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Impact of Improper Municipal Solid and Liquid Waste Management on the Health of Internally Displaced Persons (IDPs) in Maiduguri, Borno State.

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Abstract

Waste mismanagement has exacerbated to the spread of diseases and vectors in Maiduguri Internally Displaced Persons (IDP) camps. While previous studies have linked solid waste management to disease prevalence, limited attention has been given to liquid waste, which presumably have a more direct impact on health. This study therefore examined (i) solid waste management (ii) liquid Waste Management and (iii) their combined effects on the health of IDPs. A mixed research approach, involving physical measurement, personal observations, focus group discussion and structured questionnaires was employed to determine the quant of waste generated, improper collection and disposal and its effect on disease prevalence among IDPs between September 2020-August, 2021. Findings revealed approximately 99% of solid and 11.3% of liquid waste generated were improperly collected while 65.11% of solid and 78.65% of liquid wastes were improperly managed, leading to 251,957 incidences of disease. Multiple regression analysis between improper solid and liquid waste management and IDPs disease prevalence showed a weak insignificant relationship. Whereas solid waste mismanagement alone showed a negative relationship with disease prevalence, liquid waste mismanagement indicated a weak positive relationship with disease incidence. The study concludes that the high prevalence of disease were not solely caused by improper solid and liquid waste management, other environmental and personal hygiene factors also contributed. It recommends integrating of waste management action plans and periodic assessment of waste management impacts into camp planning in addition to continuous medical intervention like outreach programme.

Keywords: Impact, Improper, Solid and Liquid Waste Management, Health, Internally Displaced Persons.

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Introduction

Maiduguri Internally Displaced Persons (IDPs) lived in severe overcrowded living spaces (2m2) that were previously 20 times lower than acceptable standard for camp refugees (ECHO, 2019). According to the Sphere Association (2018), the acceptable standard is 3.5m2-5.5m2 per person for living space and 20 persons per toilet. In Maiduguri, the living space and toilet ratio to IDP population is less than 1.5m2 per person and 477-159 IDP per toilet (Owoseye, 2019; Asaku, 2022) making the living condition favourable for the spread of contagious disease (Hamza, 2022; Jaber et al. 2023; Ofre et al., 2024). Due to overcrowding, municipal solid and liquid waste generated is improperly collected and managed and improper managed have promoted the frequencies of fire and disease outbreaks (Olugbode, 2020; Ofre, et al., 2024) while stagnant water in the neighborhood provided breeding ground for malaria parasites (Ofre, et al., 2024). The frequent incidences of water sanitation and hygiene –related disease outbreaks like Cholera, malaria, typhoid, diarrheal, and many others in camps where personal and environmental hygiene is at its lowest ebb (Hamza, 2022) suggest that improper municipal waste management may be a contributing factor hence its consideration since waste is evacuated only when trucks are available, not necessary when adequate quantity are gathered.

Municipal solid and liquid waste are major contributors to environmental pollution globally (World Bank, 2025). Solid waste refers to discarded materials no longer in use (Ofre, et al., 2024) while liquid waste includes domestic sewage, industrial effluence and toxic substances generated at home and work places (Omani, 2021). Both forms of waste pose significant environmental and public health risks, particularly in vulnerable settings like Maiduguri IDP camps. Globally, environmental risk factors account for approximately 12.6 million deaths annually and these factors include physical, chemical and biological hazards (Prüss-Ustün et al., 2016). Solid and liquid waste are considered primary risk factors because their generation, collection and management using evacuation, burning, composting, burying, disinfection, sedimentation, dewatering and solidification constitutes an environmental risk (Ziraba et al., 2016; Omani, 2021; Omani and Acakpovi, 2022; Ofre, et al., 2024).

Internally Displaced Persons (IDPs) are individuals forced to relocate within their country due to conflict or disasters (Adamu and Rasheed, 2016). Camps in Maiduguri have evolved into densely populated settlements with limited infrastructure, making them highly susceptible to environmental health challenges (Olugbode, 2020; Ofre et al., 2024). Previous studies have shown that approximately 70% of municipal Solid Waste (MSW) generated in these camps is improperly collected and disposed of (Ofre et al., 2024). While solid waste has been widely studied, liquid waste management, despite its closer link to waterborne diseases remained underexplored. Poor sanitation facilities, overcrowding, and inadequate water supply have further worsened the health risks in these camps (Jaber et al., 2023). Despite the frequens re-ocurrence of sanitation and hygiene-related ailments in these camps, the relationship between both solid and liquid waste mismanagement with disease prevalence has not been insufficiently examined hence the need for this study.

This study will address this gap by assessing the relationship between municipal solid and liquid waste management with the health of IDPs in Maiduguri before their relocation and resettlement in 2021. Further more, the statisstical significance of the relationship between solid waste management and disease prevalence, liquid waste management and –disease prevalence or both will attest whetter or not the occurrence of water sanitation and hygiener-related disease in the study area happened by chance or due to improper waster management.

Literature Review

Municipal Solid Waste Management

Municipal Solid Waste Management (MSWM) refers Municipal Solid Waste Management (MSWM) refers to the collection, evacuation and disposal of urban solid waste (Ziraba, et al., 2016). Solid waste collection, evacuation and disposal methods like burning, evacuation, burying and composting have been recorded in municipalities and IDP camps (Lim et al., 2016; Onazi, et al., 2018; Ofre et al., 2024). MSW management is the most persistent environmental challenge confronting urban and rural areas in Nigeria. Due to the aforementioned, only about 70-80% of the quantity generated is neither collected and nor disposed (Bakare, 2021), leading to an environmental catastrophe (Ziraba, et al., 2016). The United Nation Development Project (UNDP, 2016) reported waste and debris assessment for North-East Nigeria including IDP camps. The Report shows MSW were collected in bins and subsequently transferred to collection trucks (UNDP, 2016). Onazi et al. (2018) studied waste management characteristics of selected IDP camps in Maiduguri using survey method. The study reported the use of dustbins and disposable refuse bags for solid waste collection and storage while (Caprecon 2018; Al-Khatib et al., 2021; Ofre et al., 2024) separately confirmed MSW collection

in IDP camps in Nigeria.

Collected MSW can be disposed using burning, evacuation, burying and composting. Evacuation refers to the transportation of collected waste from collection to disposal sites within or outside the camps. This practiced in Maiduguri IDP camps have been recorded by (UNDP, 2016; Ofre et al., 2024) using evacuation trucks. Although waste burning was not officially embraced by authorized agencies concerned with waste management, such as the Borno State Environmental Protection Agency (BOSEPA), Water Sanitation and Hygiene (WASH), United Nation Children Emergency Funds (UNICEF) and International Office on Migration (IOM) due to its hazards in over congested camps where several incidences of fire outbreaks have been reported (Olugbode, 2020) however, intensive waste burning have been practiced officially and unofficially in schools, health facilities and markets (Onazi, et al., 2018; Khatib et al. 2021; Ofre et al., 2024).

MSW composting involves the spontaneous biological decomposition of organic matter leading to a reduction in quantity and subsequent formation of soil nutrients (Lim et al., 2016). Composting has been reported in Maiduguri camps located toward the outskirts for organic manure production (Ofre et al., 2024). MSW burying has also been practiced officially and unofficially (Caprecon, 2018; Onazi, et al., 2018; Ofre, et al., 2024). Officially, MSW was buried in trenches at Dalori IDP camp while the unofficial disposal was practiced by schools, clinic, marketers and IDPs. Municipal solid waste was mostly buried in broken pit toilets, broken and abandoned suck away pits, rectangular and circular shallow and deep pits of various sizes were used for burying (Ofre, et al., 2024).

Municipal Liquid Waste Management (MLWM) in IDP Camps

Municipal Liquid Waste Management (MLWM) refers to the planned process of cautious assembling, handling, treatment and disposal of liquid waste with the intent of protecting the health of the people, prevent environmental contamination and disease outbreak (Omani and Acakpovi, 2022). Liquid waste comprises domestic sewage, industrial effluence and toxic substances generated at home and workplaces which can best be managed by prevention, reduction, consistent and proper physical, chemical and biological treatment before disposal under suitable sanitary condition in safe places (Omani, 2021). MLWM treatments include disinfection, evacuation, sedimentation, dewatering, composting, incineration and solidification (Omani, 2021; Omani and Acakpovi, 2022). In Maiduguri IDP camps, MLW refers to faeces in toilets and dumpsites as well as dirty water from showers, hand washing, storage containers, cooking and the washing of plates and clothes.

In Maiduguri IDP camps, the few available Water Sanitation and Hygiene (WASH) facilities have been overwhelmed and outbreaks of WASH-related disease have been reported (Hamza, 2022). The lack of a systematic and well-coordinated liquid waste collection, treatment and handling, improperly and irregularly practices of MLW evacuation (Jaber et al., 2023) have led to food, water and waste contamination of the environmental. Irregular evacuation of filled toilets, poor cleaning of spilled toilet content during evacuation and openly defecation have been recorded in Maiduguri camps (Jaber et al., 2023; Ofre, et al., 2024). In one of the camp, Jaber et al. (2023) examined environmental, social, water sanitation and hygiene (WASH) factors affecting the recurrence of cholera outbreaks in Borno State IDP camps using semi-structured interviews, participatory transect walks and field observations. The results shows most camps have inadequate latrines compared to the minimum international humanitarian standard for emergency (Sphere Association 2018) due to overcrowding. Also, Jaber et al. (2023) reported post-collection water contamination due to poor water storage triggered by scarcity.

In view of the overcrowding, most of the sanitation facilities provided were not hygienic leading to the practice of open defecation (Jaber et al., 2023) which negatively affected the health of IDPs. Also, in order to monitor the progress of infrastructure and personal hygiene, Asaku (2022) assessed emergency WASH response in Borno State IDPs camps where a humanitarian project propose to rehabilitate 150 showers, construct 200 latrine and evacuate 250 emergency latrines for 71,575 returning IDPs. From the proposal, each shower and toilet was offered to 477 and 159 IDPs making the shower and toilet allocation a nightmare thereby encouraging the practice of open defecation (Asaku, 2022). Finally, the practice of open defecation in flooded IDP camps where the few available WASH infrastructure has been overstressed, overused and destroyed (Jaber et al., 2023; Ofre, et al., 2024) will help to promote the occurrence and recurrence of disease hence the need for the study.

Environmental Health associated with Solid and Liquid Waste in IDP Camps

Both contagious and non-contagious infections and diseases like malaria, typhoid, eye infection, flu, asthma and HIV/AIDs have been reported in Maiduguri IDP camps (Caprecon, 2018; Ofre et al., 2024). Maiduguri IDPs lived in the neighborhoods of solid and liquid waste dumpsites. Their vicinity is littered with stagnant water which boosts the breeding

and spread of mosquitoes and other disease-causing vectors (Ofre, et al., 2024). In these camps, solid and liquid waste have been collected and disposed in toilets, broken and abandoned toilets, concrete and earthen pits, on streets and stagnant waters (Ofre, et al., 2024). These dumpsites inspired and heightened incidences of fire and disease outbreaks in severely overcrowded camp environment (Olugbode, 2020; Ofre, et al., 2024) leading to detrimental environment and public health impacts. Hamza (2022) observed increasing outbreaks and spread of water sanitation and hygiene-related diseases in Borno state IDP camps while Jaber et al. (2023) recorded open defecation and post-collection water contamination due to scarcity. Asaku (2022) reported the sharing of one shower and toilet by 477 and 159 IDPs respectively while Owoseye (2019) reported the designation of one unhygienic toilet to 466 IDPs making the situation unhealthy and unhygienic. These unhealthy and unhygienic situations in camps where water sanitation and hygiene related diseases have been increasingly reported (Hamza, 2022) can exacerbate the health of IDPs living in camps.

Prüss-Ustün et al. (2016) documented a World Health Organization (WHO) global assessment of the disease burden from environmental risks. The study estimates that 12.6 million of all deaths globally were attributable to the environment risk which comprises of the physical, chemical and biological manmade factors external to a person (Prüss-Ustün et al., 2016). Solid and liquid waste in their entirety constitute an environmental risk (Ziraba et al., 2016; Omani and Acakpovi, 2022). Before their relocation and resettlement, incidences of cholera, HIV and AIDs, Tuberculosis (TB), skin infections, measles, chicken pox, vomiting, fever, diarrhea and measles were recorded (Caprecon, 2018; ECHO, 2019; Owoseye, 2019; Olugbode, 2020) most of which are linked to improper solid or liquid waste management (Hamza, 2022; Ofre et al., 2024) hence the need for this study to determine the extent of relation between waste management and ill-health in the study area.

Methodology

Study Area and Methodology

Study Area

In addition to being the capital of Borno state, Maiduguri is the most developed place in the state located between Latitude 11° 50’ 22”N of the equator and Longitude 13° 9’ 13”E of the Greenwich Meridian (Onazi et al., 2018). Maiduguri Township is divided into Maiduguri Metropolitan Council (MMC), Jere Local Government Council and Konduga Local Government Area (LGA).

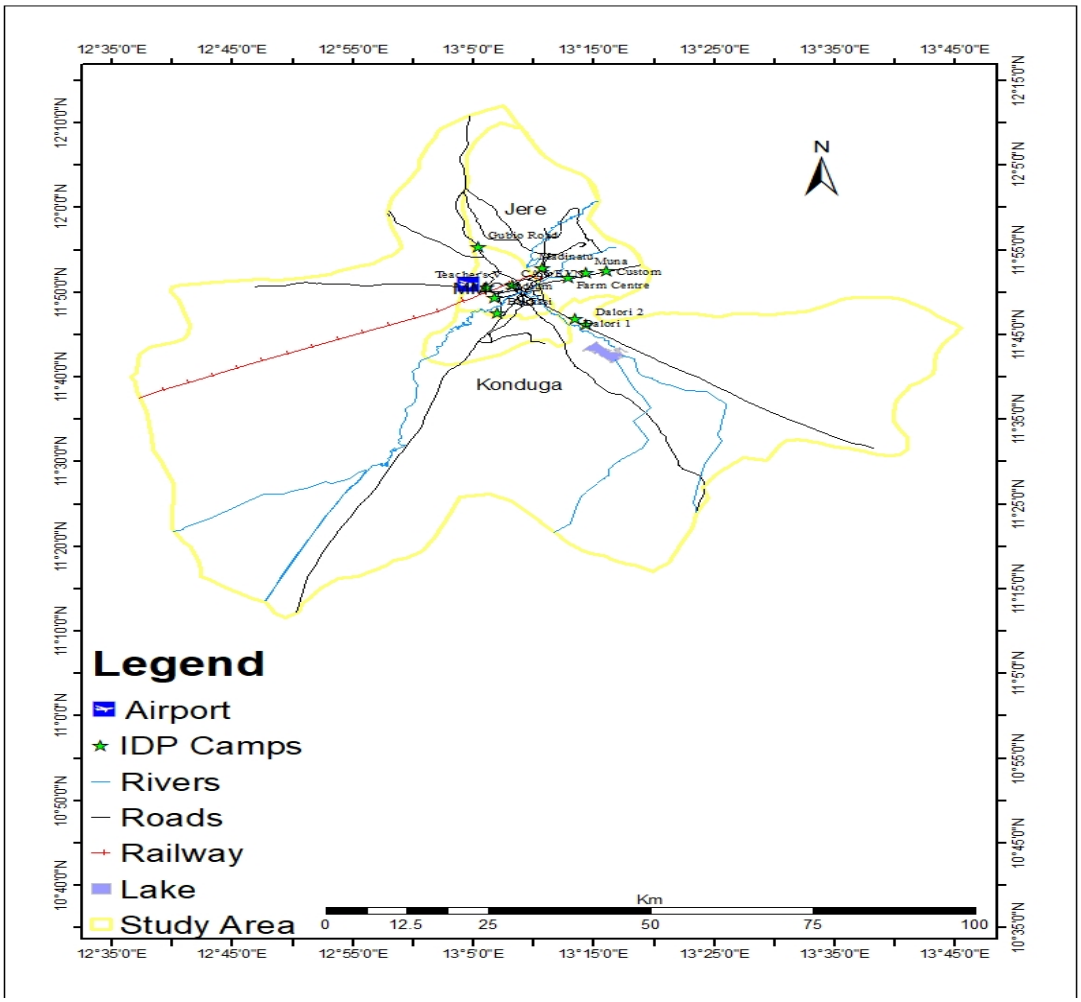

Figure 1: Study Area

Source: Field Work, 2021

More than 1.6 million persons were displaced by Boko Haram terrorist from 2009-2020 (Onifade & Osinowo, 2019). Displaced persons came from 21 out of the 27 Local Government Areas (LGA) in the state to Maiduguri and its environs to seek refuge because security in these places were adjudged impassable (Yakubu et al., 2015). The mass movement of displaced people trooping into Maiduguri and LGA secretariats led to their reception and accommodation in available places which later became Camps. Borno IDPs were officially accommodated in 24 camps and 14 of these camps were located in Maiduguri while others were at LGAs secretariats (Isa, 2021). Until IDP's relocation and resettlement in November 2021, unofficial camps were managed by NGOs in collaboration with the government (Njoku, 2020; Olugbode, 2020).

Methodology

Nine official and two unofficial IDP camps in MMC, Konduga and Jere LGA of Borno State were selected and studied using personal observations, quantitative physical measurement, Focus Group Discussions (FGD) and structured questionnaires. The camps in MMC LGA are Bakassi, Stadium, Gubio Road, CAN/EYN and Teachers Village. Dalori 1 and Dalari 2 are in Konduga LGA while Farm Centre, Custom, Madinatu and Munna Elbadawy camps are in Jere LGA as shown in Figure 1. The study period was September 2020 to August, 2021. Samples of solid and liquid waste generated from 3 selected IDP households, one school, clinic, skill acquisition center and markets in each camp were collected over a period of 16 separate days, cutting across the dry and wet season. Waste samples were collected using plastic buckets and quantitative physical measurement was done using measuring tanks or weighing scale to determine the daily rate from each source. From these data, an estimated average daily generation rates in kg for solid and M^3 for liquid waste was obtained. From these daily averages obtained, 30 minutes single session FGD was organized with 10 waste generators, 5 waste managers and 5 camp managers to harmonize their supposition with the quantitative generation results computed as a means of validation. From the

FGD validated process, the average daily, weekly, monthly and yearly quantities of waste generation ware computed.

To determine the Municipal Solid and Liquid Waste (MSLW) collection pattern, each collection points (CP) was physically observed and recorded while their coordinates were obtained using a Global Positioning System (GPS). The coordinates of CP were computed in Microsoft excel, imported into ArcGIS and overlaid on the study area using map overlay to prevent duplication. From the number of CPs obtained, classification was done based on the number of approved CPs provided by camp managers for each camp. From the harmonize result, classified solid waste collection sites were ranked with IDP population to obtain the pattern as shown in table 1. Having determined solid waste collection pattern, another FGD was granted to waste generators and camp management to determine authorized waste managers (BOSEPA, IOM, UNICEF, WASH) and the un-authorized waste managers (IDPs, Schools and Hospital management, Skill acquisition Centre, camp Managers and Markets).

Based on the results obtained from the second FGD, the sample size (400) of waste managers was obtained using Yamane (1967) formula. From the sample size, 24 structured questionnaires were administered to 24 clinics while 376 questionnaires were proportionate administered to authorized and un-authorized waste managers apart from health personnel in 11 camps as shown in table 2, 3, 4 and 5 respectively. The questionnaire administered contained four sections. Section "A" quantity municipal liquid waste collection in each site while section "B" estimates the quantity of liquid waste managed under each technique. Section "C" estimates the quantity of solid waste managed under each technique while section 'D' estimates the prevalence of sanitation-related ailments in the study area as shown in figure 2. Section A-D of the questionnaire was administered to clinics while section A-C was given to others waste generators managers apart from health personnel.

The quantity of solid and liquid waste not/or improperly managed was obtained from subtracting quantity generated from the quantity managed properly in each camp as shown in table 6 while the relationship between improper solid and liquid waste management with prevalence of sanitation-related ailments was obtained using multiple regression analysis in Statistical Package for Social Science (SPSS) as shown in table 7.

Ethical Consideration and Approval: Ethical approval for the study was obtained from relevant authorities including the National Emergency Management Agency (NEMA) Borno State chapter, the Borno State Emergency Management Agency (SEMA), State Primary Healthcare Development Agency, Borno State Ministry of Women Affairs and Alliance for International Medical Action (ALIMA) clinic. Participation was based on informed consent of the camp management, NGO's representatives, IDPs and BOSEPA

Results/Findings

Municipal Solid Waste Collection Pattern in IDP Camps

Municipal solid waste collection sites on the earth surface, stagnant water, pits and central collection points were collected were using personal observation and GPS. These points were counted, ranked and compared with the population of each camp to determine the collection pattern as shown in table 1 below.

Table 1: MSW collection Pattern in IDP Camps

S/N	Name Of Idp Camp	No. Of Approved Solid Waste Collection Points	No. Of Unapproved Solid Waste Collection Points	Total No. Of Solid Waste Collection Points	Idp Population	Ranks Of Idp Population	Ranks Of Msw Collection Points
1	Madinatu	2	122	124	21,027	5th	4th
2	Farm Centre	2	124	126	23,782	4th	3rd
3	Munaelbadawy	2	191	193	49,922	1st	1st
4	Custom	2	111	113	9,605	10th	5th
5	Dalori 1	1	86	87	19,649	7th	7th
6	Dalori 2	1	108	109	13,157	9th	6th
7	Gubio Road	1	167	168	33,322	3rd	2rd
8	Teachers' Village	1	57	58	19,880	6th	10th
9	Stadium	1	66	67	18,151	8th	9th
10	Bakassi	1	68	69	41,865	2nd	8th
11	Can/Eyn	1	3	4	400	11th	11th
	Total	**15**	**1,103**	**1,118**	**250,770**		

Source: Field Survey, 2021

It was observed from table 1 that Madinatu, Farm Centre, Muna Elbadawy and Custom camps have 2 approved collection sites each while the remaining camps have 1 approved collection points each. Also, from table 1, 15 approved and 1,103 unapproved camps were observed making a total of 1,118 points. The high number of MSW collection points suggest that the pattern of collection was improper. This result agrees with Ofre *et al* (2024) who observed that 69.6% of the total MSW collection points in Maiduguri IDP camps were unapproved. With the exception of Muna Elbadawy and CAN/EYN camps whose IDP population were proportional to the number of collection points, the remaining camp shows an inverse relationship. The inverse relationship between IDP populations and the frequency of collection points in each camp confirmed improper collection pattern which can increase incidences, severity and circle of infection of disease in the study area.

Municipal Solid Waste (MSW) Management Techniques in IDP Camps

The quantities of MSW generated and managed in each camps using different techniques was obtained from section B of the structured questionnaires administered to 400 respondents as shown in the table 2.

It was observed from table 2 that from all the camps, about 34.89% of the total (32,035.87 tons) MSW generated was disposed by evacuation**,** 37.66% by burning, 16.37% by composting and 11.08% by burying. These results aligned with (Onazi, *et al.,* 2018; Al-Khatib *et al.,* 2021; Ofre *et al.,* 2024) who recorded similar disposal techniques in IDP camps. The high quantity (65.11%) of solid waste disposed by burning (37.66%), composting (16.66%) and burying (11.08%) suggest that solid waste was improperly managed and improper management can negatively affect the environmental and public health of IDPs living in camps thereby increasing the prevalence and circles of disease.

Table 2: The Quantity and Techniques of MSW Management in each Camp

Name of IDP Camp	Camp Pop.	Qty. (tons) of MSW Generated per annum	% of MSW Evacuated	Qty. (tons) of MSW Evacuated	% of MSW Burned	Qty. (tons) of MSW Burned	% of MSW Composted	Qty. (tons) of MSW Composted	% of MSW Buried	Qty. (tons) of MSW Buried	Total % mgt.	Total Qty. mgt. (tons)
Madinatu	21,027	2686.2	19.02	510.9151	51.33	1378.8261	13.19	354.30968	16.46	442.1484	100	2686.20
Farm Centre	23,782	3038.15	54.15	1645.1585	23.27	706.97762	7.09	215.40487	15.49	470.60951	100	3038.15
Muna Elbadawy	49,922	6377.54	41.28	2632.6467	22.57	1439.4098	34.43	2195.7855	1.72	109.69361	100	6377.54
Custom	9,605	1227.04	5.84	71.659063	44.14	541.6149	37.16	455.9676	12.86	157.79718	100	1227.04
Dalori 1	19,649	2510.16	25.17	631.80721	31.49	790.44931	19.87	498.76874	23.47	589.13449	100	2510.16
Dalori 2	13,157	1680.81	14.83	249.26364	57.48	966.12772	14.43	242.54041	13.26	222.87498	100	1680.81
Gubio road	33,332	4258.16	49.64	2113.7521	31.75	1351.9668	4.89	208.22417	13.72	584.21996	100	4258.16
Teachers' Village	19,880	2539.67	33.45	849.51962	46.12	1171.2958	16.83	427.42646	3.6	91.42812	100	2539.67
Stadium	18,151	2318.79	51.77	1200.4377	33.91	786.30177	5.33	123.59152	8.99	208.45924	100	2318.80
Bakassi	41,865	5348.25	53.86	2880.5695	27.15	1452.0509	8.41	449.78814	10.58	565.84525	100	5348.25
CAN/ EYN	400	51.1	34.82	17.79302	45.06	23.02566	18.37	9.38707	1.75	0.89425	100	51.1
Total	**250,770**	32,035.87	**34.89**	**12803.52**	**37.66**	**10608.05**	**16.37**	**5181.194**	**11.08**	**3443.105**	**1100**	**32,035.87**

Source: Field Survey, 2021.

Table 3 summarized the quantity of MSW managed using different techniques in all the camps from 400 structured questionnaires administered in 11 camps.

Table 3: Quantity of MSW Disposed using Different Techniques in the Study Area

Management techniques	% Mgt. per day	Qty. (in kg) Mgt. per day	Qty. (in tons) Mgt. per day	Qty. (in tons) Mgt. per month	Qty. (in tons) Mgt. per year
Evacuation	34.89	4673285563	4673286	421.17	12803.52
Burning	37.66	3871936889	3871937	348.95	10608.05
Composting	16.37	1891135862	1891136	170.43	5181.19
Burying	11.08	1256733323	1256733	113.26	3443.11
Total	**100**	**11,693,091,638**	**11,693,092**	**1,053.811**	**32,035.87**

Source: Field Survey, 2021.

It was observed from table 3 that 12,803.52tons of the total MSW generated from 11 Maiduguri IDP camps was disposed via evacuation, 10,608.05tons by burning, 5,181.19tons by composting while 3,443.11tons was done via burying. From the same table, it was also observed that in a day and month, 4,673,286tons and 421.175tons of MSW were disposed by evacuation; 3871937tons and 348.95tons were disposed by burning; 1,891,136tons and 170.43tons by composting while 1.256.733tons and 113.26tons respectively of MSW were disposed by burying. From the above, the highest quantity of MSW was disposed by burning while the least quantity was disposed using burying techniques. Since the agencies concerned with MSWM in IDP camps officially use evacuation method only, burning, burying and composting are considered improper management techniques. These results corroborate (Onazi, *et al.,* 2018; Ofre *et al.,* 2024) who recorded high quantities of improperly managed MSW in Maiduguri camp. High quantities of improperly managed MSW in camp implies high prevalence of disease in affected camps.

Municipal Liquid Waste Collection (MLWC) Pattern in IDP Camps

Table 4 shows the quantity and pattern of municipal liquid waste collection obtained in each camp from section "A" of the structured questionnaires administered to 400 respondents. The daily generation rates obtained from the first FGD was multiply by the result obtained from section A of the questionnaire to obtain the pattern shown in table 4 below.

Table 4: Quantity and Techniques of Municipal Liquid Waste Collection in each IDP Camps

Camps	IDP Pop.	Qty. (m^3) of MLW Gener-ated Per Ann.	%	Toilet & Showers		Dumpsites		Broken Toilets & Showers		Moving Paths & Backyard		Gutters & Stagnant water	
				Qty.	%	Qty.	%	Qty.	%	Qty.	%	Qty.	
Madinatu	21,027	115122.83	79.2	91177.28	3.7	4259.55	11.2	12893.76	5.3	6101.51	0.6	690.74	
Farm Centre	23,782	130206.45	87.3	113670.23	3.7	4817.64	4.5	5859.29	3.2	4166.61	1.3	1692.68	
Muna Elbadawy	49,922	273322.95	75.7	206905.47	7.9	21592.51	5	13666.15	7.3	19952.58	4.1	11206.24	
Custom	9,605	52587.38	77.2	40597.45	7.7	4049.23	10.3	5416.5	4.8	2524.19	0	0	
Dalori 1	19,649	107578.28	87.1	93700.678	5.1	5486.49	0.4	430.31	6.1	6562.28	1.3	1398.52	
Dalori 2	13,157	72034.58	91.3	65767.57	2.2	1584.76	1.4	1008.48	5.1	3673.76	0	0	
Gubio road	33,332	182492.7	90.2	164608.42	0.3	547.48	0.9	1642.43	5.9	10767.07	2.7	4927.30	
Teachers' Village	19,880	108843	83.1	90448.53	5.5	5986.37	4.9	5333.31	2.6	2829.92	3.9	4244.88	
Stadium	18,151	99376.73	80.6	80097.64	7.2	7155.12	5.3	5266.97	1.4	1391.27	5.5	5465.72	
Bakassi	41,865	229210.88	79.3	181764.22	3.4	7793.17	8.1	18566.08	4	9168.44	5.2	11918.97	
CAN/EYN	400	2190	89.7	1964.43	0.2	4.38	0	0	0	0	10.1	221.19	
Total	**250,770**	**1372965.75**	**83.7**	**1130701.922**	**4.3**	**63276.69**	**4.7**	**70083.28**	**4.2**	**67137.62**	**3.2**	**41766.23**	

Source: Field Survey, 2021.

It was observe from table 4 that 83.7% of the total liquid waste generated was collected in toilets and showers, 4.3% was collected in dumpsites, 4.7% in broken toilets and showers, 4.2% in moving paths and backyards while 3.2% in gutters and stagnant waters. The collection of a greater part of the liquid waste in toilets and showers imply the agencies in charge of waste management were up and doing therefore, the inadequate water sanitation and hygiene facilities recorded in most camps may be due to insufficient funds provided for camp management. These results align with (Hamza, 2022; Asaku, 2022; Jaber *et al.,* 2023) who recorded MLW collection in toilets, showers and dumpsites. The practice of open defecation and the collection of untreated liquid waste from hand washing during covid 19 era represents a serious threat. Also, the disposal of MLW in gutters, stagnant waters, moving paths and backyards suggested that in addition to improper collection, liquid waste treatment was not practiced and the absent of such prctice can increase the prevalence and circle of infections and disease in IDP camps.

Municipal Liquid Waste Management (MLWM) Techniques in IDP Camps

Table 5 shows the quantity and techniques of municipal liquid waste management in each camps using different techniques obtained from section "C" of the 400 structured questionnaires to authorize and the un-authorized waste managers.

Table 5: Quantity and Techniques of Municipal Liquid Waste Management in each IDP Camps

Camps	IDP Pop.	Qty. Gen. (m^3) Per Ann.	Qty. Sedimented (m^3)	Qty. Dewatered (m^3)	Qty. Disinfected (m^3)	Qty. Composted (m^3)	Qty. Incinerated (m^3)	Qty. Treated using Root-zone (m^3)	Qty. Solidified (m^3)	De-sludged/ Evacuated (m^3)	Qty. not Mgt. / improperly Mgt.
Madinatu	21,027	115122.825	0	0	2290.94	0	0	0	0	14160.11	98671.77
Farm Centre	23,782	130206.45	0	0	6900.94	0	0	0	0	10025.9	113279.6
Muna Elbadawy	49,922	273322.95	0	0	6013.10	0	0	0	0	38538.54	228771.3
Custom	9,605	52587.375	0	0	999.160	0	0	0	0	4890.63	46697.59
Dalori 1	19,649	107578.275			2904.61					9789.62	94884.04
Dalori 2	13,157	72034.575			1512.73					9868.74	60653.11
Gubio road	33,332	182492.7			8942.14					21716.63	151833.9
Teachers' Village	19,880	108843	0	0	8163.23	0	0	0	0	31393.1	69286.68
Stadium	18,151	99376.725	0	0	5217.28	0	0	0	0	31618.9	62540.55
Bakassi	41,865	229210.875	0	0	3621.53	0	0	0	0	74241.6	151347.8
CAN/EYN	400	2190	0	0	203.67	0	0	0	0	127.02	1859.31
Total	**250,770**	**1372965.75**	0	0	46769.34	**0**	**0**	**0**	**0**	**246370.7**	**1079826**
%			**0.00**	**0.00**	**3.41**	**0.00**	**0.00**	**0.00**	**0.00**	**17.94**	**78.65**

Source: Field Survey, 2021.

It was observed from table 5 which shows the quantity and techniques of municipal liquid waste management in each camp that 3.41% of the MLW generated was managed by disinfection while 17.94% was managed by evacuation with 78.65% of the waste not being managed. This result agree with (Hamza, 2022; Asaku, 2022; Jaber *et al.,* 2023) who recorded poor personal and environmental conditions that triggered WASH-related disease outbreaks in IDP camps. It also agree with (Onazi, *et al.* 2018; Ofre *et al.,* 2024) who record a large amount of unmanaged municipal waste in IDP camps. The absent of municipal liquid waste management could be injurious to the public and environment health hence the increase in disease prevalence.

Prevalence of Disease in IDP camps

Figure 2 shows the prevalence of disease that are directly and indirectly associated with improper municipal solid and liquid waste management in IDP camps obtained from section "D" of the questionnaire included in the 24 copies administered to healthcare facilities in 11 IDP camps.

It was observed from figure 2 that there were 58,593 cases of Malaria, 23,045 cases of Typhoid, 1,855 cases of cholera, 6,368 cases of Asthma and 30,842 cases of Cough and Sore bronchitis recorded by 23 health facilities from September, 2020 to August 2021. Within the same period, 5,837 cases of Flue, 16,497 cases of eye infections, 39,586 cases of sexual transmitted infections/disease were recorded. Also, 5,954 cases of Hepatitis, 33,912 cases of Diarrheal and 29,468 cases of Skin infections with a total disease

burden of 251,957 incidences.

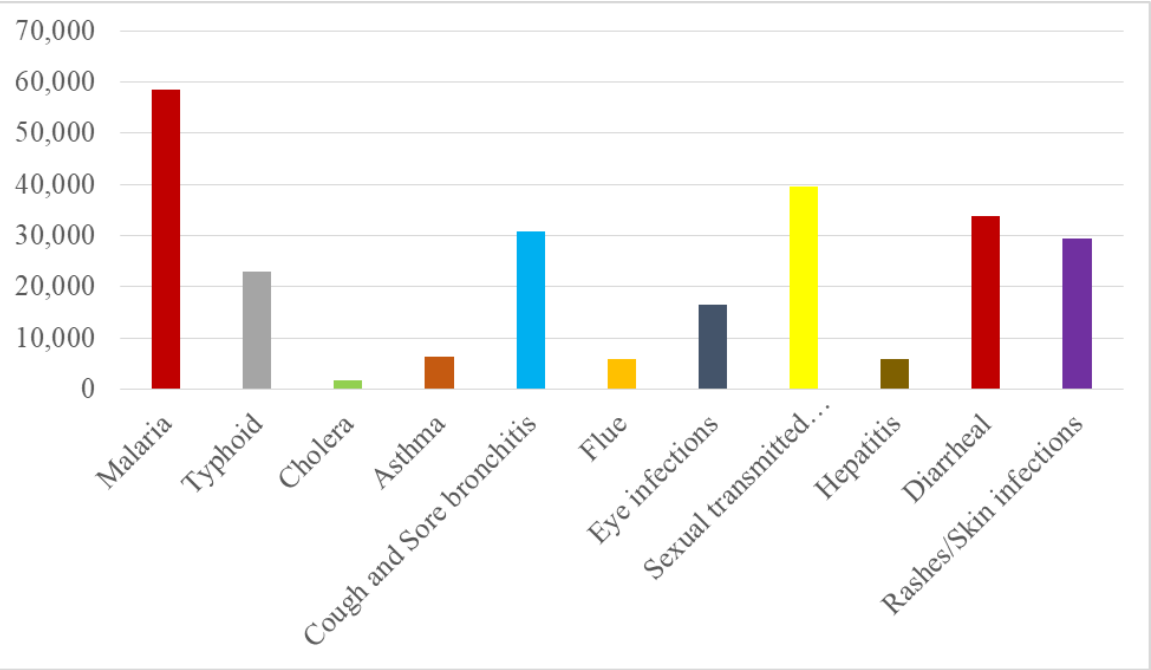

Figure 2: Prevalence of Ill-Health in IDP Camps

Due to improper solid and liquid waste management, the prominent cases of ailments were Malaria, STI/D, Diarrheal, Cough Sore bronchitis, Skin infections and Typhoid. This result agree with Ofre *et al.* (2024) and Hamza (2022) who recorded similar result in Borno state IDP camps due to improper municipal waste management, poor personal and environment hygiene. The ratio of the leading cases of disease to IDP population which expresses the severity shows that in every four IDPs, one had Malaria. Also, in every six IDP, one has STI/D, while one in every seven IDP had Diarrhea. Furthermore, one in every eight IDP had Cough and Sore bronchitis while one in every nine and one in every 135 has Skin infections and typhoid respectively. This disturbing revelation can discomfort victims, increase their physical and mental stress, reduce body immunity and finances. It can also increase the national and state health budges for intervention emergency.

Relationship between Disease Prevalence and Improper Municipal Solid and Liquid Waste Management

Table 6 shows the relationship between improper municipal solid and liquid waste management with the health of IDPs. The improperly managed quantities were obtained by subtracting the generated quantities from the properly managed quantities in each camp as shown in table 2 and 5 respectively. Prevalence of disease were obtained from figure 2.

Table 6: Relationship between improper Waste Management and Prevalence of Disease

Camps	IDP Pop.	Qty. of MLW Gen. (m^3) Per Ann.	Qty. of MLW (m^3) improperly managed Per Ann. X	Qty. (tons) of MSW Generated per annum	Qty. of MSW (m^3) improperly managed Per Ann. Y	Incidences of Disease in Camps Z
Madinatu	21,027	115122.825	98671.77	2686.2	2175.29	9409
Farm Centre	23,782	130206.45	113279.6	3038.15	1392.99	21418
Muna Elbadawy	49,922	273322.95	228771.3	6377.54	3744.89	12709
Custom	9,605	52587.375	46697.59	1227.04	1155.38	11383
Dalori 1	19,649	107578.275	94884.04	2510.16	1878.35	35057
Dalori 2	13,157	72034.575	60653.11	1680.81	1431.55	12337
Gubio road	33,332	182492.7	151833.9	4258.16	2144.41	24176
Teachers' Village	19,880	108843	69286.68	2539.67	1690.15	17161
Stadium	18,151	99376.725	62540.55	2318.79	1118.35	34737
Bakassi	41,865	229210.875	151347.8	5348.25	2467.68	55233
CAN/EYN	400	2190	1859.31	51.1	33.31	18337
Total	**250,770**	**1372965.75**	**1079826**	**32035.87**	**19232.35**	**251957**
Multiple regression Model Summary of Result						
Predictor B SE B β t p						
Constant 22,940 10,015 — 2.29 0.051						
Liquid Waste (X) 0.20 0.22 0.31 0.92 0.386						
Solid Waste (Y) −11.39 14.59 −0.26 −0.78 0.458						

Source: Field Survey, 2021

Note: R^2 = 0.101; Adjusted R^2 = −0.123; F (2, 8) = 0.45; p = 0.652.

It was observed from the multiple regression model summary in table 6 that the influence of improper solid and liquid waste management on disease prevalence was not statistically significant as shown by F (2, 8) = 0.45 and p = 0.652 values. According to the model, solid and liquid waste mismanagement accounted for only about 10.1% of the variance in disease prevalence (R^2 = 0.101), indicating a weak explanatory power. Also, improperly liquid waste management showed a non-significant positive relationship with disease prevalence (β = 0.31, p = 0.386), suggesting that despite the non-statistically significance, increases in quantity of improper liquid waste management was responsible for the high prevalence of disease. On the contrary, improperly managed solid waste exhibited a negative and non-significant relationship with disease prevalence (β = −0.26, p = 0.458). This indicates that variations in solid waste mismanagement did not significantly predict increases in disease outbreaks. Summarily, the findings imply that disease prevalence in the IDP camps cannot be adequately explained by waste quantities alone, other environmental, social, and health-related factors also influenced the outcome.

The non-significant effect of solid waste mismanagement with disease prevalence disagrees with (Amoah *et al.,* 2018; UNEP, 2015) who strongly linked communicable diseases such as cholera and typhoid to improper waste disposal in informal urban settlements. Occasional intervention programme in IDP camps like periodic waste evacuation, health surveillance and emergency medical responses coordinated by humanitarian agencies my account for this disparity. The results align with Howard *et al.* (2016) who posited that waste volume alone cannot sufficiently predict disease outbreaks without considering exposure pathways such as contaminated water supply and hygiene. Also, the weak correlation coefficient of the regression model corroborates WHO (2017) who assert that disease outbreaks in displaced populations are largely driven by overcrowding, inadequate water supply, poor sanitation infrastructure, vector proliferation, and limited access to healthcare, rather than waste generation alone. Camps with fewer reported disease prevalence have incomplete medical records due to the closure of some health facilities before the data collection period whereas those with complete record have higher reported disease cases

Conclusion

Municipal solid and liquid waste generated in IDP camps was improperly collected and managed and the poor management was partly responsible for the high prevalence of disease in camps. The inverse relationship between camp population and solid collection points as well as the quantities of solid and liquid waste mismanaged strongly suggested the public health of IDPs is endangered. Although no strong statistical significance between improper solid waste management with prevalence of disease was reported however, frequent solid waste management intervention and incomplete medical records account for this disparity. Liquid waste mismanagement on the contrary showed a weak positive relationship with disease prevalence because lesser attention was devoted to mitigate open defaecation, spilled toilet content and contaminated wastewater which promote disease outbreaks. Conclusively, this study supports the view that waste management must be addressed as part of an integrated public health framework, alongside water quality management, hygiene promotion, and healthcare delivery to effectively reduce disease outbreaks in IDP camps.

Recommendations

The study therefore recommends the following;

1. More than two third of the total quantity of solid waste generated was improperly managed by the agencies concerned (BOSEPA, IOM and WASH) due to improper camp planning. Therefore, municipal waste action and management plans should be integrated into IDP camp planning programmed in future IDP camps.
2. Municipal liquid waste treatment was not practiced hence municipal waste management action plans like mini-municipal liquid waste treatment plants should be introduces into IDP camp management to reduce the hazards associated with untreated liquid waste disposal.
3. Medical outreach and other surveillance programme tailored to monitor the status and severity of the prominent disease identified should be taken to the IDPs new settlements to reduce the severity, occurrence and recurrence of disease after treatment due to resistance to medication.

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