Assessment of Health Risk Associated with Sanitation System: A case Study of Iten Municipality, Elgeiyo-Marakwet, Kenya

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Abstract: Sustainable Development Goal (SDGS) advocates for access to adequate sanitation and safe water, which are essential for public health. However, deficiencies in sanitation infrastructure remain a significant concern in many urban areas. The study examined the health risks associated with the existing sanitation service chain in Iten Municipality, Elgeiyo-Marakwet County, Kenya. A mixed-methods research design was employed to obtain quantitative data using structured questionnaires, water sampling forms, and qualitative data using interview guides. Purposive, Cluster, and proportionate simple random sampling were employed to identify 388 household heads, four community water points, and informants. Quantitative data was analyzed using Statistical Package for Social Sciences (SPSS) version 27 using descriptive statistics techniques and Pearson's R correlation, while qualitative data was analyzed through categorization into various themes. The findings revealed that only 69% of excreta was safely managed. Significant correlations were identified between inadequate waste management and sanitation-related illnesses ($r = 0.30$, $p = 0.03$), waterborne diseases ($r = 0.33$, $p = 0.014$), and contamination of water sources ($r = -0.13$, $p < 0.003$). Water quality testing showed that all sampled sources were contaminated with coliforms and *E. coli*. surpassing the World Health Organization (WHO) safety limits of zero *E. coli* and total coliforms per 100 mL. Qualitative data highlighted that inadequate waste collection and unsafe disposal practices were key drivers of disease spread. Informants pointed out that pest infestations, such as rodents and flies, and persistent odors from poorly maintained sanitation facilities, significantly exacerbated health risks. In conclusion, the study underscores the urgent need for improved sanitation infrastructure and management, as deficiencies contribute to significant public health risks, including sanitation-related illnesses, water contamination, and environmental hazards.The study recommends that sanitation stakeholders, such as the county government, improve sanitation infrastructure, implement routine water quality testing, and strengthen behaviour change communication campaigns on handwashing and sanitation.

Keywords: *Health Risk, Sanitation System, Sustainable Development Goals, Public Health.*

I. INTRODUCTION

Sanitation is globally recognized as a fundamental human right and a critical pillar for ensuring public health, environmental sustainability, and socio-economic advancement (World Health Organization [WHO], 2020; United Nations [UN], 2015). Access to safely managed sanitation facilities reduces exposure to fecal pathogens and prevents the transmission of numerous infectious diseases, which remain a leading cause of morbidity and mortality worldwide (UNICEF & WHO, 2021). Despite international progress, substantial sanitation challenges persist, particularly in urban areas of low- and middle-income countries (LMICs), driven by rapid urbanization, inadequate

infrastructure investment, and limited financial and technical resources (JMP, 2021; Abdulhadi et al., 2024). Globally, approximately 3.5 billion people lack access to safely managed sanitation services, including 419 million who practice open defecation (WHO & UNICEF, 2023). In many secondary urban centers, such as Iten Municipality in Kenya's Rift Valley region, onsite sanitation solutions, primarily pit latrines and septic tanks, remain the dominant sanitation technology due to low sewerage network coverage and resource constraints (Omonei et al., 2019; Trepanier et al., 2021). While these systems can be effective when properly managed, numerous operational challenges in containment, emptying, transport, treatment, and disposal stages frequently result in unsafe management practices (Blackett et al., 2019).

A sanitation system encompasses the entire infrastructure, technologies, and management processes designed to safely contain, transport, treat, and dispose of human excreta and wastewater. This system includes onsite facilities such as pit latrines, septic tanks, and centralized sewer networks connected to treatment plants (Peal et al., 2020; Blackett et al., 2019). The sanitation service chain comprises a continuum of critical stages from excreta generation and containment to safe treatment and disposal or resource recovery. Breakdowns at any point along this chain can cause environmental contamination by pathogenic microorganisms, contributing to waterborne and sanitation-related diseases (Peal et al., 2020; Contreras & Eisenberg, 2020). The inadequate management of sanitation systems has significant health implications. Waterborne and sanitation-related diseases such as diarrhea, cholera, typhoid fever, and parasitic infections disproportionately affect vulnerable groups, including children under five and immunocompromised individuals (WHO, 2020; Mulatya & Ochieng, 2020). In Kenya, rapid urban growth has intensified sanitation challenges in secondary towns, including county headquarters, where population pressures exceed the capacity of existing sanitation infrastructure, leading to an increased risk of fecal contamination of water sources and the environment (Bishoge, 2021). Despite national and local policies aiming to improve sanitation coverage, the prevalence of inadequately managed sanitation systems remains high, exacerbated by weak regulatory enforcement and insufficient community awareness (Mallory et al., 2022).

Given these challenges, a comprehensive assessment of health risks associated with sanitation systems in Iten Municipality is urgently needed to inform targeted interventions. This study sought to evaluate sanitation-related health risks by investigating current sanitation practices, water quality contamination, and environmental hazards linked to the sanitation service chain in the municipality. Understanding these dynamics was vital for guiding sustainable sanitation management and protecting public health in rapidly urbanizing contexts.

II. MATERIALS AND METHODS

➤ *Study Design*
The research adopted a mixed-methods approach, combining qualitative and quantitative data to evaluate potential health risks associated with the current sanitation service chain at Iten Municipality, Elgeiyo-Marakwet County. This approach allows for the combination of statistical data with in-depth qualitative insights, thus offers a well-rounded view of both the measurable outcomes and the social, behavioral, and contextual factors influencing those outcomes (Lantagne et al., 2021)

➤ *Study Area*
Iten Municipality is the administrative and economic center of Elgeyo Marakwet County, with an estimated 60,685 residents (KNBS, 2019). The municipality covers 15 sub-locations that comprise Bugar, Sin'gore, Kapkonga, Mindililwo, Iten township, Chebokokwo, Kapkessum, Sergoit, Kiplamai, Kiptabus, Katalel, Chesitek, and parts of Rimoi, Anin, and Kessup. The area experiences a bimodal rainfall pattern, influencing water availability and sanitation infrastructure performance. The predominant sanitation facilities include pit latrines and septic tanks, with emerging anaerobic digesters.

➤ *Target Population*
The study focused on household heads aged above 18 years from households within Iten Municipality who had lived there for more than six months to ensure that participants had a solid understanding of local sanitation practices and challenges. With a total of 13,821 households in the municipality (KNBS, 2019), selecting household heads provided reliable insights on household sanitation practices and health risks, as they are typically the primary decision-makers regarding sanitation and hygiene in their households.

The inclusion of key informants (KIs) such as Exhauster Vacuum Truck Drivers, the WASH Coordinator (Public Health Officer), the ITWASCO Technical Manager, the Municipal public toilet attendants, the ELDOWAS Technical Operator, and the Environmental Officer was essential for gaining a comprehensive understanding of the sanitation system and its operational challenges. These KIs, who have specialized knowledge, helped provide a broader context of the local sanitation infrastructure, waste management practices, and public health efforts.

➤ *Sampling Method*
A representative sample of 388 households was determined using Yamane's formula (Yamane, 1967). This formula is widely used in research to calculate sample sizes when the total population is known. The cluster random sampling technique selected households from the municipality's wards. The sampling was proportionate to size, meaning that the number of households sampled from each ward was directly proportional to the number of households in each ward.

This approach ensured that the sample accurately represented the geographic diversity of Iten Municipality, which consists of 15 sub-locations (KNBS, 2019) as shown in Table 1.0. This method is commonly used in large, diverse populations to enhance representativeness while minimizing selection bias (Mweshi & Sakyi,2020). In addition, purposive sampling was employed to select key informants and water

sampling points. Purposive sampling is particularly useful in qualitative research as it allows for selecting individuals who are most knowledgeable or relevant to the study, ensuring the collection of rich, relevant data (Patton, 2002).

Table 1 Sampling Frame

Sub-Location	Total No. of Households	Sample Size by Location
Bugar	640	18
Singore	236	7
Kapkonga	421	12
Mindililiwo	976	27
Iten Township	2960	83
Chebokokwo	336	9
Kapkessum	391	11
Sergoit	1871	52
Kiplamai	563	16
Kiptabus	1490	42
Katalel	1095	31
Chesitek	703	20
Rimoi	572	16
Anin	753	71
Kessup	814	23
Total	13821	388

Source: (Kenya National Bureau of Statistics [KNBS], 2019)

➤ *Data Collection and Analysis*

A structured questionnaire was employed to collect demographic data, details on sanitation facility types, hygiene practices, and the prevalence of sanitation-related illnesses, including diarrhea, dysentery, and amoebiasis. The questionnaire was pretested for reliability, achieving a Cronbach's alpha of 0.78, which was deemed acceptable (Izha et al., 2023). In addition to the survey, semi-structured interviews were conducted with key stakeholders, such as Exhauster Vacuum Truck Drivers, WASH Coordinators, and Environmental Officers, to capture insights into the perceived health risks, sanitation challenges, and mitigation strategies in place. The quantitative data were analyzed using SPSS version 27, applying descriptive statistics like frequencies and percentages and inferential tests such as Pearson's chi-square and correlation analyses at a 95% confidence interval to identify significant associations between sanitation practices, waste management, and health risks. Qualitative data were transcribed verbatim, manually coded, and thematically analyzed to uncover recurring patterns, enriching the understanding of the contextual factors influencing sanitation and public health in the study area.

For the water quality analysis, water samples were collected from key community sources and analyzed for microbial contamination, specifically total coliforms and E. coli, using membrane filtration techniques in accordance with WHO guidelines (Kemper et al., 2023). To ensure the integrity of the samples, laboratory analysis was conducted within six hours of collection. This rigorous approach allowed for a comprehensive understanding of the microbial quality of water sources and their potential role in public health risks in the study area.

➤ *Ethical Consideration*

The Meru University Ethics Review Board granted ethical approval. All participants provided written informed consent. Data confidentiality and anonymity were maintained throughout the study. Furthermore, the research complied with the regulations regarding ethical research practice. Approval was sought from NACOSTI license no. NACOSTI/P/23/29278. Approval from Elgeiyo-Marakwet County Commissioner and County Secretary was also sought before the commencement of data collection within Iten municipality, and the participants signed informed consent before participating in the study.

III. RESEARCH RESULTS

➤ *Demographic Information*

The survey targeted 388 household heads with a response rate of 90% (350). The majority, 60.6% (n=212) of the respondents were female, while 39.4%%% % (n=138) were males, as presented in Table 3.1. As depicted in Table 2, 44.3% (n=155) of the participants were aged 18-35 years, and 39.7% (n=139) indicated 36-50 years. A small proportion of 16.0% (n=56) were 51 years or more. As summarized in Table 1, the majority, 85.4% (n=299), were living in single-family houses, while 6.6% (n=23), 3.1% (n=11), 2.0% (n=7), and 2.9% (n=10), indicated semi-detached houses, apartments, townhouses, and other housing, respectively. The study further explored ownership status and found that 74% (n=259) of the participants were the owners, 3.0% (n=0.9) were mortgaged, 4.0% (n=14) indicated rent-free, and 21.1% (n=74) were residing in rental houses.

Table 2 Demographic Information of Respondents (N=350)

Variable	Frequency (N=350)	Percent (100%)
Gender		
Female	212	60.6
Male	138	39.4
Age bracket in years		
18-35	155	44.3
36-50	139	39.7
51 and above	56	16.0
Type of housing		
Apartment	11	3.1
Semi-detached house	23	6.6
Single-family house	299	85.4
Townhouse	7	2.0
Others	10	2.9
Ownership Status		
Mortgaged	3	.9
Owned	259	74.0
Rent free	14	4.0
Rented	74	21.1

Source: (Research Data, 2024)

➢ *Sanitation Infrastructure and Practices*

In Iten Municipality, as depicted as in Table 3.0, the most common sanitation facility was pit latrines, which account for 69.1% of households, followed by septic tanks at 22.9%, and anaerobic digesters at 2.9%. A small proportion, 3%, of households still practice open defecation. Additionally, 24.6% of pit latrines are located within 15 meters of water sources, posing significant contamination risks. In terms of sanitation practices, a majority of households do not report the presence of pests (58%), but 11.4% report frequent pest infestations, and 30.6% report occasional pest presence. Odor issues are also widespread, with 58.3% of respondents reporting no odor, while 10.9% experience frequent odors, and 30.9% encounter occasional odors. Regarding latrine placement, 24.6% of latrines are located within 15 meters of a well or handpump, and among these, 74.4% are positioned lower than the handpump, increasing the likelihood of water contamination.

Table 3 Sanitation Infrastructure and Practices (N=350

Variables	Frequency (N=350)	Percent (100%)
Sanitation Facilities		
Flush toilets connected to anaerobic digesters	10	2.9
Flush toilet draining into a septic tank	80	22.9
Pit latrine	242	69.1
Others	18	5.1
Presence of pest		
No	203	58.0
Yes frequently	40	11.4
Yes occasionally	107	30.6
Presence of Odors		
No	204	58.3
Yes frequently	38	10.9
Yes occasionally	108	30.9
Latrine within 15m of the well and handpump		
No	264	75.4%
Yes	86	24.6%
Is there a latrine on higher ground than the handpump (N=86)		
No	64	74.4%
Yes	22	25.6%

Source: (Research Data, 2024)

➢ *Sanitation-Related Illness Prevalence*

Table 4 outlines several key findings regarding sanitation issues within Iten Municipality. Among respondents, approximately 28.0% reported instances of sanitation-related illnesses affecting household members, while the majority, constituting 72.0%, indicated no such occurrences. Regarding the prevalence of water-related diseases (Amoeba, Typhoid, and Diarrhea) in the area, 12.9% of respondents acknowledged their existence, while a larger proportion, around 82.6%, reported no prevalence of such

diseases. However, a notable 4.6% expressed uncertainty about the prevalence. Furthermore, the table delves into handwashing practices among respondents, revealing that a significant majority, accounting for 62.3%, reported always washing their hands with soap and water. Additionally, 33.1% stated that they washed their hands most of the time. Only a small fraction reported occasional (3.4%) or rare (0.6%) handwashing, while an even smaller portion, constituting 0.6%, admitted to never washing their hands with soap and water.

Table 4 Sanitation-Related Issues in Iten Municipality(N=350)

Variable	Frequency	Percent
A household member experiences sanitation illness.		
No	252	72.0
Yes	98	28.0
Are there water-related diseases prevalent in the study area		
No	289	82.6
Not sure	16	4.6
Yes	45	12.9
Handwashing with soap and water		
Never	2	0.6
Always	218	62.3
Most of the time	116	33.1
Occasionally	12	3.4
Rarely	2	.6

Source: (Research Data, 2024)

The study explored whether respondents believed there was a link between sanitation and the spread of diseases, whether they were trained on proper sanitation practices, the frequency of seeking medical treatment, the contamination of water sources, and the adequacy of waste management. The findings were as tabulated in Table 5. The study showed that the majority of the respondents, 89.7% (n=314), strongly believed there was a link between sanitation and the spread of sanitation-related diseases. Of the 350 respondents, only 30.9%(n=108) indicated having been trained on the proper sanitation practices. The study further noted that more than half, 59.7%(n=209), had never sought medical treatment for

sanitation-related issues, while 27.7%(n=97), 10.9%(n=38), and 1.7%(n=6) indicated rarely, occasionally, and regularly, respectively. Also, 89.1%(n=312) of the participants believed there was a need to improve sanitation infrastructure in the study area. When respondents were asked whether the current sanitation service chain adequately addresses waste management and disposal, 90.67%(n=317) agreed, 3.1%(n=11) were not sure, and 6.3%(n=22) disagreed. The study found that 73.4%(n=257) of the respondents were not aware of the contamination of water sources due to improper sanitation practices.

Table 5 Health Predictors of the Adequacy of Waste Management (N=350)

Variable	Frequency	Percent
Link of Sanitation and the spread of diseases		
No, I do not believe	5	1.4
Not sure	7	2.0
Yes, I somewhat believe	24	6.9
Yes, I strongly believe	314	89.7
Contamination of water sources		
No	260	74.3
Not sure	23	6.6
Yes	67	19.1
Trained on proper sanitation practices		
No	242	69.1
Yes	108	30.9
Medical treatment		
Never	209	59.7
Occasionally	38	10.9
Rarely	97	27.7
Regularly	6	1.7
Need to improve the Sanitation infrastructure		
Not sure	4	1.1
No, I do not believe	24	6.9
Yes, I somewhat believe	10	2.9
Yes, I strongly believe	312	89.1
Total	**350**	**100.0**

Adequate waste management and disposal		
No	22	6.3
Not sure	11	3.1
Yes	317	90.6

Source: (Research Data, 2024)

- ➤ *Water Source Contamination*

The study further conducted water tests in the laboratory to investigate the level of E. coli and Total coliform units, and the findings are presented in Table 6**.** The laboratory results for water tests from various sources in Iten Municipality indicate that all tested community water sources fail to meet the drinking water quality standards for total coliforms and *E. coli*. Borehole, spring, and river water all show Total Coliforms Too Numerous to Count (TNTC) and *E. coli* counts of 22, 30, and 40 CFU/100ml, respectively, significantly exceeding safe levels. Tap water from ITWASCO, although showing a lower contamination level with 100 CFU/100ml of total coliforms and 3 CFU/100ml of *E. coli*, still fails to meet acceptable standards. According to drinking water quality standards, such as those set by the World Health Organization (WHO), water intended for human consumption should have zero *E. coli* and total coliform counts per 100 ml to ensure safety. These bacteria indicate fecal contamination and pose significant health risks, underscoring the urgent need for improved water treatment and sanitation measures in Iten Municipality.

Table 6 Laboratory Results for the Water Test

Water source	Test Results		
	Total Coliforms (CFU/100ml)	*E. coli* (CFU/100ml)	WHO Safe Limit((CFU/100ml)
Borehole water (Iten Municipality)	TNTC	22	0
Spring (Rorget)	TNTC	30	0
Tap water (ITWASCO)	100	3	0
River (Kipsinende)	TNTC	40	0

Source: (Research Data, 2024)

- ➤ *Pearson Chi-Square Test of Association Between Health Predictors and Adequacy of Waste Management*

The Pearson chi-square test was conducted at a 95% Confidence Interval (CI) to determine associations of different health predictors and waste management, adequacy, and findings demonstrated in Table 7. Sanitation illness had a significant association with waste management adequacy ($\chi2(1, N=350) =26.350$, p <0.000), where a participant who had a sanitation illness was more likely to report that waste management was poor. The second health predictor was handwashing behavior, which also had a significant association with waste management adequacy ($\chi2(4, N=350) =48.200$, p< 0.000). Similarly, the awareness of water-related diseases was also significantly associated with waste management adequacy, $\chi2(2, N=350) =48.808$, p 0.000). As indicated by the results, some environmental factors regarding potentials for odor ($\chi2(3, N=350) =26.950$, p<0.000), and the presence of pests ($\chi2(2, N=350) =38.273$, p<0.000), were also significantly associated with waste management adequacy.

Table 7 Pearson Chi-Square test of Association between Health Predictors and Adequacy of Waste Management (N=350)

Independent Variable	Categories	Adequacy of waste management		Statistical significance
		Good 92(26.3%)	Poor 258(73.7%	
Sanitation illness	Yes	7(2.0%)	40(11.4%)	$X^2= 26.350$ df= 1 p=0.000
	No	85(24.3%)	218(62.3%)	
Handwashing	Always	61(17.4%)	157(44.9%)	$X^2= 48.20$ df= 4 p=0.000
	Most of the time	29(8.3%)	87(24.9%)	
	Never	0(0.0%)	2(0.6%)	
	Occasionally	2(0.6%)	10(2.9%)	
	Rarely	0(0%)	2(0.6%)	
Water-related diseases	No	84(24%)	205(58.6%)	$X^2= 48.808$ df= 2 p=0.000
	Not sure	2(0.6%)	14(4.0%)	
	Yes	6(1.7%)	39(15.1%)	
Link of Sanitation, and the spread of the diseases	Not sure	2(0.6%)	5(1.4%)	$X^2= 26.950$ df= 2 p=0.000
	Yes Somewhat	10(2.9%)	14(4.0%)	
	Yes Strongly	80(22.9%)	239(68.3%)	
Presence of odor	No	67(19.1%)	137(39.1%)	$X^2= 26.950$ df= 3 p=0.000
	Yes frequently	10(2.9%)	28(68.0)	
	Yes occasionally	15(4.3%)	93(26.6%)	

Presence of pest	No	69(19.7%)	134(38.3%)	X^2= 38.273 df= 2 p=0.000
	Yes, frequently	8(2.3%)	32(9.1%)	
	Yes occasionally	15(4.3%)	92(26.3%)	
Contamination of water sources	No	75(21.4%)	185(52.9%)	X^2= 37.173 df= 2 p=0.000
	Not sure	9(2.6%)	14(4.0%)	
	Yes	8(2.3%)	59(16.9%)	
Training	No	65(18.6%)	177(50.6%)	X^2= 2.285 df= 1 p=0.000
	Yes	27(7.7%)	81(23.1%)	
Medical treatment	Never	132(37.7%)	77(22%)	X^2= 16.940 df= 3 p=0.000
	Occasionally	35(10.0%)	3(0.9%)	
	Rarely	86(24.6%)	11(3.1%)	
	Regularly	5(14%)	1(0.3%)	

Source: (Research Data, 2024)

➤ *Correlation Analysis*

A Pearson's correlation analysis was conducted at a 95% Confidence Interval to establish the relationship between health indicators and the perceived adequacy of waste management. The findings revealed significant results, as shown in Table 8. A moderate positive correlation was present between sanitation illness and perceptions of waste management adequacy (r = 0.30, p = 0.03), which implies that people with sanitation illness perceptions report poorer waste management practices. Conversely, for those with water-related diseases, there was a significant negative correlation with waste management adequacy (r = -0.50, p = 0.014). This

implies that people's perceptions of water-related diseases as a problem resulted in their perceptions of inadequate waste management practices. In the same way, there was a significant positive correlation between hand washing and sanitation illness (r = 0.298, p < 0.001), which implies that those with better hand washing practices reported fewer sanitation-related illnesses. Other significant correlations were found for perceptions of odor, which was negatively correlated with waste management adequacy (r = -0.207, p < 0.001), as well as pests, which were also negatively correlated with waste management adequacy (r = -0.192, p < 0.001).

Table 8 Correlation Matrix of Health Predictors and Adequacy of Waste Management(N=350)

		Adequacy of waste management	Sanitation illness	Handwashing	Water-related diseases	Sanitation and diseases	Presence of odor	Presence of pest	Contamination of water sources
Adequacy of waste management	Pearson Correlation	1							
	Sig. (2-tailed)								
Sanitation illness	Pearson Correlation	.30	1						
	Sig. (2-tailed)	.03							
Handwashing	Pearson Correlation	-.072	.298**	1					
	Sig. (2-tailed)	.179	.000						
Water related diseases	Pearson Correlation	-50*	.499**	.242**	1				
	Sig. (2-tailed)	.014	.000	.000					
Link of Sanitation, and the spread of the diseases	Pearson Correlation	-.070	-.179**	-.319**	-.118*	1			
	Sig. (2-tailed)	.189	.001	.000	.027				
Presence of odor	Pearson Correlation	-.207**	.222**	.282**	.274**	-.064	1		
	Sig. (2-tailed)	.000	.000	.000	.000	.235			
Presence of pest	Pearson Correlation	-.192**	.222**	.238**	.315**	-.046	.603**	1	
	Sig. (2-tailed)	.000	.000	.000	.000	.387	.000		
Contamination of water sources	Pearson Correlation	-.133*	.221**	.160**	.371**	-.029	.304**	.331**	1
	Sig. (2-tailed)	.013	.000	.003	.000	.592	.000	.000	

*Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.001 level (2-tailed)

Source: (Research Data, 2024)

➤ *Qualitative Insights*

Key informants highlighted inadequate waste collection and unsafe disposal as major contributors to disease spread. Lack of community awareness and resource constraints were cited as key barriers to effective sanitation. Respondents emphasized the need for regular water testing and sustained hygiene education programs.

IV. DISCUSSION

This study revealed that the sanitation service chain in Iten Municipality presents significant public health risks, manifested through the prevalence of sanitation-related

illnesses, widespread microbial contamination of water sources, and environmental factors that exacerbate disease transmission. The self-reported 28% prevalence of sanitation-related illnesses aligns closely with studies conducted in other urban centers within Kenya and similar low- and middle-income countries (LMICs), emphasizing the persistent burden of diarrheal diseases associated with fecal contamination (Ellis et al., 2020; Merid et al., 2023; Mulatya & Ochieng, 2020). These illnesses, primarily diarrhea, amoebiasis, and dysentery, contribute significantly to morbidity, particularly among vulnerable populations such as children under five years of age. While subject to recall bias, the self-reported illness data in this study reflect an ongoing

public health challenge exacerbated by deficiencies at multiple stages of the sanitation service chain. The interplay of insufficient containment, inadequate emptying and transport services, and ineffective waste treatment culminates in environmental contamination and heightened disease transmission (Blackett et al., 2014). The clustering of sanitation-related illnesses in households lacking consistent hygiene practices further emphasizes the multifactorial nature of disease propagation.

The detected microbial contamination across all tested water sources is of particular concern, as access to safe drinking water is foundational to public health. All sampled sources exhibited total coliform and *Escherichia coli* counts substantially exceeding WHO guidelines for safe drinking water (WHO, 2017; Kemper et al., 2023). The presence of *E. coli* is a direct indicator of fecal contamination, signaling the potential presence of enteric pathogens, including Vibrio cholerae, Shigella spp., and Giardia lamblia (Holcomb & Stewart, 2020). Despite the county treating its water, there was still contamination, possibly due to leaking pipes and poor storage. Interestingly, despite widespread contamination, few people are reported to be getting sick, which may be due to traditional water boiling practices and underreporting of waterborne illnesses. The spatial proximity of pit latrines to groundwater and surface water sources, with nearly 25% located within the WHO-recommended safe distance of 30 meters, significantly increases the risk of pathogen seepage (Wechuli et al., 2021). Rainwater infiltration and runoff during rainy seasons further facilitate pathogen transport from sanitation facilities to water points, perpetuating fecal contamination cycles. This environmental contamination directly contributes to outbreaks of waterborne diseases documented in Kenya and sub-Saharan Africa (WHO, 2020; Merid et al., 2023).

The study further reveals a gap in hygiene behaviors: while 62.3% of respondents consistently washed their hands with soap, a significant number (33.7%) reported irregular or no handwashing. This is particularly critical, as hand hygiene is a proven, cost-effective intervention to reduce diarrheal disease incidence by up to 47% (Ejemot-Nwadiaro et al., 2021). Limited access to formal hygiene training (only 30.9% reported such training) suggests that educational outreach and behavior change communication remain under-resourced in the municipality. Socio-cultural barriers, misinformation, and lack of infrastructure, such as handwashing stations, may also hinder optimal hygiene (Kipngeno et al., 2024; Muchangi et al., 2024). Addressing these gaps through sustained, culturally sensitive health education and ensuring access to soap and water are essential to breaking fecal-oral transmission cycles.

Environmental nuisances, including pest infestations and persistent odors reported by a significant proportion of residents, further illustrate shortcomings in the sanitation service chain. Poorly maintained sanitation facilities provide breeding grounds for vectors such as flies and mosquitoes, which can transmit a variety of diseases beyond those traditionally associated with fecal contamination, including malaria and dengue (Olagunju et al., 2023; Tyagi et al., 2023).

Odor problems reflect the anaerobic decomposition of waste and signal insufficient waste management or facility malfunction, both of which diminish the quality of life and potentially discourage proper sanitation usage (Obeng, 2020).

V. STUDY LIMITATIONS

The study relied on self-reported health data, which may be subject to recall bias and underreporting. Microbial water testing was limited to four sources, which may not fully capture municipality-wide water quality variations. Future longitudinal and broader spatial studies are recommended.

VI. CONCLUSION

This study has demonstrated that the current sanitation service chain in Iten Municipality poses considerable public health risks. The high prevalence of sanitation-related illnesses such as diarrhea, amoebiasis, and dysentery among residents is directly linked to the inadequacies in sanitation infrastructure, unsafe excreta disposal, and poor hygiene practices. Microbial contamination of the municipality's primary water sources with total coliforms and *Escherichia coli* reflects widespread fecal pollution, largely attributable to the unsafe proximity of pit latrines and the lack of effective fecal sludge management. Environmental factors, including persistent odors and pest infestations, further compound the health risks, underscoring infrastructural and operational deficiencies within the sanitation service chain. Together, these findings highlight the urgent need for a coordinated and comprehensive approach to sanitation management that prioritizes both infrastructure and community behavior change.

RECOMMENDATIONS

A multifaceted approach is essential to effectively mitigate the health risks associated with the sanitation service chain in Iten Municipality. First, the county government should prioritize upgrading sanitation infrastructure by promoting the construction of safely managed onsite sanitation facilities, enforcing safe distances between latrines and water sources, and expanding sewer networks where feasible. Investment in fecal sludge management systems, including regular desludging and centralized treatment, will be critical in reducing environmental contamination. Second, routine microbiological testing of all major water sources must be institutionalized, coupled with timely public reporting and interventions such as source protection and disinfection. Capacity building for local water management authorities is necessary to sustain these efforts. Third, sustained behavior change communication campaigns are needed to promote handwashing with soap, and safe sanitation facility uses, and hygienic water handling practices; these should be culturally sensitive and supported by accessible handwashing infrastructure in households and public spaces.

Furthermore, local policies and regulatory frameworks governing sanitation facility construction, maintenance, and fecal sludge disposal must be strengthened, with enforcement

mechanisms including regular inspections and penalties for non-compliance. This requires coordinated efforts across the health, water, and environmental sectors. Fifth, stakeholder engagement should be enhanced through multi-sectoral collaboration involving government agencies, NGOs, community-based organizations, and residents to foster ownership and sustainability of sanitation improvements. Training programs for community health workers and sanitation service providers will help build the necessary technical and operational capacity. Finally, further research, including longitudinal studies, is recommended to monitor the impact of sanitation interventions on health outcomes alongside expanded water quality surveillance integrated into public health monitoring systems. Addressing the sanitation challenges in Iten Municipality requires holistic and inclusive strategies combining infrastructure development, community education, policy enforcement, and continuous monitoring. Such efforts will contribute significantly towards achieving Sustainable Development Goal 6, ensuring availability and sustainable management of water and sanitation for all, and ultimately improve the health and well-being of the Iten community.

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➢ *Conflict of Interest*

The authors declare that there is no conflict of interest regarding the publication of this manuscript. The research was conducted independently, and no external influences affected the integrity of the study or the interpretation of the results.

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