rodenticides	0	0	5	5
Total	1	3	83	87

4. Discussion

In Nanumba-North Municipality, pesticide poisoning is common among farm

workers because the area is predominantly agrarian according to [5]. Herbicides caused the highest number of poisonings cases by ($n = 105$), and from this category, atrazine was the main contributing agent, and this was followed closely by glyphosate (**Figure 1**). This finding alluded to the American Association of Poison Control Centres in the year 2015, which proved that herbicides were found to be the most frequently used pesticides in induced poisoning cases in the country. Also, it was justified in South Korea as herbicides to be the most commonly used pesticide as a suicide agent between 2006 and 2010.

These data are further alluded to by published literature which stated that this type of pesticide has been reported to be the primary cause of pesticide poisoning in many Asian countries. Indeed, Nanumba-North Municipality consists of diverse ethnicities, Nanumbas, Dagombas, Komkobas, Basaris, and Chokosis. In the Nanumba-North vicinity, incidence and patterns of suicide are normally attributed to cultural, religious, social and even political factors. Looking at the characteristics of demography in **Table 1**, adults (males) of the Bincheratanga area recorded the highest involvement in pesticide poisoning cases. The supremacy of males as found in the current study is associated with other pesticide poisoning studies. However, the contributing factors could be largely attributed to financial burden, family disharmony and stress. This finding is buttressed by other local studies and some factors could be having a close connection to poverty, alcoholism, psychiatry morbidity, caste issues, other social distress, cultural and religious factors and attitude to suicide. The Bimbilla-Dankpe on the other hand, though the capital of the Municipality remains the area with the lowest suicide attempts as they practice Christianity and Islam, a religion which forbids suicide. Population between adults and teenagers have shown to be most affected with pesticide poisoning cases at 55% and 26%, respectively. This finding attested to [9], who found that people who were most susceptible to pesticide poisoning cases in Malaysia were adults, and a few South-Asia-based studies also further confirmed this finding. It has been reported that people from this age particularly deal with higher stress levels in comparison to other age groups. Rightly, these are the age group who deal with psychoemotional problems involving unemployment, economic hardship, family pressure and so on, in the sense that most of them want to bridge the generation gap. Subsequently, they are afflicted with depression or face unpleasant perceptions of life, putting them at a higher probability to have suicide attempts. The occurrences of poisoning cases were reported to be highest in the Joshiya and Jonayili communities in the Bincheratanga area.

The indigents rely heavily on farming and other agricultural developments and therefore depends highly on the utilisation of pesticide for a good harvest. These farm workers, most of whom are residing in rural agricultural areas, are vulnerable to pesticides daily, and this could be a factor which triggers suicide tendencies. Of the total number of poisoning cases, ($n = 172$) were caused by acute exposure while ($n = 85$) were caused by chronic exposure. In addition, 51% of cases occurred at home. Previous reports have indicated that increased suicide attempts

were contributed to by the easy availability and accessibility of these potentially toxic chemicals.

In fact, in China, it has been reported that those with no intention to commit suicide might be triggered by suicidal thoughts by the availability of pesticides. These data agree with reports from the WHO which found that using agricultural pesticides as a mode of self-poisoning is the major contributor to the global burden of suicide.

Looking at the types of poisoning cases suicide attempts accounted for 83 of these poisoning cases. While poisonings with criminal intent and to cause abortion represented only a modicum percentage of 1 and 3 (**Table 2** and **Figure 2**). In numerical terms, these values are very low compared to what has been reported by [10] [11]. Meanwhile, studies on suicide attempts and suicides have shown that every year, nearly one million people die of suicide around the world [10]. Most of the cases occurred at home and adults were the unsurpassed group involved.

This finding is pretty much perturbing as adults have a higher susceptibility to these potentially toxic chemicals and therefore could cause a fast rate of absorption through the skin, which can subsequently lead to abrasions and rashes since farmers in the area do not use personal protective equipment (PPE), therefore their skin can be exposed to abrasion, and this could easily lead to increased dermal absorption as a proportion of body weight as depicted in **Table 1**.

This current study also reported that only 28% of poisoning cases were due to occupational negligence at the workplace (**Table 1**). However, studies have shown that most occupational poisoning cases were under-reported as the cases were either not presented to healthcare facilities or cases presented were incorrectly recorded.

Even in other agriculture-based developing areas, the proportion of chronic pesticide poisoning arising from occupational exposure was very low when compared with the use of pesticides for intended self-harm, and this corresponds to the findings of the current study. This is also compatible with a South African study which substantiated that occupational poisoning cases were hugely under-reported as compared with suicides.

Moreover, this study suggested that 76% of men were involved in occupational poisoning. This is expected in Nanumba-North Municipality where men are more commonly involved in the agricultural industry than women, thus enabling more access to pesticides. In Nanumba-North Municipality, the average incidence rate of pesticide poisoning cases is considered lower than the rate of other studies such as El Salvador and Nicaragua in Sri Lanka and Central America, respectively. However, the increasing incidence rate of pesticide poisoning cases between 2014 and 2024 proved that this issue is not improving and is progressively deteriorating, as shown in **Table 3** and **Figure 3**. The pesticide poisoning incidence has steadily increased from 2014 to 2021 and dropped dramatically in 2024. In addition, this finding showed that pesticide poisoning among men and women at a ratio of 3:1 corresponds with the national statistics reporting a higher ratio of men

showing suicide tendencies than women. Clearly, this could be attributed to the fact that women do not own land in the study area and are sparingly involved in making production decisions, which can be explained by cultural factors such as household leadership in such a patriarchal society. Suicide by self-poisoning of pesticides is a global health issue and therefore must be addressed with effective community and government interventions.

Countries namely China, India and Sri Lanka reported serious cases of pesticide poisoning and therefore recognised the need for urgent action and addressed the issue through community engagement. While China implemented combining household lockboxes with community education about suicide prevention, India is not left out of this heinous act, since they implemented central communal storage of pesticides and Sri Lanka implemented safely securing pesticides within households. The findings of these projects were optimistic, with participants finding the methods useful and acceptable, having greater awareness regarding risks of pesticide storage at home, and the countries recording a substantial drop in suicidal behaviours. In addition, government intervention has also proven to be effective as countries or regions namely Sri Lanka, Bangladesh, South Korea, Taiwan region and Japan have implemented national bans on highly hazardous pesticides (WHO class I) which are commonly ingested in acts of self-poisoning. This action resulted in an immediate decline in pesticide-poisoning suicides as well as the overall suicide mortality rate. Therefore, it could be postulated that reduced access to highly hazardous pesticides is associated with a reduction in the national suicide rate, and a worldwide ban on these chemicals can prevent tens of thousands of deaths every year. Due to the retrospective nature of this study, recall bias might be a limitation whereby inaccuracy might have occurred in the ability of patients to recall past exposures accurately. Since the researcher of the study have no control over exposures, it was solely dependent on patients to provide information on their exposure to pesticides.

In addition, the actual number of pesticides poisoning cases as presented in this study may be under-reported. Moreover, such cases may not be reported to the Clinics and Bimbilla Hospital within the Municipality. Another important limitation worth noting is the lack of information on the medical outcome of the patients. This information may provide an insight into the very depth of the problem, and subsequent appropriate action can be taken to remedy the problem. For example, fatal intoxication cases can bring forth some regulatory implementation strategies regarding pesticide use in the Municipality. Therefore, initiatives have been made to include this information for future use. However, the lack of stricter and more assertive regulations enabled certain high-risk individuals to have access to these pesticides. Since the easy availability of pesticides may convert several impulsive acts into suicide using pesticide ingestion, the Agricultural Extension Officers within the Nanumba-North Municipality should prioritise better strategies for the regulation of pesticide use. Moreover, they should provide information regarding proper pesticide storage and handling as a major priority.

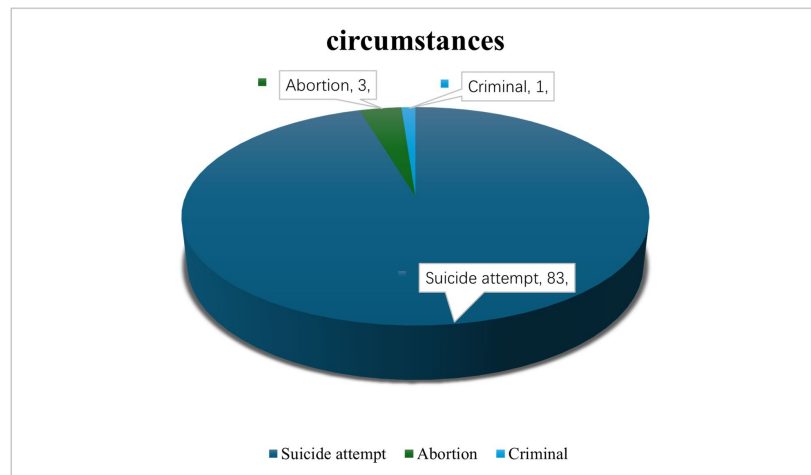


Figure 1. Distribution of the types of pesticides used according to circumstances.

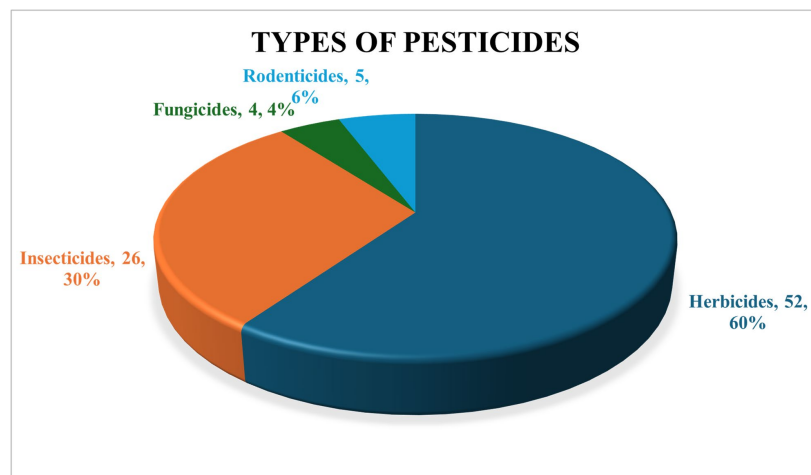


Figure 2. Types of pesticides.

Table 3. Pesticide poisoning incidence rates in the study area.

Years	Clinical status			p-value
	Number of cases	Recovery	Death	
2010	3	3	0	0.000595
2011	5	5	0	0.000595
2012	7	6	1	0.000595
2013	24	21	3	0.000595
2014	37	32	5	0.000595
2015	38	31	7	0.000595
2016	39	30	9	0.000595
2017	47	37	10	0.000595
2018	22	19	3	0.000595
2019	20	19	1	0.000595
2020	15	15	0	0.000595
Total	257	218	39	p < 0.5

Distribution of pesticides poisoning cases (n = 257) yearly.

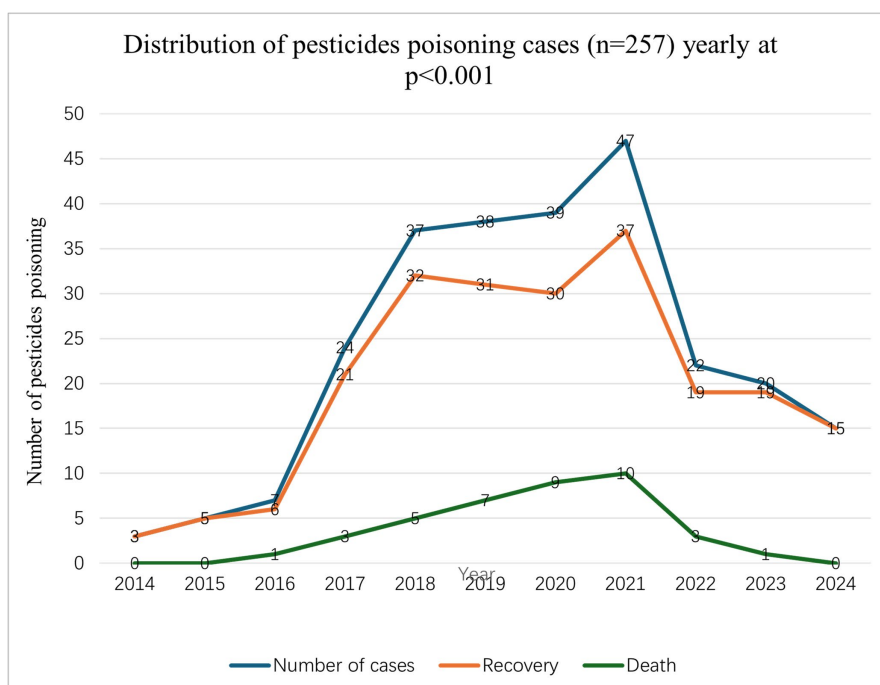


Figure 3. Distribution of pesticides poisoning.

4.1. Preventive Measures and Intervention Strategies

Pesticide poisoning can be reduced through various preventive measures. Firstly, the use of personal protective equipment can reduce occupational pesticide poisoning among farmers [12]. Secondly, better pesticide management can reduce non-occupational pesticide poisoning caused by accidents. This includes new closed-system packaging, special training for certified applicators, and changes to pesticide labelling and warning materials [13]. However, improving household storage methods does not effectively reduce pesticide poisoning. For pesticide suicides with the highest fatality, multiple methods should be adopted. Restricting lethal means can reduce suicide, and many countries have implemented strategies to reduce intentional poisoning. For instance, the replacement of highly toxic pesticides could potentially prevent 150,000 pesticide suicides globally annually [12]. However, the incidence of ingestion and deaths remains high. Promoting low-toxicity pesticides can increase patient survival rates. Improving medical care in resource-poor hospitals can improve cure rates. Lastly, appropriate psychological intervention and physical therapy should be implemented to reduce repeat suicides.

4.2. Study Limitations and Future Research Directions

The study on pesticide poisoning in Nanumba-North Municipality offers valuable insights into fatalities and risk factors. However, it has limitations, including a reliance on data from clinics and the Bimbilla-hospital, which may underestimate the actual incidence of pesticide poisoning. The geographical scope of the study is restricted to clinics and the Bimbilla-hospital, which may not fully reflect the di-

verse situations in the municipality. The research also focuses on short-term outcomes of pesticide poisoning cases, overlooking long-term health implications, such as neurological disorders, endocrine disruption, and an elevated risk of certain cancers. The results are more relevant to areas with similar agricultural activities and healthcare systems in the Northern Region of Ghana. Future research should adopt more comprehensive data-collection methods, integrate community-based monitoring approaches, and establish long-term follow-up mechanisms for pesticide-poisoned patients to better evaluate long-term health impacts and provide more in-depth knowledge for the prevention and management of pesticide-related health risks.

5. Conclusion

The upward trend of pesticide poisoning between 2014 and 2024 revealed that pesticide poisoning is a prevalent public health problem in Nanumba-North Municipality. Younger male adults had higher tendencies to resort to the pesticide as a mode of suicide attempt, whereby the high-risk individuals were mostly from the Bincheratanga and Chamba areas. Major factors which caused the high rate of pesticide poisoning in Nanumba-North Municipality were suggested to be easy access to pesticides and lack of suicide awareness and education among the people. Therefore, intensive intervention efforts, such as prevention efforts directed at controlling suicide, and mental health programmes for vulnerable groups, proper enforcement systems on the use of pesticides, are needed to reduce the burden of pesticide poisoning in Nanumba-North Municipality.

6. Recommendation

Based on the findings of the study, the following effective measures are recommended.

- The Ministry of Agriculture and the Environmental Protection Agency need to check and enforce regulations on the use of pesticides by farmers in the study area.
- The Crop Research Division of the Council for Scientific and Industrial Research (CSIR) in collaboration with the Crop Research Institute of Ghana (CRIG) should research Integrated Pest Management for crops to solve the problem of pesticide residues bedeviling food production in Ghana.
- EPA (Environmental Protection Agency) should provide information regarding proper pesticide storage and handling as a major priority.

Data Availability Statement

The data that support the findings of this study was Statistical Package for the Social Sciences (SPSS) version 16.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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