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Prevalence, Etiology, and Treatment of Diarrheal Diseases in Kenya: A Scoping Review

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Abstract Annually, diarrhea causes approximately 1.6 million deaths worldwide, predominantly in Sub-Saharan Africa. In Kenya, diarrheal diseases are among the leading causes of morbidity and mortality, particularly affecting children under five. Despite various studies and interventions on diarrhea, the overall prevalence, distribution, pathogens and risk factors for diarrhea in Kenya remain inadequately investigated especially for atypical pathogens and adults. This scoping review aimed to synthesize available evidence on the prevalence, etiology, treatment, and risk factors associated with diarrheal diseases in Kenya across all age groups. The review followed Arksey and O'Malley's framework and the Preferred Reporting Items for systematic review and Meta-analysis -scoping review guidelines. Comprehensive searches of databases such as MEDLINE and EMBASE, were conducted to identify studies for inclusion using the following criteria: all observational studies conducted in Kenya, reported in English, without restriction on publication year. Exclusion criteria included randomized control trials and reviews. A total of 210 studies were included in the study, covering diverse regions and study settings in Kenya. The studies primarily focused on children under five but also included adult populations. The pooled prevalence of diarrheal diseases varies significantly across different Kenyan regions. The Eastern region showed the highest prevalence at 20.79%, followed by Nairobi with 16%. The Northeastern region had the lowest prevalence at 3.44%. The most common bacterial causes were *Escherichia coli*, *Salmonella*, and *Shigella*, while Rotavirus was the predominant viral cause. Socioeconomic factors, hygiene practices, and environmental conditions were the major risk factors. The review highlighted a high prevalence of antibiotic resistance, with notable resistance to ampicillin, tetracycline, and trimethoprim/sulfamethoxazole. Several studies reported multidrug-resistant *E. coli* strains, with 27% being *Enteroaggregative E. coli* (EAEC) and 50% *Enterotoxigenic E. coli* (ETEC) isolates producing extended spectrum beta-lactamases. Diarrheal diseases in Kenya exhibit significant regional and demographic variability in prevalence and etiology. Major risk factors include poor hygiene, low socioeconomic status, and inadequate sanitation. The rise of multidrug-resistant Extended spectrum β-lactamase producing *E. coli* strain, poses a significant public health challenge, complicating treatment options. The widespread antibiotic resistance underscores the need for region-specific public health interventions and improved antibiotic stewardship. Further action is necessary to address national gaps in adult population data and to improve strategies for diarrhea diagnosis, prevention and management in Kenya.

Keywords: *Antimicrobial resistance, Diarrhea, Etiology, Prevalence, Risk factors, Treatment*

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1. Introduction

It is estimated that by 2030, 4.4 million children 0-59 months of age will die from infectious diseases annually and 60% of those deaths will occur in Sub-Saharan Africa unless the appropriate mitigation measure is taken [1]. Acute diarrhea defined is the passage of three or more loose or liquid stools per day (or more frequent passage than is normal for the individual) over a period of 14 days or less [2], is caused by mixed etiologies and contributes a significant proportion to that mortality. Globally, the burden of diarrheal disease across all age groups remains high, with approximately 1.6 million deaths annually and the highest-burden reported in Sub-Saharan Africa [3]. According to the World Health Organization (WHO), diarrheal disease is still one of the major causes of death among children 0-59 months of age worldwide, contributing to about 525,000 deaths every year [2]. Although mortality rates among adults are lower than those observed in children 0-59 months of age, diarrhea

still poses a substantial burden to adults [4].

In Kenya, diarrheal diseases are ranked among the top ten causes of morbidity and mortality [5], which according to WHO data (WHO, 2020), caused about 15,420 of total deaths in Kenya in the year 2019. Known risk factors associated with diarrheal diseases are socio-economic status, type of latrine used, presence of flies, garbage, open defecation, age when the child starts using the latrine, disposal of the child's feces and can be spread through water, flies, food, and improper washing of the hands [6]. Known causes of diarrheal diseases in Kenya are viral, parasitic, and bacterial in nature [7]. Despite several interventions, innovations and guidelines deployed to prevent and manage diarrheal diseases [8] mortality related to diarrhea still remains a major concern in Kenya.

In Kenya, several studies have been conducted to estimate the distribution, prevalence, treatment and factors associated to diarrheal diseases [4]. However, these studies vary widely in prevalence levels and some regions in Kenya are underrepresented limiting the generalizability of outcomes. Without a clear understanding of the prevalence, etiology, treatment and risk factors associated with diarrheal diseases, it is challenging to implement targeted and relevant interventions. A comprehensive review of existing data would begin to provide this information yet no current or in-progress scoping reviews on diarrheal diseases in Kenya were identified in PROSPERO, MEDLINE, the Cochrane Database of Systematic Reviews, and JBI Evidence Synthesis. Therefore, this scoping review aimed to determine the pooled prevalence, causes, treatment and risk factors and interventions associated with diarrheal diseases among all age groups using available evidence in Kenya.

Review question

What is the prevalence, etiology, distribution, risk factors, intervention and treatment of diarrheal infections across all ages in Kenya?

2. Methods

This scoping review was conducted according to the framework outlined by Arksey and O'Malley [9], and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) [10]. A systematic approach was used to map existing literature and identification of evidence sources available. The steps entailed: identifying the research question, identifying relevant studies, study screening, collating, summarizing, and reporting of results, and consultation with stakeholders to inform and validate study findings. The study focused on published and unpublished (preprints) research conducted in Kenya, written in English and included all age groups. Observational study designs were such as cross-sectional, case-control, and cohort studies were included. However, randomized control studies, quasi-experimental studies, systematic reviews, and scoping reviews were not included. There were no limitations on the publication year of the articles. The pooled prevalence was calculated as per the formula by DerSimonian and Laird (1986) [11].

$$\text{Pooled Prevalence} = \frac{\sum(w_i \times p_i)}{\sum w_i}$$

Where:

- p_i is the prevalence in the i-th study,
- w_i is the weight assigned to the i-th study, typically based on the inverse variance of the prevalence estimate, $w_i = \frac{1}{\text{Var}(p_i)}$,
- The variance of p_i is often calculated using the binomial distribution as:

$$\text{Var}(p_i) = \frac{p_i(1-p_i)}{n_i}$$

Where n_i is the sample size of the i-th study.

Search strategy

The search strategy aimed to locate both published and unpublished primary studies, grey literature, and text and opinion papers in Kenya to identify studies reporting prevalence, causes, treatment and risk factors of diarrheal disease in all age groups. An initial limited search of MEDLINE (PubMed) and Cumulative Index to Nursing and Allied Health Literature (CINAHL) was undertaken to identify articles on the topic. The text words contained in the titles and abstracts of relevant articles, and the index terms used to describe the articles were used to develop a full search strategy. To identify eligible studies, a comprehensive literature search with no date limits was conducted in MEDLINE/PubMed, EMBASE, Web of Science, CINAHL, Science Direct, Google Scholar and Cochrane Library and medRxiv pre-prints. All the literature search terms were restricted to English language. Eligible studies were extracted using google forms. The Covidence software (Covidence, Veritas Health Innovation, Melbourne, Australia) was used to manage the screening, data extraction, and quality assessment processes.

The search terms were: "prevalence", "diarrhea", "diarrheal", "under-five", "children", "adults" "causes", "associated factors" and "Kenya".

Source of evidence selection

Following the search, all identified records were collated and uploaded into Zotero software [12] to manage citation and remove duplicates. The titles and abstracts were screened by 2 independent reviewers to ensure that all inclusion criteria were met. Full-text studies that did not meet the inclusion criteria were excluded, and reasons for their exclusion are provided in Figure 1. Any disagreements that arose between the reviewers were resolved by a third reviewer. The remaining papers were retrieved in full and their citation details imported into the Covidence software for unified management, assessment and review of the records.

Data extraction

After full text review, data were extracted independently by two reviewers using a standardized data abstraction format, adapted from the preferred reporting items for systematic reviews and meta-analyses extension for scoping reviews (PRISMA-ScR) guidelines [10]. In case of discrepancies during the data extraction, a third reviewer was used to provide additional information or

clarifications. For the first objective (prevalence), the data extraction format included primary author, publication year, region(s) within the country where the study was conducted, sample size, age categories: 0-59 months, and ≥ 5 years of age, study area, response rate, prevalence with 95% Confidence Interval. For the second objective (causes), data was extracted in a format of frequency and percentages with a specific causal agent. For the third objective (risk factors), data was extracted using the Supporting the Use of Research Evidence (SURE) framework [13].

Data analysis and presentation

The results are presented in a descriptive narrative format focusing on emerging themes from the extracted data. These themes include analysis of prevalence and distribution of diarrheal disease and the burden stratified into distinct age; causes, treatment and risk factors associated with diarrheal disease. The scoping review followed the format of PRISMA-ScR checklist [14] and data analysis for prevalence was done using pooled prevalence [15]. Graphs and tables were generated in Microsoft Excel.

Limitations

As the objective of the scoping review was to map existing literature and synthesize available evidence on the prevalence, etiology, treatment, and risk factors associated with diarrheal diseases in Kenya across all age groups however, heterogeneity, methodological quality or bias risk of included articles was not assessed.

Ethical considerations

Ethics approval was not required for this scoping review of existing and publicly available literature.

3. Results

This scoping review examined a total of 210 studies after applying the inclusion and exclusion criteria as summarized in Figure 1. The studies were conducted in various regions within Kenya, encompassing different study designs. The included studies were comprised of 125 cross-sectional studies, 31 interventional, 27 case-control, 14 cohorts, and 8 longitudinal studies. The studies collectively investigated various aspects of diarrhea, including the prevalence, etiology, associated risk factors, interventions, and antibiotic susceptibility patterns.

Study settings and population

The studies collected data from both hospitals and community settings across diverse settings: 30% in rural areas, 29% in urban settings, and 19% in mixed urban and rural settings. Notably, 22% of the studies lacked clear specification of the study setting. Geographically, the studies covered extensive an extensive area across Kenya, including Western, Luo Nyanza, Kisii, Central, Coastal, North-Eastern, Eastern, Rift valley and the Nairobi Metropolitan regions. Most studies were carried out in the Nairobi Metropolitan region (66, 31.4%), followed by the Luo Nyanza region (59, 28.1%).

The review of 210 studies revealed a significant focus on children, especially those under 5 years. Specifically, 142 (67.6%) studies focused on children, 17 studies targeted the adult population, while 51 studies examined both adults and children. The study encompassed a total of 2,772,162 participants, among whom 2,265,424 were confirmed cases of diarrhea.

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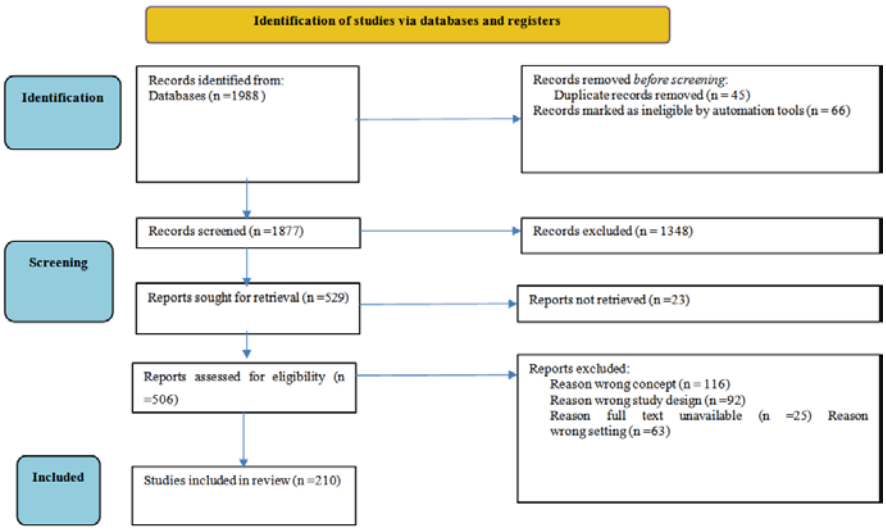

Figure 1. Search results and study selection and inclusion process (10)The PRISMA 2020 statement

Diarrheal etiology

Among the bacterial causes of diarrhea, *Escherichia coli*, *Salmonella enterica*, and *Shigella spp*. emerged as the most reported diarrheal agents, appearing in 125, 65, and 47 studies respectively to synthesize available evidence on the prevalence, etiology, treatment, and risk factors associated with diarrheal diseases in Kenya across all age groups.

s shown in Figure 2. *Vibrio cholerae* was the focus of investigation in 29 research papers while *Clostridium difficile* was studied in 3 research papers. Viral etiologies were represented in 29 studies with Rotavirus reported in 48, Norovirus in 19 studies, and Adenovirus in 15 studies as the most frequent causes of viral diarrhea (Figure 3). The main parasites associated with diarrhea were *Giardia spp.*, *Cryptosporidium spp.*, and *Entamoeba spp*. appearing in 34, 21, and 18 studies respectively Figure 4. Other less prevalent causes of diarrheal diseases were *Vibrio fluvialis*, *Plesiomonas shigelloides*, *Hymenolepsis nana*, *Aeromonas spp.*, *Providencia alcalifaciens*, *B. hominis*, *Campylobacter jejuni*, and *Campylobacter coli*.

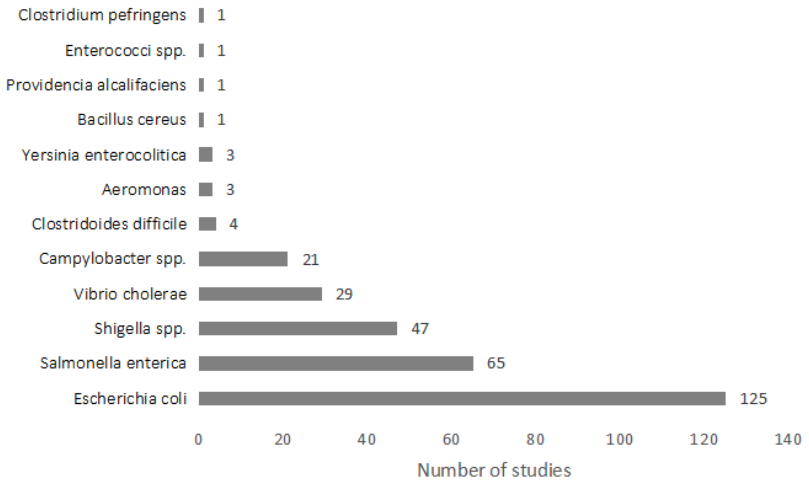

Figure 2. Bacterial etiologies of diarrhea in Kenya

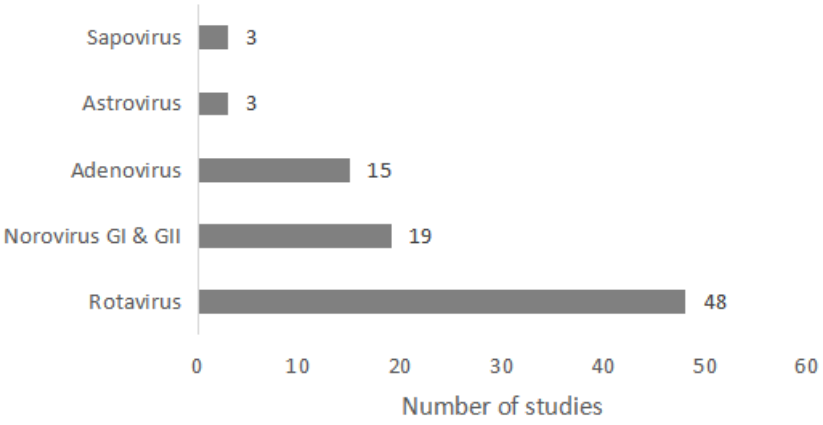

Figure 3. Major viral etiologies of diarrhea in Kenya

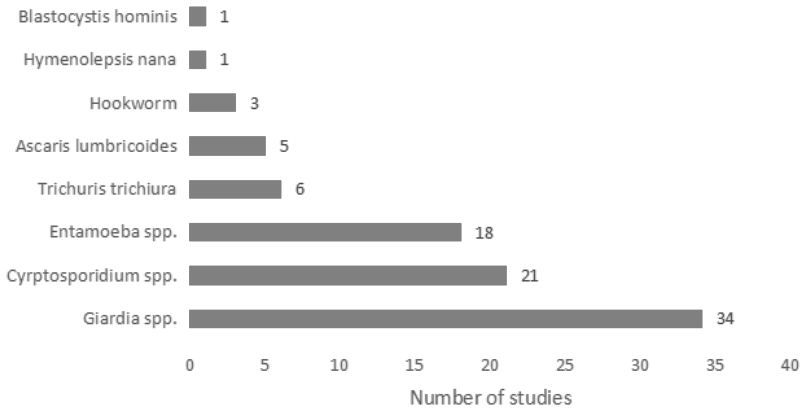

Figure 4. Parasitic etiologies of diarrhea in Kenya

Prevalence and distribution of diarrhea

The pooled prevalence of diarrheal diseases varies significantly across different regions as shown in Figure 5. The Eastern region and Nairobi metropolitan area had the highest prevalence at 20.79% and 16% respectively, indicating a major health concern in those regions. Rift Valley and Coastal regions had moderate prevalence of 13.3% and 11.36% while Central and Western regions had comparable prevalence rates of 9.65% and 9.2%, respectively. Luo Nyanza and Kisii had slightly lower prevalence rates at 8.7% and 7.4%. In stark contrast, the Northeastern region had the lowest prevalence at 3.44%.

Significant variations in the occurrence of enteric pathogens were observed in the pooled prevalence [11] and distribution of diarrheal cases throughout different regions. *E. coli* and Rotavirus had the highest prevalence in the Central region, specifically in the counties of Murang'a and Kiambu, at 29.83% and 29.52%, respectively. *Salmonella spp.* (4.25%), *Shigella spp*. (4.44%), *Aeromonas spp*. (4.37%), *Yersinia spp.* (1.09%), *Vibrio* (0.55%), and *Providencia* (3.18%) had lower prevalence. Within the central region, no studies were reported from the counties of Kirinyaga, Nyandarua, and Nyeri.

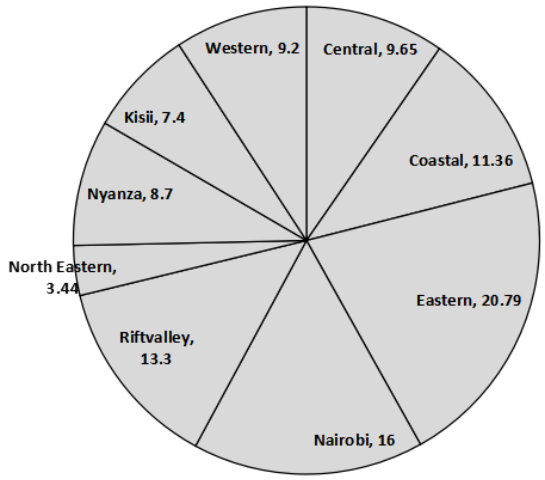

Figure 5. Regional distribution of diarrheal pooled prevalence (%) in Kenya by regions

In the Coast region, encompassing Kilifi, Kwale, and Mombasa counties, the highest prevalence was observed for *E. coli* (at 13.71%), followed by Cryptosporidium (21.67%), Salmonella (7.37%) and Shigella (6.49%). Other pathogens like *Giardia lamblia* (4.93%), *Campylobacter* spp. (4.91%), Rotavirus (16.20%), and Non-Typhoidal Salmonella (NTS) (15.56%) were also reported. No data was available for Tana River and Taita Taveta counties.

Marsabit and Meru counties had an overall pooled prevalence of approximately 20.79% for diarrheal pathogens. In the Nairobi metropolitan region, the pooled prevalence suggested overlapping cases due to multiple infections, resulting in a cumulative prevalence exceeding 100%. Assuming independence, the average prevalence per pathogen was estimated at 11.55%. In the Rift Valley, studies from Nandi, Kericho, and Turkana reported a pooled prevalence ranging between 2.1% and 20% for *Salmonella*, *Shigella*, *Campylobacter*, *Rotavirus*, and *Giardia*. The Northeastern Region, covering Garissa and Mandera counties, had an overall average prevalence of 3.44% for *V. cholerae* and *E. coli*.

Within the Luo Nyanza region, in the Lake Victoria region, specifically Kisumu, Siaya, and Homa Bay, *E. coli* had a prevalence of 16.78%, followed by *Giardia* (22.57%), *Campylobacter* (14.48%), *Cryptosporidium* (9.22%), *Shigella* (5.25%), *Salmonella* (3.08%), Rotavirus (13.32%), and NTS (4.00%). In the neighboring counties of Migori, Kisii, and Nyamira, *E. coli* prevalence was 14.69%, with *Giardia* at 10.50%, *Campylobacter* at 6.29%, with lower rates observed for other pathogens such as *Cryptosporidium* (3.80%) and *Salmonella* (1.20%). The Luo Nyanza region reported pooled prevalence for various enteroviruses, including Norovirus (13.9%), Sapovirus (10%). Adenovirus (9.1%), and Astrovirus (3.9%). In the Western region, covering Bungoma, Vihiga, Kakamega, and Busia counties, the pooled prevalence was highest for *Giardia duodenalis* (12.36%), followed by soil-transmitted helminths (9.06%), A. lumbricoides (3.86%), *E. coli* (3.07%), *Salmonella* (1.99%), *Shigella* (0.61%), and *Vibrio species* (0.15%). The distribution underscores the significant regional and county variations in the prevalence of diarrheal pathogens across different counties, highlighting the need for targeted region- and county-specific public health interventions.

Table 1. Showing distribution of diarrheal etiologies in Kenya

Region	Bacterial pathogens	Viral pathogens	Parasitic pathogens
Luo Nyanza	*E.coli, Salmonella spp, Shigella spp.*	Norovirus, Sapovirus, Adenovirus	*Giardia, A. lumbricoides*
Central	*E. coli*	Rotavirus	
Coast	*E.coli, Shigella, Salmonella, Campylobacter jejuni, and Non-typhoidal salmonella*	Rotavirus	*Cryptosporidium Giardia lamblia*
Rift Valley North Eastern	*Salmonella, Shigella, Campylobacter V. cholerae* and *E. coli*	Rotavirus	*Giardia lamblia*
Western	*Salmonella spp. Shigella spp.,, E.coli, Vibrio spp.*		*Giardia duodenalis Soil-transmitted helminthes Askaris lumbricoides*
Nairobi	*C. difficile, V. cholerae, E. coli, Non-typhoidal salmonella*	Rotavirus, Adenovirus	*Giardia, A.lumbricoides*
Eastern	*V. cholerae , Salmonella*	Rotavirus	*Cryptosporidium, Giardia lamblia, Entamoeba histolytica*

Risk factors for diarrhea

Several studies reported multifaceted risk factors contributing to the prevalence of diarrhea, focusing on socioeconomic factors, immunocompromised states, age-related factors, hygiene practices, environmental risks, malnutrition, gender, occupation, and seasonality.

Poverty and lack of education were associated with a high incidence of diarrhea. In a study done in Nairobi [5],

infants living in households with a pit latrine and in crowded households had almost 1.5 times higher risk of diarrhea than infants with a flush toilet or non-crowded households [6]. Low-income households had a prevalence of 52.3% as compared to high income households which had 27.6% prevalence of diarrhea according to a study done in Kisumu [16].

On hygiene practices, several studies reported poor hand washing, poor personal hygiene, food hygiene and cleanliness of the household surrounding to be associated with acquisition of diarrhea [1,7,17]. Drinking water from natural sources predisposes one to a higher risk of getting diarrhea compared to drinking water from taps and wells [3,6]. Open defecation and lack of proper sanitation was also associated with high incidences of diarrhea [7]. A number of studies reported that diarrhea was more prevalent in children aged five years and below compared to older age groups [5,7].

Diarrhea Interventions, antibiotic use and antibiotic resistance

As reported by these studies, a number of medical interventions exist for the management of diarrheal diseases in Kenya. These interventions are administered according to the WHO guidelines for the prevention, management and treatment of diarrhea. Zinc supplementation, recommended by the WHO as part of the standard treatment for acute diarrhea in children, was reported to significantly reduce diarrhea-related mortality.

Oral Rehydration Therapy which is used to replenish fluid and electrolytes lost during a diarrheal episode was found to be effective in managing diarrhea caused by *Vibrio cholerae* and Enteropathogenic *E. coli*. Rotarix, a monovalent rotavirus vaccine that was introduced in Kenya in the year 2014 is administered as a 2-dose vaccine at 6 weeks and 10 weeks of age, was reported to have reduced the prevalence of rotavirus by 10.5% at the coastal region since the introduction of this vaccine.

Antibiotics usage are reserved for cases where bacterial pathogens are identified [18]. The literature in this scoping review revealed a significant pattern of antibiotic utilization. Ampicillin, Tetracycline, Chloramphenicol, Ceftriaxone and Gentamicin were the most reported antibiotics used for treatment of diarrhea related illness followed by Clotrimazole, Erythromycin, Streptomycin, cefuroxime among others.

This review identified notable disparities in antimicrobial resistance patterns across various geographical regions and pathogens. Antibiotic resistance rates for ampicillin ranged from 42% to 100%, tetracycline from 50% to 92%, and trimethoprim/sulfamethoxazole from 83% to 100% for different organisms and locations. Antibiotics like ciprofloxacin exhibited variable susceptibility profiles between bacterial pathogens; 42% of enteroaggregative E. coli (EAEC) and 8% of Shigella isolates. Apart from individual antibiotic resistance, the reported multi drug-resistant strains was alarming, with 33.9% of bacterial isolates displaying resistance to multiple antibiotics. *E. coli* had notably high extended-spectrum beta-lactamase (ESBL)-producing isolates among enteroaggregative *E. coli* (EAEC) (27%) and enterotoxigenic *E. coli* (ETEC) (50%) isolates. Three papers reported on *C.difficile*, two in Nairobi and one in Coastal Kenya. The prevalence in Nairobi was ~25% while in Southern Coastal Kenya, the prevalence reported was 35% with resistance levels reported for rifampicin (91.5%), erythromycin (88.7%), metronidazole (85%), ciprofloxacin (83.1%), and clindamycin (8%).

4. Discussion

Study sources

This scoping review was conducted to fill gaps in the understanding of the overall prevalence, diarrheal disease etiologies and distribution across Kenya in all ages. The review extracted data from 210 published and unpublished reports. Approximately 2/3 of the studies focused on pediatric populations, especially children under five years old, 8% focused solely on adults, and 24% included both age groups. This indicates a significant emphasis on researching diarrheal diseases in young children, highlighting their vulnerability to diarrhea. However, there is a notable lack of research on adult populations, pointing to a need for more inclusive studies to better understand the epidemiology of diarrhea across all age groups [2]. This Scoping review brings together results from different study designs giving a broad perspective on the prevalence of diarrheal diseases. It includes 125 cross-sectional studies, which collects information at a specific point in time, and 8 longitudinal studies, which in contrast to the cross-sectional studies follow individuals over a period of time [19,20,21,22]. Furthermore, 27 case-control studies were included to determine if an exposure is associated with an outcome by comparing cases (individuals with the outcome) and controls (those without the outcome) [21]. We also examined 14 cohort studies which assess associations between multiple exposures and multiple outcomes over time [19]. 31 interventional studies were included to evaluate the direct impact of therapeutic or preventive measures by assigning participants to treatment or control groups [22].

Diarrheal etiologies

The most frequently reported bacterial causes of diarrhea were E. coli, Salmonella enterica, and Shigella spp., identified in 125, 65, and 47 studies, respectively. Vibrio cholerae was examined in 29 studies, while Clostridium difficile appeared in 3 studies. Cholera emerges periodically as outbreaks which prompts investigation and increased reporting. C. difficile is likely more prevalent than reported as it's infection is triggered by antibiotic use which is widespread in hospitals but it's detection is complicated due to limited diagnostics and culture capabilities as it is a strict anaerobe. Among viral agents, Rotavirus was the most reported, followed by Norovirus and Adenovirus. Parasitic causes such as *Giardia spp.*, *Cryptosporidium spp.*, and *Entamoeba spp.* were significant in 34, 21, and 18 studies, respectively [23,24]. The review demonstrates that bacteria are the most common etiological agents, especially Escherichia coli, Shigella, Salmonella and Vibrio cholerae [25]. These bacteria are highly prevalent because they are easily ingested via contact with contaminated food, water, environment, fecal matter and animals. As a result these bacterial pathogens have been extensively studied in these

papers compared to other pathogens. Shigella causes approximately, 125 million diarrhea episodes and 160,000 deaths every year, with a third affecting children aged 5 years and below [26], while diarrheagenic E. coli causes about 70,000 deaths in children under 5 years of age in Africa [6].

Despite the dominance of bacterial etiologies, parasite and viral etiologies are not insignificant and the treatment and mitigation for non-bacterial etiologies could be optimized to reduce the burden of diarrhea diseases. The rates of parasitic infections were low most likely due to the administration of deworming treatment for children. These easy interventions should be more aggressively implemented to further reduce the incidence of parasitic infections not only cause diarrhea but can contribute to nutritional deficiencies and stunting in children [26].

Geographical variations in etiology

Western Kenya had the most prevalent parasitic causes which could be due to flooding events frequently experienced in this region [27] as supported by a study in Pacific Island that amoebiasis was associated with flooding [28]. These flooding events can overwhelm wastewater treatment plants, septic tanks and latrines releasing raw sewage into the environment and into water sources with viable microbial pathogens causing upsurges in diarrheal disease [28]. Bacterial, viral, and parasitic pathogens infections were significantly high in Luo Nyanza. Central Kenya had predominantly bacterial and viral pathogens while the Coastal region had a higher burden of viral etiologies. The North Eastern region reported high prevalence of bacterial pathogens [29] which could suggest that viral pathogens do not thrive in persistently dry regions. With the identification of the pathogens independently associated with moderate to severe diarrhea and their respective pathogen-specific AF, it is estimated that 35.62–46.03% of MSD could be reduced with specific interventions against those particular pathogens such as effective vaccines [30].

It is important to note that no studies of diarrheal diseases were conducted in counties like Tana River, Taita Taveta, Kirinyaga, Nyandarua and Nyeri counties had. This underreporting could reflect a truly low incidence of disease but could also be due to historic misconceptions about the distribution of diarrheal disease leading to low research interest in those regions. Another reason could be because of the logistical challenges of conducting research in remote and hard to reach areas with low population density (Tana River and Taita Taveta). Outbreaks of other infectious diseases or public health emergencies can overshadow diarrheal diseases leading to a neglect in diarrheal diseases.

Risk factors associated with diarrhea

Seasonal changes significantly impacted the prevalence and etiology of diarrheal diseases. Studies indicated that dry months were associated with higher incidences of Norovirus, while rainy seasons saw increased cases of *Shigella* and *E. coli.* In Malindi, *E. coli* infections were more common during dry seasons [4]. Rotavirus and adenovirus cases peaked in the dry months while norovirus GII and sapovirus peaked in the rainy season. Astrovirus did not display clear seasonality according to another study done in Kilifi [31,32]. Similar patterns in the seasonality of rotavirus, adenovirus, norovirus and sapovirus have been observed elsewhere [26,33,34]. These findings underscore the influence of seasonal variations on diarrheal disease patterns, necessitating tailored public health responses based on seasonal trends [31]. Our findings however are in contrast with a study done by Fan *et al*., 2019 in Malawi, where the prevalence of Norovirus was lower in the dry seasons compared to the rainy seasons) [35].

Multiple studies identified socioeconomic factors, hygiene practices, and environmental risks as key contributors to diarrheal prevalence. Poor hygiene, lack of sanitation, and use of natural water sources were consistently associated with higher diarrhea incidence [2]. Children under five years were particularly vulnerable, with peak incidences during weaning periods. Other studies also highlighted gender disparities, with male children experiencing higher rates of Rotavirus infection [16].

Hygiene practices related with washing hands and having facilities to dispose child's stool have been associated with increased risk of diarrhea [30]. Limited access to safe water and poor sanitation, coupled with poor hygiene practices have been reported to be high risk factor for diarrhea by several studies [30]. Toilet sharing creates unsanitary and unkempt conditions, which provide conducive environments for vectors and pathogens associated with diarrhea, increasing also the possibility of inter-household transmission [27]. Thus, our findings reinforce the need to improve the implementation of general sanitation practices (such as washing hands and having facilities to dispose child's stools safely), particularly among children aged 0–59 months who presented the highest risk. Breast-feeding, especially if this is the only source of nutrition, has been shown to protect children against diarrhea in Africa as elsewhere in the developing world [36]. High diarrhea incidences during weaning period can be attributed to introduction of external food and interacting with an increase exposure of the toddler to contaminated food and to lack of sanitation and personal and domestic hygiene.

Interventions to prevent Diarrheal diseases

Many interventions have been explored to reduce the high prevalence of diarrheal diseases. The Integrated Global Action Plan for the Prevention and Control of Pneumonia and Diarrhea by WHO/UNICEF is a document by countries that came together to outline strategies that can be employed by member countries to reduce diarrheal diseases and pneumonia in children under the age of 5 years by 2025. The specific goals are: To reduce mortality from diarrhea in children less than 5 years of age to fewer than 1 per 1000 live births and to reduce the incidence of severe diarrhea by 75% in children less than 5 years of age compared to 2010 levels. These goals are envisioned to be strategically achieved through three arms Protection, Prevention, and Treatment. Under protection, some of the interventions outlined include: Exclusive breastfeeding for six months and continued breastfeeding with appropriate complementary feeding reduces the onset and severity of diarrhea. A study by Bhutta *et al*, reported that not breastfeeding was associated with a 165% increase in diarrhea incidence in 0-5 month-old infants [2]. Interventions that helped prevent diarrheal diseases

include improved sanitation was reported to reduce the risk of diarrhea by 36% [2]. Hand-washing practices reduced the risk of diarrhea by 48% [37]. House-hold water treatment and safe storage to ensure safe-drinking water reduced the risk of diarrhea by 31-52% [38]. In the Treatment arm, the use of ORS was noted to reduce diarrheal mortality by 93% in the case of 100% coverage [39], and the use of Zinc in the treatment of diarrhea reduced mortality by 23 % [38].

The use of vaccines against Rotavirus, the most common cause of childhood diarrhea deaths, substantially reduces the disease burden and deaths. After the monovalent Rotarix® vaccine was introduced into Kenya's National Immunization Programme in July 2014, with doses given at 6 and 10 weeks of life, a multi-site case-control study found an overall 2-dose vaccine effectiveness of about 64% in under five years old children resulting in a significant decline of rotavirus group A (RVA) disease burden in Kenya [40]. A 10.5% reduction ~~of~~ in rotavirus prevalence in coastal Kenya following the rotarix vaccine introduction has been reported [32]. These findings concur with findings of a recent multi-site study in Kenya that reported RVA vaccine effectiveness of ~64% (95% CI: 35–80%) and a reduction in rotavirus-associated hospital admissions two years post-vaccine introduction of ~80% (95% CI: 46–93%) [31,32]. A significant increase in the prevalence of norovirus GII in post-rotavirus vaccine introduction has been reported in Kilifi [32], similar findings have been observed in the United States, Nicaragua and Bolivia following RVA vaccine introduction [41]. The driving force behind this phenomenon is unclear. It has also been noted that the introduction of rotavirus vaccines may result in the shift of diarrhea disease burden to slightly older age groups (12.5 months) compared 11.2 months pre-introduction. This in part may be explained by the higher immunity at both individual and population levels against rotavirus that wanes as children grow older. This finding reinforces evidence of the continued benefit of rotavirus vaccination in Kenya.

The role of Water, Sanitation and Hygiene (WASH) in diarrheal infections

Poor water, sanitation, and hygiene conditions are the primary routes of exposure and infection. Sanitation and hygiene interventions are estimated to generate a 36% and 48% reduction in diarrheal risk in young children, respectively [41]. Target 6.2 of the Sustainable Development Goals(SDG) aims to ensure adequate sanitation for all and to end open defecation, which contaminates water and spreads diseases such as cholera, diarrhea, and dysentery, by 2030 [42]. In sub-Saharan Africa, an estimated 215 million people engage in open defecation [43]. Only 3 countries (Ethiopia, Angola and Sao Tome and Principe) decreased open defecation by 10 % or more between 2005 and 2010 [42]. In Kenya, an estimated 5.6 million people still defecate in the open [44]. This review notes that Open defecation and lack of proper sanitation are associated with high incidences of diarrhea. Ninety percent of diarrhea deaths in children under five years in Kenya are attributed to poor water, sanitation, and hygiene [2]. A study conducted in Kisumu and Busia in 2012,2013 and 2014 revealed that sub-counties certified as Open Defecation Free showed a decline in diarrhea cases in children across the three years compared to sub-counties yet to attain this status [45]. A review of historical data from the Kenya Health and Demographic Surveys (KHDHS) from the years 1989,1993,1998,2003,2008-09,2014,2022 shows a decreasing prevalence of diarrhea in children under five years old over the years, from as high as 17% in 1998 to 14% in 2022 [6,46]. This decrease reflects the national efforts to improve hygiene and sanitation in agreement with the global goal of SDG 6.2. Antimicrobial use and resistance patterns.

Antimicrobial use and resistance patterns.

Antibiotic resistance emerged as a critical concern, with high resistance rates reported for commonly used antibiotics such as ampicillin, tetracycline, and trimethoprim/sulfamethoxazole. These antibiotics are widely used due to their availability and affordability in Kenya. The widespread usage of tetracycline in livestock husbandry in Kenya could be a contributing factor to its high resistance [47]. Exposure to commercial-scale farm raised chickens [48] and consumption of retail meat [49] have been shown to increase individuals' risk for carriage of and infection by antibiotic-resistant E. coli, and the causal link between the carriage of resistant fecal flora in human populations and the use of antibiotics in farm animals has been amply demonstrated [50,51]. Although most diarrheal diseases are self-resolving and should not be treated with antimicrobial agents, in the event of prolonged diarrhea that necessitate treatment, fluid and electrolyte administration is indicated. Correct fluid prescription has been proven to significantly reduce the risk of early mortality (within 2 days) in all subgroups [52]. The use of oral rehydration salts has been reported to reduce diarrhea related mortality in Kenya by 10.2% [45]. Antimicrobial drug therapy is indicated for acute infectious gastroenteritis especially among children [47]. This review noted significant patterns of antibiotic use, which may be due to uncontrolled use of antibiotics such as self – medicating and access to drugs without prescription with widespread consideration of ampicillin, tetracycline, chloramphenicol, ceftriaxone, and gentamicin. The emergence of multidrug-resistant strains and ESBL-producing organisms, particularly among diarrheagenic E. coli, represents a major public health challenge. Particularly concerning is the high prevalence of extended-spectrum beta-lactamase (ESBL)-producing organisms. Our review found that 27% of enteroaggregative E. coli (EAEC) and 50% of enterotoxigenic E. coli (ETEC) isolates were ESBL producers. These organisms can hydrolyze a wide range of beta-lactam antibiotics, rendering them ineffective and complicating treatment options [53]. Horizontal gene transfer which occur more commonly among E. coli isolates than the other pathogen genera, leads to a higher prevalence of non-susceptibility to commonly used antibiotics further complicating their treatment [37]. In this review, Shigella species showed multiple drug resistance pattern which is in tandem with the detection of multiple-resistant Shigella strains in Africa, England and Asia [54,55]. The resistance pattern in our study could be explained by the presence of *dhfr Ia* gene previously

described in Shigella and considered the most common dihydrofolate reductase gene in the genus [36,56]. In East Africa and other African countries, low resistance to nalidixic acid and no resistance to ciprofloxacin has been observed in Shigella isolates [57]. Low resistance to ciprofloxacin, norfloxacin, ceftriaxone and cefuroxime by Shigella species indicates that these drugs may be more effective therapeutic alternatives and further supports the current use of these regimens [58,59]. This finding is critical considering the numerous factors that include frequent overuse and misuse of antimicrobials that may contribute to resistance by pathogens causing gastroenteritis in developing countries like Kenya. Resistance patterns for *C. difficile* also indicated high levels of resistance to multiple antibiotics [18,60]. The high frequency of antimicrobial resistance reported in these findings is not unique to Kenya. Similar findings have been reported in studies conducted among children in Vietnam, Central Africa, Tanzania, México, Argentina and Mozambique, where high levels of erythromycin and ampicillin resistance was observed for all the tested pathogens [61,62]. This also concurs with an earlier report of a worldwide occurrence of drug resistant enteric pathogens, a development attributed to inaccurate diagnosis and inappropriate use of these drugs in the treatment of infections [57,63]. These findings highlight the critical nature of problems caused by antimicrobial resistance in many developing countries where frequent illnesses coupled with ready access to unregulated antibiotics diminishes the value of these agents for those patients who actually need them.

Study limitations

This review aimed to map existing literature on the prevalence, etiology, risk factors, and interventions of diarrheal diseases in Kenya. However, there were limitations in the reliance on only formal publicly available publications and not grey literature sources, such as the public databases such as Kenya Health Information Software (KHIS]. This data was not included due to concerns about data quality and consistency however, the exclusion may have led to an underrepresentation of diarrhea incidence and prevalence data from some counties, and trends and interventions documented in grey sources. During article screening, it is possible that some studies were missed due to the terms and databases used and due to the reviewer's subjective judgement on what to include. The importance of reliable and consistent public health data cannot be overemphasized for implementing targeted interventions for high burden diseases such as diarrhea for generating alerts to public health events like outbreaks.

5. Conclusions

From the scoping review the prevalence of diarrhea varies considerably and ranges from 3.44% to 20.79% across countries. The data is skewed towards children under 5 but is also a significant disease in adults especially in outbreaks. The causes of diarrhea are varied and regrettably include vaccine preventable disease such as rotavirus and easily managed infections such as parasitic diseases. Some etiologies are likely underrepresented such as *C. difficile* due to diagnostic challenges and poor representation by adults. Geographical variations require regional specific interventions or therapies and more studies in understudied regions and counties in Kenya. The seasonality trends in some of infections calls for adequate preparedness for timely interventions to reduce the impact of their spike. There is need for implementation of public health policies that have been put in place to address the issues on sanitation, hygiene and antibiotic utilization for effective response to high prevalence of diarrhea and the emerging increase of antibiotic resistance to some of the widely used antibiotics.

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