

# Evaluating the Environmental Impacts of the Whein Town Landfill Facility on Residents of Whein Town, Paynesville City, Liberia

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## Abstract

Reports and claims have been made reflecting opinions of the environmental impacts of the Whein Town Landfill Facility on the residents of the Whein Town Community. This study seeks to examine the environmental effects of the Whein Town Landfill on nearby residents, and the effectiveness of the existing mitigation schemes. This cross-sectional study used 4-point-Likert and 2-point-dichotomous scales questionnaires to collect information from 352 Whein Town community household heads. The findings reveal that “odorous emissions” represent the most critical environmental challenge, severely impacting residents’ well-being and quality of life. By contrast, “garbage spillage along routes” has a minimal impact on residents’ lives, with many residents rating it as “Not Serious”. Six out of eight mitigation implemented schemes achieved a success rate below 25%, one performed at approximately 50%, and only one scheme—the landfill fencing—was effectively implemented, reaching a near-perfect success rate of 99.99%. Therefore, residents of Whein Town are experiencing adverse environmental effects that can be remediated with proper planning and the implementation of existing schemes.

## Keywords

Landfill, Environmental Problems, Mitigation Schemes, Residents, Pollution

## 1. Introduction

Dumping non-segregated solid waste to landfill sites is developing countries’ most prevalent waste disposal practice (Siddiqua et al., 2022). The improper management

of landfills and the generation of toxic leachate exert significant impacts on surrounding freshwater and groundwater (Danthurebandara et al., 2013). The principal concern about municipal landfills is the potential for pollution due to the mobilization of the generated leachate through the subsoil into the surface and groundwater (Hredoy et al., 2022).

According to Statista (2024), waste generation has increased to more than 2 billion metric tons every year worldwide in recent decades. By 2050, it is estimated that worldwide municipal solid waste generation is expected to have increased by roughly 70 percent to 3.4 billion metric tons. This is due to population growth, urbanization, economic growth, and consumer shopping habits. Humans produce millions of tons of waste yearly, which is increasingly becoming a significant issue worldwide. However, less than 30 percent of waste is reportedly recycled yearly, with huge quantities still sent to landfill sites. With such immense volumes of waste arising, the need for authorities to provide adequate waste treatment and disposal services has become ever more critical (Bhowmick et al., 2024).

Although significant progress has been made in landfill management and utilization, there are limitations in some developed countries (Swati et al., 2018). African countries have shown limited strategies and inadequate control of many related landfill problems (Kharlamova et al., 2016). A Review of Landfill Gas Generation and Utilization in Africa by Njoku et al. (2018) spotted several reasons that could have influenced the low development, management, and utilization of landfills in Africa ranging from lack of skilled expertise, inadequate knowledge of the technology involved, lack of political will, inadequate funding for Landfill management projects, and monopoly of the power sector among others.

In Liberia, around 50.7 percent of the population lives in urban areas (Worldometer, 2024). This has contributed to the increased generation of waste in urban areas. Urbanization also significantly contributes to the increasingly poor environmental conditions in various urban centers in Liberia leading to environmental degradation, pollution, and waste disposal problems. Other precursors to Liberia's increased daily waste generation include economic or commercial activities, rapid urbanization, changes in consumption patterns, rapid population growth, etc. (Liang et al., 2019).

Between 2008 and 2018, the Emergency Monrovia Urban Sanitation Project (EMUS), and the EU Water Facility Project, funded by the World Bank and the European Union, were primarily focused on providing support for the key and minor waste assortment and enhancing disposal and sanitation in Monrovia with infrastructure support at two transfer stations (Stockton Creek and Fiamah), three installed weighbridges (landfill and transfer stations), and 120 communal disposal locations throughout the Greater Monrovia area (David et al., 2020; MCC, 2010).

The EMUS Project, regarded as the Whein Town Landfill Facility (WLF), was originally an emergency impact five-year project, aimed at improving access to solid waste collection and disposal in Monrovia and Paynesville (MCC, 2010). Up to 2024, the Whein Town landfill is yet to be closed and continues to serve its purpose with many constraints (New Dawn, 2024). While it is true that there are

few regulations put in place to reduce the many environmental effects of the out-lived landfill, there exist many environmental concerns that this paper tends to investigate (Azango, 2019; Levi & Aslanova, 2022). An analysis of potential impacts that could have incurred due to the implementation of the Whein Town Facility revealed limited adverse environmental impacts during the short-term facility construction and site preparation phase (MCC, 2010). However, due to operations and overuse, the facility is now associated with substantial negative impacts due mainly to leachate generation with potential surface and/or groundwater contamination, visual/landscape intrusion, biodiversity, air quality, traffic, and health and safety issues. Other less severe concern impacts include odorous emissions, soil contamination, landfill stability/settlement, and socio-economics (David et al., 2020; New Republic Liberia News, 2024).

Landfills are potential sources of pollution that can cause water pollution, air pollution, soil pollution, and pollution of the natural environment (Danthurebandara et al., 2013; Kharlamova et al., 2016).

This paper aims to narrow some critical research gaps in understanding the environmental problems faced by the Whein Town Landfill residents and the effectiveness of the mitigating schemes implemented. It shall present how the Whein Town Community residents perceive the existing environmental problems that affect their daily lives and how effective are the existing mitigation schemes. Importantly, this study will help bridge these knowledge gaps, offering data-driven insights and recommendations to safeguard the environment and the health of Whein Town's residents.

*What are the existing environmental problems at the Whein Town Landfill Site that are affecting the lives of the residents of the Whein Town Community?*

This question seeks to identify and analyze the residents' perspectives on the existing environmental problems caused by the landfill's operation. It aims to uncover to what extent these problems impede their day-to-day activities.

*How effective are the environmental programs or mitigation schemes in remediating the existing problems at the Whein Town Landfill Facility?*

This question seeks to evaluate and analyze the effectiveness of the ongoing mitigation schemes at the landfill in raising residents' awareness of the landfill's impacts and evaluating each scheme. It will also explore the residents' perceptions of the landfill, highlighting social and environmental justice issues while emphasizing the need for community-based solutions.

This research seeks to investigate the environmental considerations for controlling landfill impacts, provide localized data and insights into the extent of pollution, and identify potential health risks to residents. It will also recommend practical, evidence-based measures that shall address the site's challenges, such as improved landfill covering methods and pollution monitoring protocols.

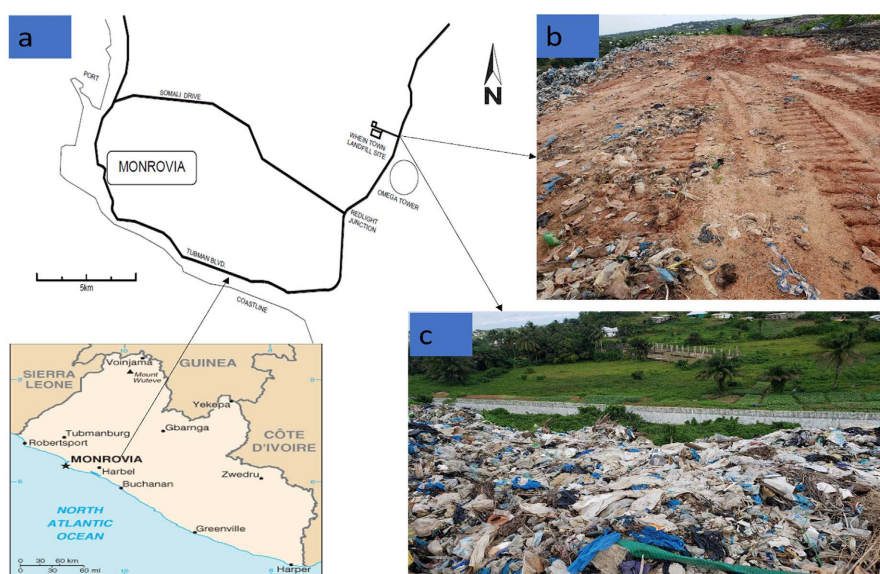
## 2. Method

### 2.1. Study Area

This research focuses on the Whein Town Landfill and its associated borders

(Figure 1). The Whein Town Landfill Facility is the largest landfill in Liberia, receiving assorted municipal solid waste from Monrovia and Paynesville. This facility is located in a small community, Whein Town, on the outskirts of Monrovia City, which is located in Montserrado County. The town lies 13 km north-east of Monrovia, 7.5 km east of Gardnersville, 3.9 km south-west of Mount Barclay, and 7 km north-north-east of Paynesville. The site falls approximately 29 N 0314899 UTM 0698921. The elevation ranges between 10 and 20 m above sea level. It is also 16 km east of the Atlantic Ocean, 12 km northwest of St. Paul River, and 4 km west of Muu Creek. The site area is approximately 10 ha in size (MCC, 2010). The topography of Whein Town is a mix of low-lying terrain and hilly areas identical to the greater Monrovia region and experiences high rainfall during the rainy season and relatively dry periods during the dry season. The landfill covers roughly 25 acres and is surrounded by dispersed residential settlements and farmland. It receives an estimated 350 tons of municipal daily. It was originally expected to operate for 5 - 8 years (2008-2016), yet it is still in use today (CDM, 2006; MCC, 2010).

The residents of this community come from various ethnic backgrounds and practice a blend of traditional Liberian customs and modern urban lifestyles. Despite infrastructure and environmental challenges, Whein Town has a strong sense of community centered around religious institutions, local markets, and communal efforts.



**Figure 1.** Location of the study area: (a) position of Whein from Monrovia City (MCC, 2010); (b) Soil covering scheme at WLF; (c) partial view of the fence around the landfill.

## 2.2. Study Population

This research's targeted population comprises the residents of Whein Town Community household heads. This community is geographically divided into eight Blocks: Block A, Block B, Block C, Block D, Block E, Block F, Block G, and Block

H. The topography of the region influences the layout of these blocks. The landfill facility's presence in Whein Town also has a notable impact on the population distribution across these blocks, with blocks closer to the landfill having lower population densities than the blocks farther away.

These geographic and demographic differences are crucial for a more targeted and nuanced analysis of the community's response to the landfill's environmental and health challenges.

The data of this research was collected between April and June 2023, during Liberia's shift from the dry season to the early rainy season. This timing was chosen carefully to reduce seasonal biases and provide a balanced representation of conditions.

An on-site, face-to-face interview approach was used, with questionnaires distributed directly to participants in their homes. This approach was critical in getting an authentic portrayal of the current situations, allowing participants to thoroughly reflect on their circumstances.

### 2.3. Sample Size and Sampling Techniques

The study employed Slovin's formula for finite population proportion to determine an appropriate sample size of 352 respondents from the target population of the Whein Town Community. This formula was selected because it is particularly effective for studies involving finite populations, where surveying the entire population would be difficult due to time, resource, or logistical constraints, and will ensure that the sample size is large enough to accurately reflect the overall population while maintaining an acceptable level of precision and confidence in the results. In this context, selecting 352 household heads ensures that the study can capture diverse perspectives across different blocks in Whein Town, which vary in population density and environmental exposure due to the landfill. This method thus supports the study's overall goal of obtaining valid and reliable data for assessing the environmental and health impacts on the community.

$$\text{Slovin Formula } n = \frac{N}{1 + Ne^2}$$

$n$  = sample size

$N$  = Universal population [total population of the coverage area]

$e^2$  = Margin of error

1 = is given as part of the standard formula

$$n = \frac{2903}{1 + 2903(0.05)^2}$$

$n = 352$

In calculating the study's sample size, a 95% Confidence Level and a 5% Margin of Error were applied. These parameters ensure that the study results will be reliable and that the likelihood of the true population characteristics falling within the estimated range is high. Given that the Whein Town Community is divided into eight blocks (A through H), a proportional sampling approach was used to

ensure that each block was adequately represented in the study. This method is essential because the population is unevenly distributed across the blocks. To ensure the sample is representative of the entire community, the number of respondents selected from each block is proportional to the size of that block's population in relation to the total population.

For example, in Block A, which has 397 household heads, the formula used to calculate the proportional number of respondents is:

$$\text{Block A} = \frac{397}{2903} * 352 = 48$$

This means that 48 questionnaires were distributed to residents of Block A, ensuring that this block is represented according to its population size. This proportional sampling ensures that the study's sample size of 352 household heads is distributed fairly across all eight blocks, based on each block's population size (Table 1). This method is crucial because it ensures that the study captures a broad and representative range of experiences and perspectives from across the entire community, despite the uneven distribution of the population. In doing so, it prevents the risk of over- or under-representing any particular block, allowing for a more accurate analysis of the environmental and health impacts related to the landfill across different geographic and social contexts within Whein Town.

**Table 1.** Record of the count of household heads in Whein Town community.

Blocks	Counts	Sample
A	397	48
B	365	45
C	330	40
D	247	30
E	290	35
F	355	43
G	405	49
H	514	62

## 2.4. Questionnaire Design

The questionnaire in this study was designed using 15 indicators: 7 of the questions related to environmental problems in Whein Town affecting the residents, and the final eight questions related to environmental mitigation schemes for reducing the effects of the environmental problems on residents of Whein Town Community. These indicators were chosen on a backdrop of a preliminary assessment of the environmental conditions of the communities. There is also a section that focuses on some personal data of respondents: gender, age bracket, education level, number of years residing in the community, and employment status. The multi-layered design of the questionnaire provides a comprehensive understanding

of respondents' perspectives, which can be utilized for a wide range of policymaking and implementation efforts.

Each responder consented to the interview and accepted that the responses were meant for research purposes and could be used to inform policymaking and implications. Each question was designed to tap into the understanding of respondents' experiences, perspectives, and expectations of existing environmental impacts at the landfill. All the questions were close-ended. The first set of seven questions used the Likert scale and provided the options: "serious", "fairly serious", "not serious", and "did not know" to respondents. This scale was meant to measure the severity and rank the order of opinions about the seriousness of the existing indicators in this bracket. The second set of eight questions used a dichotomous scale where respondents were given "Yes" and "No", representing a direct choice between opposing choices. This scale was meant to ascertain the existing programs or infrastructure at the landfill that tend to support or minimize the existing environmental conditions. Using both scales in this study provides a broader understanding, seeks to uncover complex opinions, provides balanced analysis, and is meant to reduce possible biases (Table 2).

**Table 2.** Research questionnaire parameters with related feedback options.

1) To what extent do you experience the following environmental conditions?	
Parameter	Respondents feedback options
Landfill fire	
Garbage spillage along haulage routes	Serious
Odorous emissions	Fairly Serious
Insect and Rodents encroachment	Not Serious
Water Coloration in Wells	Did not tell
Noise Disturbance from Machinery	
Dispersed Smoke	
2) Are the following environmental programs effective in mitigating the environmental conditions experienced?	
Mitigation	Respondents feedback options
Fencing of Landfill	
Garbage cover	YES
Landfill closure	
Alternative Water Supply (kiosk)	
Noise Control system	
Surface Runoff Control (Drainage)	NO
Water treatment program for wells	
Fumigation Scheme	

## 2.5. Data Analysis Procedures

The data obtained in this research are grouped into three categories: the demography of the respondents, the environmental conditions at the landfill, and the mitigation schemes in place to remediate the existing environmental conditions. The data were sufficiently organized, cleaned, and processed using the R statistical software (R Studio, version 4.4.1) to investigate the environmental impacts of the Whein Town Landfill Facility on residents of the Whein Town Community.

The first approach begins with the Principal Component Analysis (PCA), a method used to condense the number of variables in a dataset by combining them into smaller components. This method is significant as it uses the standard deviation in each component to explain the relationship to other components. In the end, the proportion of variance is determined. Subsequently, the cumulative proportion from one PC to another is determined, this is crucial as it presents the variations in each dataset component and gives a clue on which section of the data to focus on for capturing analytical information. This method was applied to process the feedback provided by the responders on the existing environmental conditions.

The following method was the statistical test for the dichotomous responses from the dataset of the mitigation schemes available at the landfill. This method is crucial as it determines the significant relationship between variables by assessing how observed data deviates from what is expected. In this analysis, the Test statistic was determined and used to evaluate the trueness of each response. This test was accompanied by the  $p$ -value, which is a probability that measures the strength of each response to an existing condition. This method aids this study in determining the relationships and differences between the different responses from each response to the level of implementation of each available parameter and how each supports the overall environmental wellness of the community.

Finally, a descriptive analysis was used to process the demographic data of the responders. This evaluated the characteristics of the populations and gained insights into their diverse opinions, providing extensive cross-across responses on the existing conditions at the landfill and the related available mitigation schemes.

The applications of these methods to process the various datasets in this research were informative, analytical, and significant in arriving at informed decisions and making discoveries about the situations being investigated. By applying these different methods, this research tends to adequately evaluate the environmental impacts of the Whein Town Landfill on residents of the Whein Town community.

## 3. Results

Residents' feedback about the environmental conditions at the landfill was divided into four components (PC1, PC2, PC3, and PC4) with associated standard deviation as seen in **Table 3**. PC1 has the most significant standard deviation of 1.3841, which shows that the dataset in this component has the most variation, followed

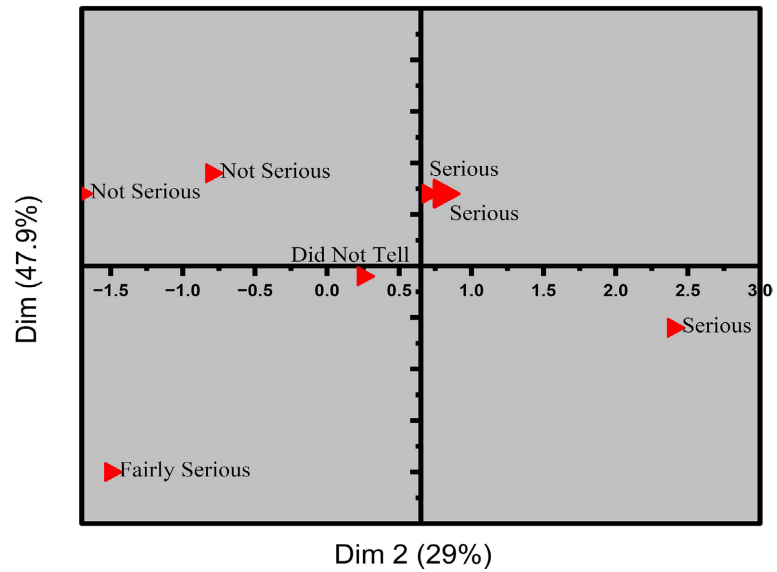
by PC2 and PC3. PC4 has a nearly zero standard deviation, making a negligible impact on the overall component analysis with a proportion of variance at 0.00. The proportions of PC1 and PC2 variance are 47.89% and 29% respectively. From a cumulative point of view, PC1, PC2, and PC3 account for 100% of the variations in the dataset and can, therefore, be used to summarize the perspectives of residents about the prevailing environmental problems affecting them by the Whein Town Landfill Facility.

The different perceptions of the seriousness of the environmental conditions at the Whein Town Landfill are shown in **Figure 2**. It is a visual cluster of the community's views on the severity of the environmental conditions. It highlights two dimensions (Dim 1 and Dim 2), showing the 47.9% and 29% proportion of variance of PC1 and PC2 as seen in **Table 3**. The four arrows labeled—Serious, Fairly Serious, Not Serious, and Did Not Tell—represent the different views of the residents about the existing environmental conditions. These views are grouped and assigned a point from 1 to 7 based on variations in perceptions, with each direction of the arrow showing the variations between the categories. The direction of each arrow shows how far or close each group's opinion is to these categories. Three of the groups are labeled Serious, showing that they view these environmental conditions as more concerning, while two other Groups align with the “Not Serious” label, showing that they view these environmental conditions as not concerning. Another Group aligns with “Fairly Serious”, showing a moderate level of concern, and finally, Group 7, which represented the group that was unwilling to give an option or undecided, aligns with the “Did Not Tell”.

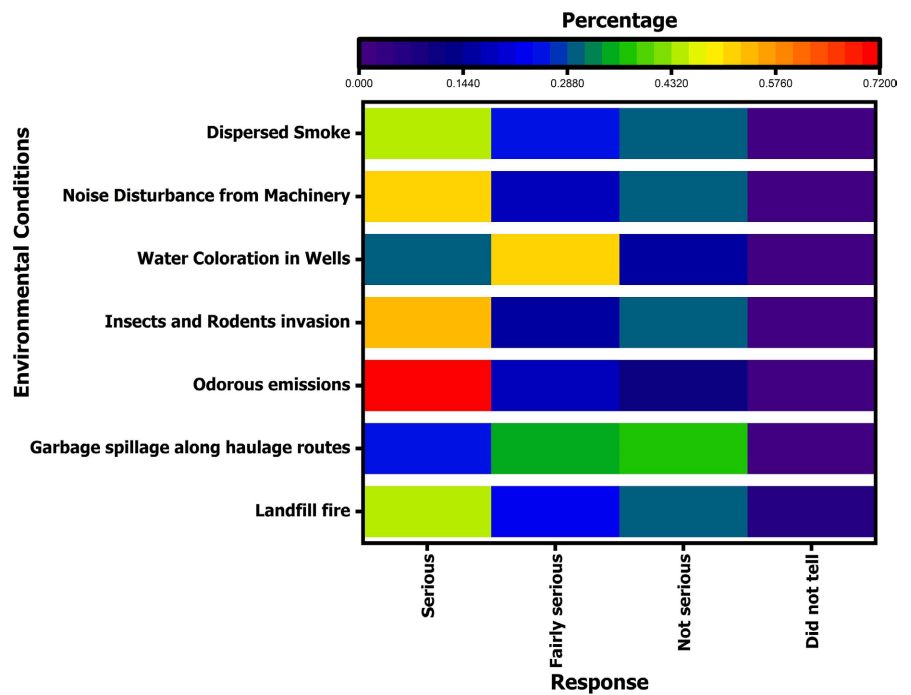
**Table 3.** Principal Component Analysis of residents' feedback on environmental conditions.

	PC1	PC2	PC3	PC4
Standard deviation	1.3841	1.077	0.9613	2.58E-16
Proportion of Variance	0.4789	0.291	0.231	0.00E+00
Cumulative Proportion	0.4789	0.7689	1.00	1.00E+00

The perspectives of Whein Town residents on the various environmental conditions at the landfill site categorized by the level of seriousness are presented accordingly as seen in **Figure 3**. The intensity of the color in each cell reflects the percentage of responses for each condition and seriousness level. The color scale represents the response percentage, and a deeper scale represents a higher percentage of responses for that particular combination of condition and type. “Garbage Spillage along Haulage routes” shows relatively low concern levels with lighter shades in the “Not Serious”, and “water coloration in wells” has a substantial color intensity in the “Fairly Serious” categories, suggesting a significant concern for many respondents. Dispersed Smoke, Landfill fire, Noise Disturbance from Machinery, and Insects and rodent Encroachment show noticeable responses in the “Serious” categories, indicating a moderate to significant concern



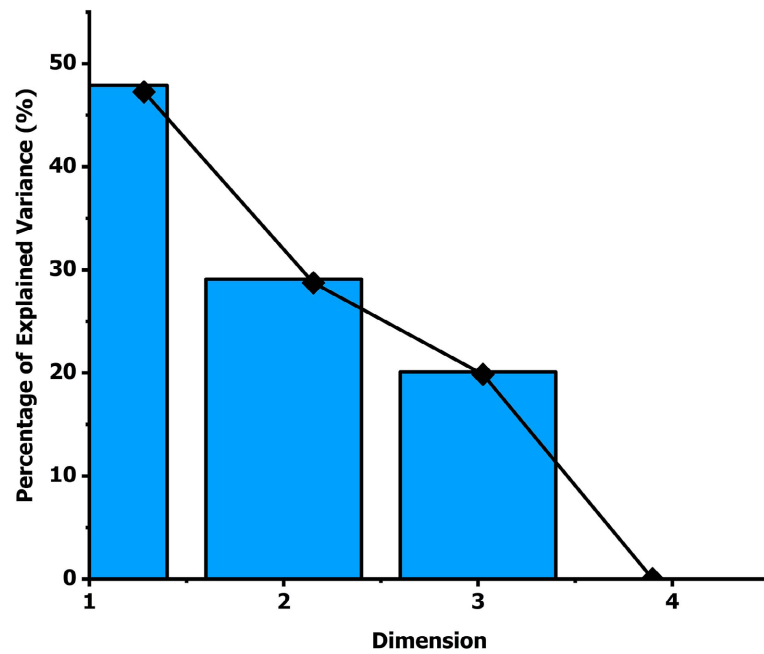
**Figure 2.** Visual cluster of the community’s views on the severity of the environmental conditions.



**Figure 3.** Residents perspectives on environmental conditions.

about these situations. Lastly, “odorous emissions” has the darkest cell under the “Serious” response type, which indicates it is perceived as the most severe issue. A high percentage of respondents consider this environmental problem a critical concern.

The perspectives of responders on the effectiveness or availability of the environmental program or scheme at the landfill are shown in **Table 4**. Each mitigation scheme was assessed on how it has helped solve an environmental problem



**Figure 4.** Scree plot of the principal component analysis.

**Table 4.** Statistic test on respondents' perspectives on the mitigation schemes.

Mitigation Schemes	Yes	No	<i>p</i> -value	Test_Statistic
Landfill fencing	349	3	1.00E-75	339
Garbage Cover	32	320	1.10E-53	238
Landfill Closure	2	350	1.39E-76	343
Alternative Water supply (Kiosk)	52	300	2.62E-40	177
Drainage system	152	200	8.91E-3	6.84
Water treatment program for well	0	352	2.57E-78	352
Fumigation	110	242	1.26E-12	50.04
Noise Control system	24	328	7.83E-59	262

captured in this research or whether it is currently being implemented. The Yes and No columns show how many responders indicated that a particular scheme had been implemented. The landfill fencing, which was meant to enclose the boundary of the entire facility by building a fence around it, had 349 “Yes” with only 3 “No” responses. This shows a significant agreement in the residents' evaluation of this scheme as being successful.

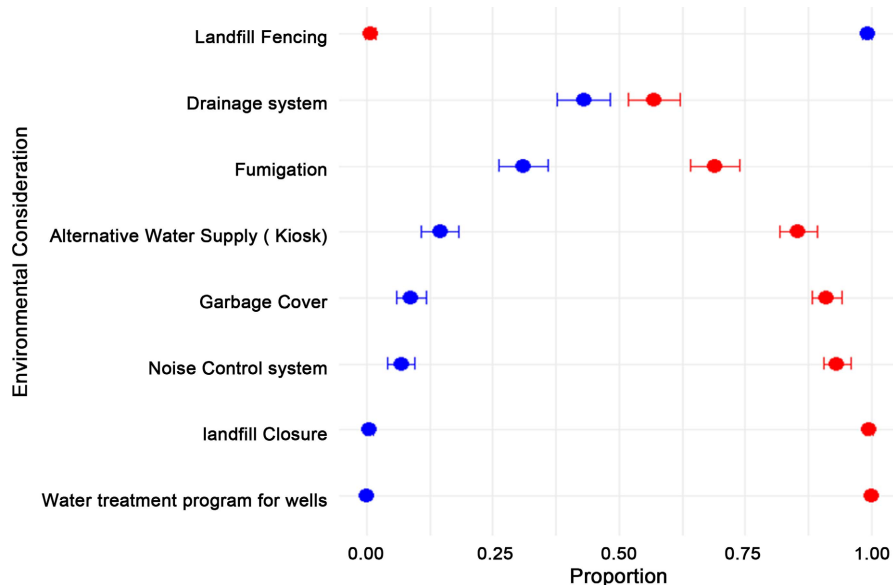
The following scheme is the Covering of Garbage, a project adopted to completely cover the garbage in landfills with soil due to the effects its exposure is creating on the nearby community. Residents' responses show 32 “Yes” out of the 352 responders. Contrary to the first scheme, as assessed by the community's views, this measure seems poorly implemented. The third mitigation scheme as seen in **Figure 4**, landfill closure, was intended to activate the closure plan of the

landfill. No municipal solid waste would be disposed of within the landfill during such a period. However, only two responders opined the Landfill closure with a Yes while the 350 others reflected a No. It is also inferred that this mitigation scheme was unsuccessful, and the Whein Town Landfill is currently active as a waste disposal site in the Whein Town Community. The following scheme is the Provision of Alternative Water Supply. This program was designed to provide other sources of potable water to the community due to the effects of the landfill on the quality of the hand-dug wells used by the various blocks within the community. However, this scheme accumulated 300 “No” responses from the responders, while 52 answered “Yes”. This also shows a considerate agreement in the residents’ opinions that this mitigation scheme was unsuccessful. The following scheme is the Drainage System. It was designed to control surface runoff of water running from the landfill into the hand-dug well used by the community. This survey data shows “152” Yes and 200 “No”. This reflects almost a balance in the residents’ views about the extent to which this program was implemented.

The following mitigation scheme is the Water Treatment Program for Wells. The scheme was designed to treat all hand-dug wells in the community periodically. This is very important as these wells are the community’s primary sources of potable water. However, the landfill facility poses a considerable threat to their sanitary status. However, the survey results show an alarming 352 “No” (all the residents think that this scheme is yet to get started or has not been implemented). The next is the fumigation scheme. It was designed to create a buffer zone around the landfill relative to the community and to periodically apply fumigants to address the health risks of insects, rodents, and landfill emissions. Responders’ opinions reflect 110 “Yes” responses and a “No” of 242. This shows that this scheme has some level of implementation.

Finally, the last scheme listed as seen in **Table 4** is the Noise Control System. This scheme was a policy designed to regulate the use of heavy machinery in the landfill and provide solutions to help reduce machinery-related noises from the landfill to the community, especially at night. The survey shows 24 “Yes” and 328 “No” from community dwellers representing their perspectives on this scheme. It shows that the scheme to reduce noise pollution within the Whein Town Community emanating from the landfill facility was unsuccessful.

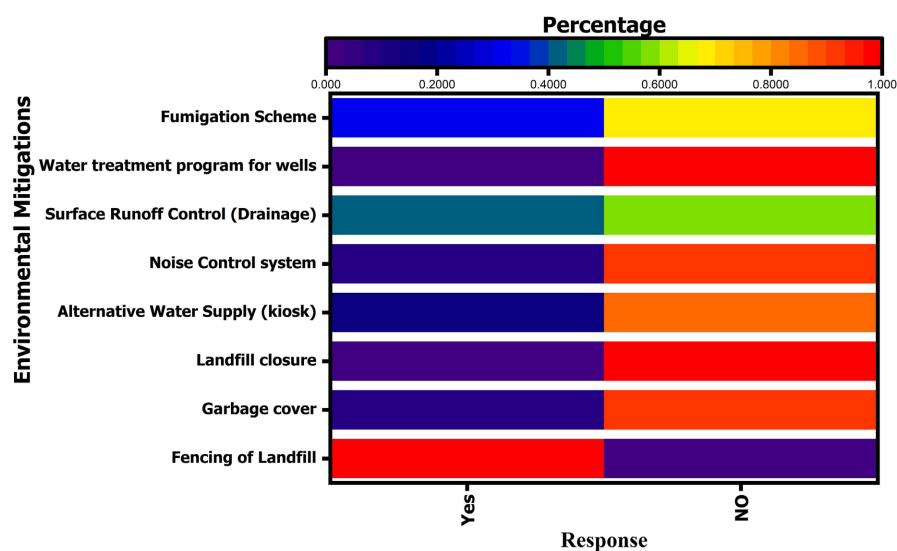
The  $p$ -value as shown in **Figure 5** shows the proportions of either a “Yes” or a “No occurrence” of functional mitigation schemes at the landfill with Yes in the Blue squares and No in the red squares. The horizontal error bars associated with the red and blue points show variability or uncertainty in the data. Higher Blue Points indicate more agreement (Yes) for the corresponding environmental consideration while higher Red Points Indicate more disagreement (No). For instance, “Landfill Fencing” has a high proportion of “Yes” and a very small proportion of “No” responses while “Water treatment program for wells” shows only “No” responses, as the red square is at 1 (100%) while the blue square is at 0. However, with the significant gap between the Yes-No scenarios, the  $p$ -value is



**Figure 5.** Correlation between Yes and NO occurrence.

statistically significant, as indicated by its lower than 0.05 value in each scheme. In principle, a  $p$ -value smaller than 0.05 is said to be statistically significant. As illustrated in **Table 4**, all the environmental programs/schemes have a  $p$ -value less than 0.05, indicating that the results are highly significant. Most of the environmental programs at the Whein Town landfill have significant differences between the Yes and the No responses. The test statistic as shown in **Table 4** highlights the responders' perspectives on the available environmental schemes. It reflects the magnitude of the observed association between the implementations of each mitigation scheme (Yes/No) and the community's perceptions of the existing situations. The test statistic is inverse to the  $p$ -value (the more significant the test statistic, the smaller the  $p$ -value). It, therefore, represents a natural pattern in the data instead of a random chance. landfill fencing has a test statistic of 339, indicating strong evidence that landfill fencing is well-implemented and effective. Garbage cover, on the other hand, has a test statistic of 238 but with a more significant "No" proportion, indicating that this scheme is not well implemented. The test statistics of water treatment for Wells is 352, which means that this mitigation scheme has not been implemented. The Landfill Closure, Noise control system, and Alternative Water Supply have test statistics of 343, 262, and 177, respectively, showing that these schemes are poorly implemented. However, the Alternative water supply is marked with progress. The test statistics of Landfill Closure as 343 and Noise control system as 262 reflect poor implementations in both scenarios.

As seen in **Figure 6**, the overview of the respondents' perspectives on the different environmental mitigation strategies is highlighted with the degree of effectiveness. The "Yes and "No" columns highlight the acceptance or rejection of implementing the mitigation measure. The color scale shows the percentage intensity for each response, from light reflecting a lower percentage to dark red



**Figure 6.** Respondents' perspectives on the different environmental mitigation strategies.

reflecting a higher percentage. The color scale shows the percentage intensity for each response, from light reflecting a lower percentage to dark red reflecting a higher percentage. In the "Yes" column, Fencing of Landfill received a dark red, indicating that most respondents find implementing this measure very effective. In the "No" column, Water Treatment Programs for Wells, Noise Control Systems, Landfill Closure, Garbage Cover, and Alternative Water Supply (Kiosk) received a dark red, suggesting that the respondents think these measures are ineffective. The Surface runoff Control (drainage system) received a fairly balanced distribution with light colors in both columns but still shows a slightly deeper color within the "No" columns, indicating that about half of the respondents opined that this measure has been effective while the rest expressed opposing ideas. The fumigation scheme also has a mix of responses but leans more toward "No." The respondents' views suggest that there may be some level of effectiveness in this measure, but it is not adequate.

**Table 5.** Socio-demographic profile of the survey respondents.

Attributes	Level	Frequency	Percentage
Sex	Male	146	41.48%
	Female	206	58.52%
Chi-squared statistic = 10.227, df = 1, <i>p</i> -value = 0.001384			
Age Bracket	18 - 25	59	16.76%
	26 - 30	64	18.18%
	31 - 35	50	14.21%
	36 - 40	49	13.92%
	41 - 45	50	14.21%
	46 - 50	22	6.25%
	51 - 55	9	8.24%
	56 - ABOVE	29	8.24%

**Continued**

Chi-squared statistic = 37.636, df = 7, <i>p</i> -value = 3.553e-06			
Education Level	No formal education	101	28.69%
	Junior High	94	26.71%
	senior High	110	31.25%
	Tertiary	47	13.35%
Chi-squared statistic = 26.932, df = 3, <i>p</i> -value = 6.084e-06			
Years of Residence	Less than 1 year		13.64%
	1 - 5 years		28.13%
	6 - 10 years		32.10%
	11 - 15 years		26.14%
Employment Status	FULL TIME	55	15.63%
	Part-time	35	9.94%
	Self-employed	137	38.92%
	unemployed	125	35.51%
Chi-squared statistic = 87.136, df = 3, <i>p</i> -value < 2.2e-16			

As presented in **Table 5**, the socio-demographic profile of the survey respondents is based on five attributes (gender, age, education level, years of residence, and employment history). Each is broken into levels with associated frequency, percentages, and the chi-squared test results. With a focus on these attributes, for example, the age bracket, diverse assessment of the sensitivity of existing environmental problems can be carried out, and the approaches to communicating the risks and solutions among different age groups can be designed. Years of residence present an insight into the extent of exposure to the prevailing environmental problems across residents to how long a resident may have resided in the community. The education level of residents can also play an important role in the awareness and understanding of the existing environmental issues within the landfill. By tailoring mitigation schemes to accommodate varying levels of environmental knowledge, health sensitivity, and historical exposure, these factors guide the development of more effective, inclusive, and sustainable environmental strategies for addressing landfill impacts.

## 4. Discussion

### 4.1. Overview

This study researched and examined the environmental conditions existing at the Whein Town Landfill facility in Liberia, and an evaluation of the effectiveness of the mitigation measures that were structured to ameliorate the overall environmental status of the impacts of the landfill on the lives of the residents of the Whein Town Community. The targeted population was the household heads of

various families that have been residing in the community for at least a year. Background information of the community had identified major environmental problems like Landfill fires, Odorous emissions, Coloration of Water in wells, Dispersed smoke and garbage spillage along haulage routes, and the encroachment of rodents and insects into the community due to the closeness of the landfill to the community. The principal component analysis used in this research was meant to streamline the different aspects of the feedback from residents of Whein Town Community about the environmental conditions affecting them due to the Whein Town Landfill facility.

#### 4.2. Perceptions of the Environmental Problems Faced by the Community

The findings prove that garbage spillage along the major streets of Whein Town community was fairly serious. In similarity and according to [Njoku et al. \(2019\)](#), fifty-six percent (56%) of participants living far from the Thohoyandou landfill in South Africa indicated that garbage and litter on the street were a fairly serious problem. The research also indicated that the dispersed smoke in the community due to the presence of the landfill was an issue of concern. Smokes emitted from landfills may endanger human health, particularly among susceptible groups such as children, pregnant women, the elderly, and those with pre-existing morbidity conditions ([Roy et al., 2023](#)). This is particularly concerning given that smokes from landfills often contain volatile organic compounds (VOCs) and particulate matter. A graduate thesis by ([Kinuthia, 2012](#)) indicated that poorly managed Dandora Landfill in Kenya emitted substantial amounts of smoke and odors, leading to respiratory problems among nearby residents and school-going kids. Also, data from this research presented that the encroachment of insects and rodents due to the proximity of the landfill to neighboring communities is a fairly serious issue. Similarly, Insects like flies, mosquitoes, cockroaches, and also rodents were found to be more abundant near Siliguri landfill sites in India due to the closeness of the landfill to the communities ([Siliguri Times, 2021](#)).

**Figure 6** highlights odorous emissions and noise disturbances from machinery as major concerns for the residents of Whein Town. Landfills are highly associated with anaerobic decompositions of organic waste leading to odorous emissions due to the generation of complex mixtures of gases (volatile organic compounds, methane, carbon dioxide) ([Gao et al., 2021](#); [Lucernoni et al., 2016](#)). Studies on the Olusosun landfill in Nigeria highlight odorous emissions as a major concern for residents living in proximity. Similar to the Whein Town landfill, odors are attributed to the decomposition of organic waste, methane generation, and open burning of waste. Residents report experiencing headaches, nausea, and sleep disturbances due to the pervasive odor ([Olawoye et al., 2019](#)). This parallels the findings from Whein Town, where odorous emissions also contribute to discomfort and health concerns.

Also, as Whein Town residents are subjected to machinery noises from the

landfill site, research conducted for noise mapping found that the Klotto Landfill in Pojok, Kediri, Indonesia had high noise values due to ongoing work, and these values impacted nearby residents (Jawwad et al., 2022). The machinery-derived noises create a difficult environment for residents to relax, concentrate, or sleep at night leading to stress and health-related issues over time (Jawwad et al., 2022). The overall effect of these disturbances can also affect the value of properties in the vicinity of the landfill (Walsh & Mui, 2017).

Lastly, as shown in **Figure 3**, the coloration of wells in the Whein Town community is a fairly serious program due to the landfill facility. The change in water color in wells in landfill areas is driven by leachate contamination (Hredoy et al., 2022). At Al-Akeeder landfill in Jordan, leachate contamination of nearby wells resulted in water with high salinity, heavy metals, and microbial contamination (Aljaradin, 2012). The affected groundwater exhibited color changes similar to those in Whein Town, indicating that the issue is not geographically confined but rather associated with inadequate landfill leachate management worldwide (Baghanam et al., 2020; Teng et al., 2021).

### 4.3. Perceptions of the Mitigation Schemes/Measure at WTL

The second set of data, which involves the respondents' perspectives on the environmental measures at the landfill, was processed by the statistics test. This test is used to validate the different aspects of the respondents' opinions about the existing environmental schemes at the Whein Town landfill that are meant to remediate related environmental problems affecting the residents of the Whein Town Community. The first component of this test, the *p*-value, measures the numerical strength of the residents' views. This analysis is followed by the test statistics, which were used to evaluate the closeness or deviations of the responses from one mitigation scheme to another. These analyses show that fencing the landfill was an overwhelming success and it proves to be a remarkable remediation technique that helped solve environmental problems relating to landfills. The strategy of landfill fencing is a critical component of modern waste management strategy. Fencing around landfills can help landfill operators contain waste, reduce environmental impact, and comply with regulatory requirements (Kansanga et al., 2020; Mayer et al., 2021).

The fumigation scheme, even though not excellent, proves to be a success in reducing some of the prevailing environmental problems the residents of Whein Town are facing due to the landfill facility. Similarly, the Pugu Kinyamwezi Landfill in Tanzania, intermittently conducts fumigation to control pests, leading to fewer complaints from residents. This demonstrates the positive impact of fumigation programs on landfill-associated health risks (Kihampa, 2013). Fumigation eliminates pests in different environments and it is effective due to its ability to penetrate all areas where pests may reside (Oladejo & Otene, 2018).

Another mitigation scheme with a high rating shows that a significant amount of success was made with the drainage system or surface runoff control scheme.

This entails building drainages to control the surface runoff from the landfill into the communities, especially during the rainy season. The scheme seems to be a proven strategy as studies about the Malagrotta landfill in Italy show that the employment of engineered drainage and leachate collection systems helped to minimize water pollution (Barbieri et al., 2014). This demonstrates the effectiveness of integrated drainage management in mitigating environmental risks (Vaverková, 2019). By redirecting surface water through perimeter drains and other structures, landfills can keep leachate levels low, lowering the danger of groundwater pollution (Feng et al., 2021). Drainage systems play a crucial role in protecting water resources by controlling both water and leachate systems (Touze-Foltz et al., 2021) and it is a mandatory regulatory requirement (Akinnuli et al., 2019; Muheirwe et al., 2022).

Referencing the heatmap as seen in **Figure 6**, The environmental conditions at the Whein Town landfill as expressed by the residents of the Whein Town Community have been deteriorating due to the poor implementations of many of the mitigation schemes highlighted. The first variable is the covering of the garbage with soil. The low feedback from the residents shows that this mitigation strategy is in place but has been poorly implemented. Soil covering is a multifaceted technique that plays a crucial role in waste management. This method can help minimize leachate generation by reducing water infiltration into the waste (Vaverková, 2019). Research findings revealed that the absence of soil covering in Mbale Landfill in Uganda led to uncontrolled waste exposure (Turyahabwe et al., 2024), akin to Whein Town, while the Tampines landfill in Singapore employs daily soil covering to effectively reduce odor, pest proliferation, and leachate generation (ESG, 2024). Covering the garbage can help mitigate odors emanating from the landfill by acting as a physical barrier and promoting microbial activity that can degrade odorous compounds (Sharma et al., 2022).

The second variable is the alternative water supply which is meant to build water kiosks across the Whein Town community for the daily use of residents due to existing water-related pollution. Residents living near landfill areas face water supply-related challenges relating to the quality and availability of potable water (Danthurebandara et al., 2013; Siddiqua et al., 2022). Residents near the Payatas Landfill in the Philippines suffered water scarcity due to the lack of alternative water supply (Galing Pook, 2008; Wikipedia, 2024). while the communities near the Al-Akeeder Landfill benefitted from government-provided alternative water supplies reducing their reliance on potentially unsafe groundwater (ISEPEI, n.d.; Qdais et al., 2010). Diversifying water supply sources enhances resilience against water scarcity issues and provides a buffer during high demand or supply disruptions (Xu et al., 2019). Alternative water supply systems can foster community involvement and educate residents about sustainable water use encourage more responsible behavior and strengthen communities' ties. Adopting alternative water supply systems in landfill communities addresses immediate water needs and contributes to long-term sustainability, economic saving, and environmental

health (Al-Hazmi et al., 2024; Xu et al., 2019).

The third variable the residents opined as being poorly implemented is the Water treatment scheme for wells (periodic treatment of hand-dug wells) in the community. Hand-dug wells are vulnerable in landfill regions due to their shallow depths and susceptibility to contamination from surface water and nearby sources (Alao, 2023). Similar to Whein Town, Bhalswa residents near the Bhalswa Landfill in India lack access to water treatment systems, leading to prolonged exposure to contaminated drinking water (Times of India, 2022). Without proper treatment, these wells can become a conduit of waterborne diseases and expose consumers to health risks and chronic hazardous substances (Yadav & Negi, 2023). Treated wells ensure that the communities living near landfill regions have access to safe, clean water, reducing the incidence of disease and improving the quality of life (Schram & Wampler, 2018).

On the fourth count, the poor implementation of noise control systems is also a recipe for the many environmental problems at the Whein Town Landfill facility. This is similar to the Thohoyandou Landfill in South Africa where significant noise pollution is due to constant vehicular movement and landfill machinery, with no measures for noise abatement (Njoku et al., 2019). Landfills are associated with high noise from heavy machinery and other operational equipment (Roy et al., 2023). This leads to significant disturbances for residents and wildlife around landfill areas. Prolonged exposure to high noise levels can lead to hearing impairment, sleep disturbances, and increased stress among nearby residents (Jariwala et al., 2017). Noise control systems can help to mitigate these risks by reducing the intensity and spread of sound from landfill operations. Such systems might include sound barriers, enclosures for machinery, and strategic landscaping, all designed to absorb or deflect noise before it reaches residential areas (Mohamed et al., 2021).

The last poorly implemented mitigation scheme is the closure of the landfill. This would stop all operational activities on the landfill. Closing landfills helps mitigate adverse effects on nearby communities while restoring environmental health and public well-being (Vaverková, 2019). Closing landfills reduces pollution and improves community health and quality of life by reusing these sites as recreational spaces, parks, or solar energy installations, as these projects limit pollutants and eliminate the influx of waste (Aryampa et al., 2022). Unlike the Whein Town Landfill, the Smokey Mountain Landfill in the Philippines implemented its full closure plan due to prolonged environmental degradation and health impacts (ADB, 2016). Converting a former landfill into an ecological preserve or renewable energy project increases property values (Pehme & Kriipsalu, 2018; Szabó et al., 2017). It also lowers environmental risks by producing safer and more usable land. These improvements assist in transforming what was once an environmental and health hazard into a community development asset (Nochian et al., 2016).

## 5. Conclusion and Policy Recommendation

This research utilized principal components analysis (PCA) and a variety of

statistical tests to thoroughly analyze the perspectives of residents in the Whein Town Community, shedding light on the multifaceted impacts of landfill operations on local populations. The findings reveal that Whein Town is experiencing severe strain due to the rapid population growth and expansion in Paynesville and Monrovia. Initially intended to serve as a controlled municipal landfill, it has become overwhelmed by the volume of waste it receives, leading to serious environmental and public health issues.

Overburdened with a large quantity of waste, the landfill frequently experiences issues such as fires, garbage overflow onto community streets, odorous emissions, and rodent and insect encroachment. The health and safety of residents are further compromised by contaminated water in hand-dug wells, noise pollution from landfill machinery, and smoke dispersion, which affects air quality. These conditions collectively degrade the quality of life in Whein Town, disrupting daily routines and impacting physical and mental well-being.

Attempts to mitigate these issues have often fallen short, largely due to gaps in implementation and the need for improved management strategies. Current practices are inadequate for the level of waste and need urgent enhancement to establish a healthier balance between waste disposal operations and community welfare. This research highlights several practical mitigation strategies that, if implemented effectively, could significantly improve conditions around the landfill. Key recommendations include:

- Regularly covering waste with soil layers to control odors, deter pests, and reduce the visual impact of the site.
- Providing alternative, potable water sources to ensure residents have access to safe drinking water, thereby reducing reliance on potentially contaminated hand-dug wells.
- Building a drainage system to manage surface runoff, minimizing the risk of leachate contamination in local water sources.
- Periodic treatment of water sources like hand-dug wells to ensure that contaminants from the landfill do not compromise water quality.
- Implementing regular fumigation and pest control measures to tackle infestations of rodents and insects.
- Adopting noise control mechanisms to manage the operational sounds associated with landfill activities.

In the face of a continually growing population and the infringement on the ecological buffer zone, these recommendations aim to minimize the adverse effects of the landfill on the community's health and safety. However, if these strategies prove ineffective and the well-being of residents remains compromised, the study suggests that closure of the landfill should be seriously considered as a final alternative.

### **Credits Authorship Contribution Statement**

Duweh Sylvester Sarpee: Investigation, Methodology, Writing—original draft,

Visualization, Data curation; Alfred Santigie Turay: Conceptualization, Project administration, Methodology, Formal analysis, Writing—review & editing; Moses Kewullay Kamara: Conceptualization, Project administration, Methodology, Formal analysis, Writing—review & editing; Sarwee Joe-Wia Faeflen: Conceptualization, Project administration, Methodology, Supervision, Formal analysis, Writing—review & editing.

## Data Availability

Data will be made available on request.

## Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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