

Research Paper

Analysis of households' vulnerability to waterborne diseases in Yenagoa, Nigeria

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ABSTRACT

Waterborne diseases have serious implications for public health and socio-economic development; hence, this study analyzes households' vulnerability to waterborne diseases in Yenagoa. The study adopted the survey research design, which involves the administration of a structured questionnaire to 400 sampled households using the stratified and systematic sampling techniques, and direct field observation of households' drinking water, sanitation and hygiene facilities. Households' vulnerability to waterborne diseases was determined by households' response to five vulnerability drivers (drinking water source, sanitation facility, hygiene, education, and income). The obtained data were analyzed using descriptive statistics, Spearman's rank correlation and a waterborne disease vulnerability (WDV) model. The findings revealed that households in Yenagoa were moderately vulnerable to waterborne diseases as the calculated WDV was 55.65%. The Spearman's correlation coefficients for education with sanitation, drinking water sources and hygiene were 0.75, 1, and 0.6, respectively. This shows that the educational status of households is a major determinant of the choice of water source, sanitation, and hygiene practices. It is therefore recommended that much effort should be made by respective households and the government to improve on the quality of the vulnerability drivers, which have the capacity to reduce households' vulnerability to waterborne diseases in Yenagoa.

Key words | drinking water, hygiene, sanitation, vulnerability, waterborne diseases

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INTRODUCTION

Waterborne diseases commonly refer to infections which are predominantly transmitted through the consumption of, or contact with, infected water. There are several types of waterborne diseases which are transmitted by microorganisms, such as bacteria, protozoa and viruses. Waterborne diseases have been identified to be among the major causes of death globally (WHO 2015). The global health burden associated with waterborne diseases is huge, with serious implications for public health and socio-economic development. For instance, waterborne diseases in 2003 accounted for about 4% of the global burden of diseases and 1.6 million deaths yearly (WHO 2007). The

prevalence of waterborne diseases has been blamed on inadequate water, sanitation and hygiene (WASH), thereby acting as primary drivers for the transmission of waterborne diseases. Therefore, their improvement helps in the control of waterborne diseases and promotes household health (Orimoloye *et al.* 2015).

Due to the consequences of inadequate WASH, a large number of households are still vulnerable to waterborne diseases in Bayelsa State. For instance, a study by Duru *et al.* (2013) on the pattern and outcome of admissions in the Pediatric Emergency Ward in the Niger Delta University Teaching Hospital, Bayelsa State, from 2008 to 2011,

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revealed that of the 1,756 patients who were admitted, 1,386 (78.9%) of them were below the age of five. One of the major causes of the admissions was diarrhea, which accounted for 389 (22.2%) of the total admissions. In addition, of the 133 (7.6%) children who died, diarrhea accounted for 11.3% of the deaths. This shows that diarrhea exerts a health burden on the population of Bayelsa State.

The concept of vulnerability in this study means the degree to which an individual or household is exposed to the risk of being infected by waterborne pathogenic organisms. The primary drivers that determine the degree of households' vulnerability to waterborne diseases as earlier identified are water, sanitation and hygiene. The degree of households' vulnerability to these drivers can, however, be exacerbated by socio-economic variables such as education and income status of individuals or households. Hence, this study adopts five waterborne disease vulnerability drivers (water, sanitation, hygiene, education, and income status of households) to determine the degree of households' vulnerability to waterborne diseases in Yenagoa.

Vulnerability analysis is an important component of risk assessment, which involves delineating the places, human groups and ecosystems that are at most risk, the sources of such vulnerability, and how the risk can be ameliorated or eliminated (Department of Agriculture Environmental Affairs and Rural Development 2010). A review of the literature has shown that a number of past studies (Pathak 2015; Olowe *et al.* 2016; Halim & Haider 2017) have concentrated on the causes or impacts of waterborne diseases, with very limited attempts regarding the analysis of households' vulnerability to waterborne diseases. In fact, no such study has been found in Yenagoa. Studies of this nature would assist in understanding of the pattern and degree of households' vulnerability to waterborne diseases, which could enable policy-makers to take proactive measures in dealing with the prevalence of waterborne diseases. Hence, this study was designed to determine the degree of households' vulnerability to waterborne diseases in Yenagoa.

LITERATURE REVIEW

The level of households' vulnerability to waterborne diseases could be influenced by sanitation, drinking water source,

hygiene practice, education and income status of households. For example, studies have revealed that safe water provision at home could ameliorate or prevent waterborne diseases; while adequate sanitation can reduce the rates of diarrhea by 32% to 37% (Waddington & Snilstveit 2009). Hand washing with water and soap reduces the risk of endemic diarrhea, respiratory and skin infection, while face washing prevents trachoma and other eye infections (Bartram & Cairncross 2010).

A study by Njiru *et al.* (2016) on the relationship between sanitation and the prevalence of waterborne diseases in Kenya concluded that sanitation which includes hygiene significantly contributed to the prevalence of waterborne diseases in the study area and recommended the provision of adequate sanitation and capacity building on hygiene practices. In Nigeria, WSP (2012) reported that about 121,800 people (with 87,100 children under the age of five) die annually from diarrhea, with 90% of the deaths directly attributed to inadequate WASH. Also, Olowe *et al.* (2016) established a relationship between the prevalence of waterborne diseases with the quality of drinking water sources, which implied that the quality of available drinking water serves as a tool in determining the health status of a community. Fewtrell *et al.* (2005) carried out a systematic review and meta-analysis on water, sanitation and hygiene interventions to reduce diarrhea in less developed countries and concluded that diarrhea episodes were reduced by 25% through improving water supply, 32% by improving sanitation, 45% through hand washing, and by 39% via household water treatment and safe storage.

Pruss-Ustun *et al.* (2008) reported that the diseases associated with poor sanitation are particularly correlated with poverty and infancy, which alone accounts for about 10% of the global disease burden. A longitudinal study in urban Brazil revealed that the socio-economic status, poor sanitation conditions, absence of prenatal examination and presence of intestinal parasites were the major risk factors for diarrheal disease among children in the first three years of life. The study therefore recommended that to decrease the rate of diarrheal disease, intervention programmes should focus on the improvement of sanitary and general living conditions of the households (Genser *et al.* 2006). The literature review has shown that WASH is a major determinant of households' vulnerability to waterborne diseases, which can be influenced by the socio-economic status of households.

THE STUDY AREA

Yenagoa is a coastal settlement in the Niger Delta region of Nigeria. It is located within latitudes 4° 55' and 5° 02' north and longitudes 6° 15' and 6° 25' east (Figure 1). Yenagoa is the administrative headquarters of Bayelsa State. It lies on a coastal plain, with a mean height of about 15 m above sea level (Ohwo 2014). The city experiences a tropical monsoon climate with two major seasons, rainy and dry; with a mean monthly temperature of about 28 °C, relative humidity of over 70% and mean annual rainfall of about 3,000 mm. In spite, of the high influx of people to Yenagoa since it was made the capital of Bayelsa State, the provision of infrastructural facilities such as water and sanitation are still inadequate. Although there is an adequate stock of surface and groundwater resources in Yenagoa, access to potable water is still a great challenge (Ohwo & Abotutu 2014) due to the failure of government to develop the water resources to the benefit of the people. The dependence of some of the population on unimproved water sources and sanitation facilities could predispose them to waterborne pathogenic diseases, which could increase their level of vulnerability to waterborne diseases.

METHOD OF STUDY

The survey research design was adopted in this study, which involved the administration of a structured questionnaire to sampled households and direct field observation of households' WASH facilities in Yenagoa. In order to obtain a representative sample for the study, Yenagoa was classified into five zones using the 20 communities that make up the city. Each zone comprises four communities, from which 80 households were respectively sampled, making a total of 400 households, from an estimated population of 75,000 households in Yenagoa (Ohwo 2016). The 400 households were considered adequate for the study using the Krejcie & Morgan (1970) equation $[S = X^2 NP (1 - P) \div d^2 (N - 1) + X^2 P (1 - P)]$ for determining sample size from a given population, where S is required sample size; X^2 , table value of chi-square at d.f. = 1 for desired confidence level; N , the population size; P , the population proportion (assumed to be 0.50 since this would provide the maximum sample

size); and d , the degree of accuracy expressed as a proportion (0.05). The sample size of 400 represents 0.53% of the entire 75,000 households. The sampled households were identified using the systematic sampling technique at an interval of every five houses. This method was adopted because there was no distinct class structure (high, medium and low income households) in the respective communities. Therefore, every household was given an opportunity to be selected for the study.

The questionnaire was administered directly by hand to household heads (male or female) that were available when the household was visited. Data for the study were obtained from the responses to the administered questionnaire, which consists of two sections. The first section focused on demographic characteristics of the respondents, while the second section focused on the WASH characteristics of households. Questions in the second section were drawn based on the UNICEF & WHO (2015) WASH ladders, which classified the provision of these facilities from best to worst.

The data obtained were analyzed using descriptive statistics, Spearman's rank correlation and waterborne disease vulnerability (WDV) additive model. The model assessed the degree of vulnerability of households to waterborne diseases based on five waterborne disease vulnerability drivers (drinking water source, sanitation facility, hygiene, education, and income). Vulnerability weight of a scale of 1–4 was assigned to each of the parameters classified as low vulnerability (1), moderate vulnerability (2), high vulnerability (3), and very high vulnerability (4). The degree of vulnerability of households to waterborne diseases was expressed in percentage by the model. The higher the percentage the more vulnerable the household is to waterborne diseases. The WDV model is as follows:

$$DI = \frac{wdvi}{hwi} \times \frac{100}{1} \quad (1)$$

where

$$wdvi = \frac{\sum_{i=1}^n ni (wi)}{TN}; i = 1, 2, 3, 4 \quad (2)$$

WDV = waterborne disease vulnerability; $wdvi$ = waterborne disease vulnerability index; wi = vulnerability unit weight, a number between 1 and 4; hwi = highest vulnerability weight value, 4; ni = number of response to a

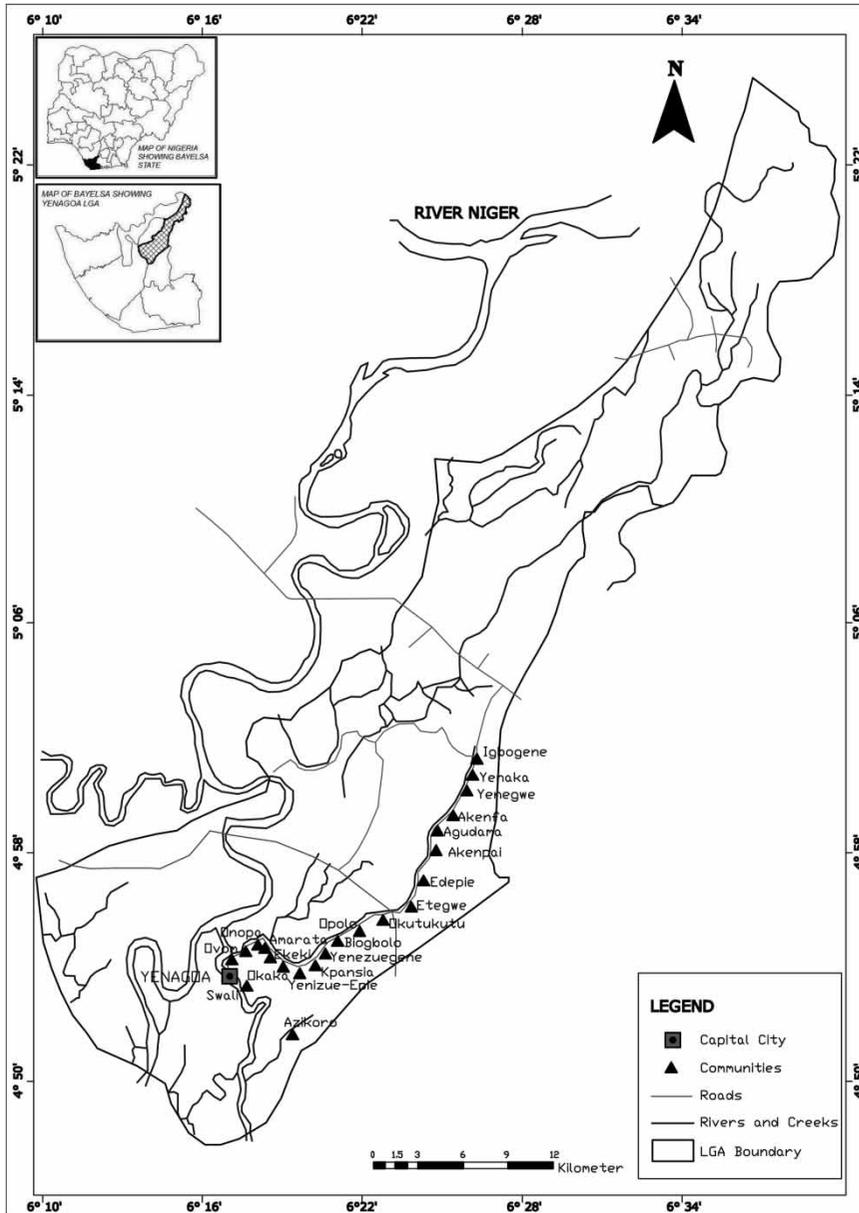


Figure 1 | Yenagoa local government area showing the study area. Source: Adapted from Koinyan *et al.* (2013).

vulnerability unit weight value (1–4) of each *i*th parameter, a number between 1 and 5; *TN* = total number of responses to all vulnerability unit weight values (1–4) of all *i*th parameters (1–5); and Σ = summation.

The interpretation scale of the model is as follows: very high vulnerability = 80–100%, high vulnerability = 60–79.99%, moderate vulnerability = 40–59.99%, and low vulnerability = below 40%.

RESULTS AND DISCUSSION

Demographic characteristics of respondents

The direct hand administration of the questionnaire made it possible to achieve 100% retrievals of the questionnaire. The demographic characteristics of the respondents, as presented in Table 1, revealed that 60% of the respondents

Table 1 | Demographic characteristics of respondents

Questionnaire variable	Response variable	Number of respondents	Percentage response (%)
Sex	Male	240	60
	Female	160	40
Age	18–30 years	82	20.5
	31–45 years	172	43
	46–60 years	111	27.75
	Above 60 years	35	8.75
Marital status	Married	232	58
	Single	148	37
	Divorced	4	1
	Widow/Widower	16	4
Household size	1–3 persons	165	41.25
	4–6 persons	150	37.5
	7–9 persons	55	13.75
	10 persons and above	30	7.5
Occupation	Civil service	52	13
	Self-employed	188	47
	Private sector	20	5
	Business	112	28
	Others	28	7

Source: Author's fieldwork, 2018.

are male, while 40% are female. The age distribution shows that 31–45 years had the highest (45%) response, while above 60 years had the lowest (8.75%) response. On the other hand, 18–30 years and 46–60 years had 20.5% and 27.75% responses, respectively, which shows that the population is probably youthful. Marital status of respondents shows that 58% and 37% are married and single, respectively, while 1% and 4% respondents were divorced and widow/widowers, respectively.

Household size with the highest (41.25%) response was 1–3 persons, while the lowest (7.5%) response was for 10 persons and above. On the other hand, households with 4–6 persons and 7–9 persons had 37.5% and 13.75% respondents, respectively. This shows that in the case of an outbreak of any infectious disease, household members may be at risk of contracting such an infection, especially when such a household has children below the age of five. The occupational distribution shows that 47% of the respondents are self-employed, 28% are in business, 13% are civil servants, 5% private sector, and 7% are engaged in other forms of occupation.

Waterborne diseases' vulnerability drivers

In order to determine the level of households' vulnerability to waterborne diseases in Yenagoa, five vulnerability drivers (drinking water sources, sanitation and hygiene facilities, education and income level) were used based on the review of the literature. The responses to these vulnerability drivers are presented in Table 2. Each of the sub-items under the respective vulnerability drivers were assigned a vulnerability weight (1–4), which means that as the value increases the degree of vulnerability equally increases. The five vulnerability drivers were used as proxy indicators for measuring the level of households' vulnerability to waterborne diseases in Yenagoa.

Drinking water sources

Since it was difficult to continuously measure the quality of each household's water supply, the major source of a household's drinking water was used as a proxy indicator for access to safe drinking water (UNICEF & WHO 2015) and the determination of a household's level of vulnerability to waterborne diseases. In addition, Koinyan *et al.* (2013) reported that 70% of households in Yenagoa do not treat their water before consumption.

Responses to this vulnerability driver show that 64% of the respondents used basic improved sources of drinking water. From direct field observation, it was revealed that boreholes and protected wells were the major water sources. This response is in-line with the findings by Ohwo (2016) that 51.95% of respondents use boreholes as one of their major sources of water supply in Yenagoa. Although 64% of the respondents used basic improved water sources, only 20% of respondents used a basic drinking water source that is located on their premises. On the other hand, 16% of the respondents still used unimproved and surface water sources for drinking. These sources, which include rivers, lakes, unprotected dug wells and carts with small tank/drum (Table 2), are veritable sources for the consumption of contaminated water, which could cause waterborne diseases. The percentage of those that still use these unimproved drinking water sources has improved when compared to the findings by Ohwo (2014) that 61.18% of respondents indicated that the sources of their major water supply was inadequate.

Table 2 | Responses to quality categorization of waterborne disease vulnerability drivers

S/N	Waterborne disease vulnerability drivers	Vulnerability weight (1-4)	No. of responses (%)
1	Drinking water sources		
a	Surface water: River, dam, lake, pond, stream, canal or irrigation channel	4	24 (6)
b	Unimproved: Drinking water from unprotected dug wells, unprotected springs, carts with small tank/drum, tanker trucks or basic sources with a total collection time of more than 30 minutes for a roundtrip including queuing	3	40 (10)
c	Basic: Piped water, boreholes or tube wells, protected dug wells, protected springs and rainwater provided collection time is not more than 30 minutes for a roundtrip including queuing	2	256 (64)
d	Safely managed: A basic drinking water source which is located on premises, available when needed and free of fecal and priority chemical contamination	1	80 (20)
2	Sanitation facilities		
a	Open defecation: Human feces disposed of in fields, forest, bushes, open bodies of water, beaches or other open spaces or disposed of with solid waste	4	44 (11)
b	Unimproved: Pit latrines without a slab or platform, hanging latrines and bucket latrines	3	44 (11)
c	Shared: Sanitation facilities of an otherwise acceptable type shared between two or more households	2	100 (25)
d	Improved: A basic sanitation facility which is not shared with other households and where excreta are safely disposed <i>in situ</i> or treated off-site; flush/pour flush to piped sewer system, septic tank or pit latrine, ventilated improved pit latrine, composting toilet or pit latrine with a slab not shared with other households	1	212 (53)
3	Hygiene facilities		
a	No facility: No hand washing facility	4	72 (18)
b	Unimproved: Hand washing facility without soap or water	3	36 (9)
c	Basic: Hand washing facility with soap and water in the household most times	2	116 (29)
d	Safely managed: Hand washing facility with soap and water in the household always	1	176 (44)
4	Education status		
a	No formal education	4	44 (11)
b	Primary (primary school leaving certificate)	3	52 (13)
c	Secondary (WAEC, GCE, NECO)	2	172 (43)
d	Tertiary (OND, NCE, HND, Degree, Masters, PhD)	1	132 (33)
5	Monthly income status		
a	Very low (below N50,000)	4	204 (51)
b	Low (N50,000–N99,999)	3	108 (27)
c	Medium (N100,000–N249,999)	2	40 (10)
d	High (above N250,000)	1	48 (12)

Source: Author's fieldwork, 2018.

Sanitation facilities

Table 2 also contains responses to sanitation facility as a waterborne disease vulnerability driver. UNICEF & WHO (2015), in the design of their sanitation ladder classified

open defecation, unimproved pit latrines and shared sanitation facilities as unimproved sanitation. Based on this classification, 47% of the respondents used unimproved sanitation facilities, which is higher than the world average of 32%, but lower than the Nigerian and sub-Saharan Africa

averages of 71% and 70%, respectively (UNICEF & WHO 2015). The direct field observation revealed that the most commonly used unimproved sanitation facilities in Yenagoa are defecation into open bodies of water, bushes, pit latrines without a slab, and sharing of an otherwise acceptable facility with two or more households in a compound. This shows that some of the inhabitants are exposed to infections, which could cause waterborne diseases. On the other hand, 53% of the respondents used improved sanitation facilities, which was less than the 67.3% that was reported for Ibadan (Orimoloye *et al.* 2015). The most commonly used sanitation facilities in Yenagoa are flush/pour flush to piped sewer system, pit latrine, and ventilated improved pit latrine which are not shared with other households. These sanitation facilities ensured that excreta are safely disposed of *in situ* or treated off-site. This practice reduces the chances of getting infected by pathogenic bacteria that can cause waterborne diseases.

Hygiene facilities

Water and sanitation improvements alone do not guarantee good health, unless adequate hygiene facilities are provided and frequent hand washing practiced. For instance, studies have shown that frequent hand washing alone, with and without soap, can reduce the incidence of diarrhea up to 33%. The importance of adequate water and hygiene practice was also emphasized in a study in Gaza (UNICEF & PHG 2010) that 'due to poor water quality and hygiene practices, one in five households (20%) had at least one child under the age of five who had been infected with diarrhea in the four weeks prior to being surveyed'. Hence, hand washing acts as a barrier to the transmission of infectious diseases and is a good indicator for determining household vulnerability to waterborne diseases. Since it was not possible to continuously monitor all households' hygiene practices, the presence of hand washing facilities with soap and water was used as a proxy indicator for good hygiene practice because availability of hand washing facilities was associated significantly with hygiene practice (Yallew *et al.* 2012). This proxy indicator has also been used by UNICEF & WHO (2015) for good hygiene practice.

Responses to hygiene facilities in households revealed that 73% of the respondents had hand washing facilities

with soap and water in their respective homes, either always (44%) and most times (29%); while 18% had no hand washing facility, and another 9% of respondents had unimproved hand washing facility without soap or water. The presence of hygiene facilities in the home may promote the act of hand washing, which could promote good health and reduce households' vulnerability to waterborne diseases. For instance Yallew *et al.* (2012) stated that those who do not have hand washing facilities are 8.7 times more likely to have poor hygiene practice compared to those who have hand washing facilities in their homes. The number of households with adequate hygiene facilities in Yenagoa is low when compared to Ibadan, where 92.9% of the respondents practice frequent hand washing (Orimoloye *et al.* 2015).

Education status

The educational status of respondents was considered a waterborne disease vulnerability driver because educated persons are more likely to access information on the causes and preventive methods of infectious diseases and take proactive measures to avoid being affected. This means that the higher an individual's educational status the less likely they are to be vulnerable to infectious diseases. This assertion is supported by past studies which showed that educational status is associated significantly with hygiene practice of individuals. For instance, Yallew *et al.* (2012) concluded that literate individuals are 2.4 times less likely to have poor hygiene practice than those who are illiterate. Similar conclusions were also reached by Bajracharya (2005) and Phaswana-Mafuya (2006) in their respective studies in Myanmar and South Africa.

The educational status of respondents in Table 2 revealed that 33% of the respondents had tertiary education, while 43% had secondary education. This shows that 76% of the respondents are literate enough to access information on the causes and preventive methods of infectious diseases. On the other hand, 13% and 11% of respondents have primary and no formal education, respectively. These groups of respondents are more likely to depend on a third party to get information on the causes and preventive methods of infectious diseases, which may increase their degree of vulnerability.

Monthly income status

The income status of households to some extent determines the nature of WASH provision. The availability of these facilities positively influences the sanitation and hygiene behavior of members of a household and promotes sustainable maintenance of the facilities, which could reduce the degree of vulnerability to waterborne diseases. Responses to monthly income in Table 2 revealed that 12% of respondents earned above N250,000, while 10% earned between N100,000 and N249,999. Another group of 27% and 51% respondents earned between N50,000 and N99,999 and below N50,000, respectively. This shows that the majority of the respondents are low income earners, who may have challenges in providing adequate WASH facilities in their respective homes. Hence, Yallew *et al.* (2012) in their study in Gondar City, Ethiopia, noted that economic reasons for the provision of soap are associated significantly with hygiene practices.

Calculated households' vulnerability to waterborne diseases in Yenagoa

Using the WDV model and the data in Table 2, households' vulnerability to waterborne diseases in Yenagoa was determined and presented in Table 3. The total weight value of each of the five vulnerability drivers was calculated and ranged from 764 to 1,268 points. The vulnerability driver with the highest total weight (1,268) based on the model specification was income status of households, while sanitation facilities of households' had the lowest total weight value

Table 3 | Calculated households' vulnerability to waterborne diseases in Yenagoa

Vulnerability drivers	ni (4)	ni (3)	ni (2)	ni (1)	Total weight	TN
Drinking water source	96	120	512	80	808	400
Sanitation facility	176	176	200	212	764	400
Hygiene facility	288	108	232	176	804	400
Education status	176	156	344	132	808	400
Income status	816	324	80	48	1,268	400
Total	1,552	884	1,368	648	4,452	2,000

$wdvi = 4452/2000 = 2.226$

$$WDI = \frac{wdvi}{hwvi} \times \frac{100}{1} = \frac{2.226}{4} \times \frac{100}{1} = 55.65\%$$

(764). This means that the income distribution of households in Yenagoa was low and exerted a drag on the overall calculated vulnerability of households to waterborne diseases. The calculated waterborne diseases' vulnerability index (WDVI) which integrates the total weight values of the vulnerability drivers was 2.226, on a four-point scale. Substituting the WDVI value (2.226) into the model, the calculated WDV of households in Yenagoa was 55.65%. Using the WDV interpretation scale as stated in the method of study, households in Yenagoa were moderately vulnerable to waterborne diseases. Also using the data in Table 2, the calculated Spearman's correlation coefficients for education with sanitation, drinking water sources, and hygiene were 0.75, 1, and 0.6, respectively; while for income with sanitation, drinking water sources and hygiene were -0.65, -1, and -0.6, respectively. This shows that as education level increases, households' sanitation and drinking water sources improve, respectively, which has reduced the impact of income level on households' used WASH facilities in Yenagoa. However, in the long run, adequate finance is required for sustainable management of WASH facilities, which would help to reduce households' vulnerability to waterborne diseases.

CONCLUSION

The analysis of households' vulnerability to waterborne diseases has revealed that households in Yenagoa are moderately vulnerable to waterborne diseases as the calculated WDV was 55.65%, which lends credence to the diarrhea prevalence rate of 22.2% in Bayelsa State (Duru *et al.* 2013). The income level of households in Yenagoa exert a drag on the calculated WDV based on the model specification because it had the highest total weight of 1,268 points, while sanitation facilities of households contributed the lowest drag with 764 points. This shows that the average income distribution of households was low and the least rated of the vulnerability drivers in Yenagoa. However, this is not to conclude that income level of households is the most important determinant in the choice of households' WASH facilities in all circumstances. The calculated Spearman's correlation coefficients for education with sanitation, drinking water sources, and hygiene were 0.75, 1, and 0.6, respectively. This shows that educational status of

households is a major determinant in the choice of WASH facilities of households in Yenagoa.

The calculated WDV (55.65%) for households in Yenagoa is an indication that much still needs to be done to further reduce this value to low vulnerability. To achieve this, the Ministry of Water Resources should provide pipe-borne water to unconnected households to improve access to potable water in Yenagoa. Also, aggressive campaigns and education on households' provision of adequate WASH facilities should be undertaken by the relevant ministries. These measures could reduce the level of households' vulnerability to waterborne diseases in Yenagoa.

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