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Prevalence and Molecular Characterization of *Rotavirus* in Meat Cuts, and Meat Handlers in Selected Abattoirs in Nairobi, Kenya

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Abstract

In Kenya, food screening exercises mostly applies to bacterial and parasitic agents, with enteric viral detection neglected. The aim of this study was to investigate the prevalence and molecular characterization of *rotavirus* in beef and pork cuts, as well as among handlers, in four selected abattoirs in Nairobi. *Rotavirus* was preferred because of its high prevalence rates and its ability to cause pathophysiologic infective gastroenteritis in humans. It has diverse strains characterized as P and G genotypes based on the VP7 and VP4 proteins, respectively. This cross-section study involved the collection of a total of 467, (165) beef/pork cuts and (302) handlers' fecal samples. Collected samples were prepared before *rotavirus* identification. Prepared meat and stool suspensions were subjected to direct RNA extraction and EIA detection respectively. All the stool suspensions and RNA extracted meat suspensions subjected to EIA and Two step RT-PCR were all non-reactive respectively. Therefore, there was no VP4 and VP7 genotyping for characterization purposes on confirmed primary PCR products. Eppicollect5 was also used to collect and store the descriptive data of study participants, and the analysis conducted using Power BI statistical software application. The study's findings, indicating no human viral infections in meat cuts, enhance public health by reassuring consumers, guiding regulatory policies, emphasizing the need for ongoing surveillance, directing resources to pressing concerns, supporting safe food handling campaigns, establishing baseline data for future assessments, and encouraging best practices in both formal and informal markets.

Keywords

Rotavirus, Adults, Meat Handlers, Meat Products, Abattoirs

1. Introduction

Background

The World Health Organization (WHO) 2019 report on foodborne diseases suggests that approximately 600 million individuals suffer from foodborne diseases yearly, leading to 420,000 deaths and 33 million HLY (healthy life years) lost. These diseases are commonly transmitted by consuming contaminated food through, direct or person-to-person contact, fecal-oral, fecal contamination of food, and contaminated environmental surfaces [1].

In another observation by the Global Burden of Disease (GBD-2019), it was reported that most developing and under-developed countries in Africa have low socioeconomic status and serve the highest population affected by diarrheal diseases [2].

In Kenya, diarrheal diseases and foodborne illnesses pose a significant public health challenge, with 29% of diarrheal cases linked to food transmission, as reported by WHO in 2024 [3]. Data from the Kenya Demographic and Health Survey (KDHS) highlighted prevalent foodborne pathogens isolated in different counties in Kenya, include *Salmonella* spp., *Listeria* spp., *Campylobacter* spp., *Vibrio* spp., Norovirus, Adenovirus, *Giardia* spp., and *Entamoeba* spp. with Nairobi having the highest disease burden at 4.6% [4]. In 2021, a study in Kiambu County revealed 725 reported cases of foodborne illnesses in adults, primarily caused by some of the pathogens such as *Salmonella* (200 cases), *Campylobacter* (165), and *E. histolytica* (156). Most self-limiting acute gastroenteritis sometimes require fluid replacement and supportive care [5]. Oral rehydration is recommended for mild to moderate dehydration, while severe cases especially in immunocompromised individuals may need intravenous or antimicrobial therapies, which are essential and should be guided by clinical manifestations and susceptibility tests. Commonly recommended therapies include antiparasitic agents (albendazole, metronidazole, entamizole, tinidazole and praziquantel), antibacterial agents (fluoroquinolones, third-generation cephalosporins, ampicillin, gentamicin, and sulfamethoxazole/trimethoprim), and vaccines.

However, by considering these previous global and regional surveillance data on diarrheal or food-borne illnesses, FAO/WHO started a collaborative program in 2008 with the Codex Alimentarius by providing recommendations to develop programs for the control of food-borne diseases. The proposed document released by FAO/WHO had relevant guidelines to decrease the number of these gastroenteric diseases, treating all gastroenteric as potentially infectious agents for food-borne infections [6]. These FAO guidelines and recommendations were implemented in Kenya through the routine detection of bacterial and parasitic agents

in food, the environment (water and surfaces), and clinical (blood, urine, and fecal) samples under the worldwide establishment of food handling programs. These programs serve as major surveillance programs to prevent potential food-borne outbreaks from contaminated food products to consumers [7].

In Nairobi County, the food handling programs' exercise involves screening for food-borne diseases caused by bacterial and parasitic agents among handlers, an exercise authorized by the Ministry of Health under the Food, Drug, and Chemical Substance Act (food hygiene) regulations, cap 254 of the Constitution [8].

Food handlers' responsibilities depend on the type of food undergoing processing and production procedures. The procedures required for meat processing by meat handlers involve skinning and evisceration of carcasses, trimming, and final washing of meat before packaging, transport, and sale to the community for consumption [9] [10]. After subsequent meat processing and production, meat products (beef and pork) are evaluated for contamination before distribution to the public. Meat contamination by bacterial, parasitic, and viral agents can be associated with poor handling of meat by handlers working in different processing dockets. Viral contamination in meat can either be through clinical or environmental contamination mechanisms [11].

However, with the increasing number of food-borne infections, the concept of one health which is a multi-disciplinary and collaborative approaches provides bridges linking animal health, human health and environmental health, these linkages are required to evaluate and comprehend the ecology of rising zoonotic diseases [12]. Most studies on enteric viral detection have also applied this concept [13].

Many of these enteric viruses tend to be non-enveloped, exhibiting greater resilience to heat, desiccation, fluctuations in pH, ultraviolet radiation, and exposure to natural light. In contrast to bacteria, these viruses do not exist as independent living organisms [14] [15]. Therefore, there replication relies on specific living host cells. Another important issue in regard to food safety is, the ability of these non-enveloped viruses to resist various environmental stresses, cleaning, and sanitation programs thus interfering with the effectiveness of hygiene programs [16].

Among the viral enteric, *rotavirus* was selected for study because of its well-known zoonotic characteristics and its high prevalence rates. *Rotavirus* is a prevalent contributor to pathophysiologic infectious gastroenteritis among children below five years. [17].

In Kenya, it is estimated that over 3000 people die annually as a result of *rotavirus* infection, with the impact being particularly severe in rural areas compared to urban settings [18]. The prevalence of *rotavirus* is notably high among children aged 6 - 11 months (27%) and those aged 12 - 23 months (24%), with significantly elevated rates observed in predominantly rural regions such as Western, Nyanza, and Coast. In contrast, urban areas like Nairobi exhibit lower prevalence rates, ranging from 16% to 20%. Additionally, the data reveals that the highest

prevalence occurs within the lowest wealth quintile (17.2%), underscoring the critical influence of socio-economic factors on the severity of *rotavirus* infections [4]. This combination of high prevalence in rural areas and socio-economic disparities highlights the critical need for targeted interventions to address *rotavirus* infections, particularly among vulnerable populations [19].

Despite the high prevalence rates in neonatal, RV has also been associated to infective gastroenteritis in adults. However, recent studies on RV in food types has significantly shown human rotaviral infections in food products, indicating there's possible contamination of food from infected individuals [14].

Rotavirus of reoviridae family is categorized as a double-stranded RNA viruses. Its RNA is enclosed within a three-layered icosahedral structure, which is classified into seven primary categories (A to G) based on the VP6 gene. Among rotaviruses, acute gastroenteric infections are known to be caused by mainly group A human rotaviruses (RVAs) [18]. *Rotavirus* also has diverse strains characterized by both P genotypes and G genotypes based on VP7 and VP4, respectively [20].

The limited viral detection procedures for food handlers and their respective food products have contributed to underdiagnosis and underreporting, despite biannual food handling exercises in Kenya. Furthermore, advanced diagnostic techniques can be expensive and may be inaccessible in many low-resource settings, restricting their use. This poses a challenge for our health practitioners in managing issues related to environmental persistence, heterogeneity, and the emergence of new viruses [21]. Therefore, the study aims to determine the prevalence of *rotavirus* in meat cuts and among meat handlers.

Most food handling screening exercises in Kenya focus only on bacterial and parasitic diagnosis, despite intestinal viruses having the capacity to cause explosive food-borne outbreaks. These outbreaks can occur due to a high rate of viral shedding from infected animals or humans, even though these enteric viruses have a low infectious dose.

Several studies have been conducted on viral detection in different food types. Some of these studies were conducted in Brazil, Italy, the United Kingdom, and the United States [1] [14] [22]. Therefore, enteric viral detection in meat products in these studies has been highly appreciated and recommended worldwide, while little has been done to associate these viral contaminations in food-to-food handlers, despite recent cases of foodborne outbreaks in Australia caused by two HEV infected individuals [23]. Detection of enteric viral infection in food handlers has also been treated insignificantly in most African countries, especially Kenya, despite the increasing number of viral foodborne outbreaks worldwide. Most studies have been done globally, with only such few studies done locally, such as norovirus detection among the food handlers working in informal set-up., [24]. These previous studies have been essential in associating study subjects to enteric viral agents and identifying any possible viral cross-contamination by applying the concept of one health approach.

Despite the increasing diversity of these viral enteric agents, there is limited

epidemiological data on intestinal viruses worldwide. However, more studies on enteric viral infections on food products/food handlers should be conducted to help design local and global health policies required to prevent future outbreaks.

In Nairobi County, studies on viral detection in food products have yet to be conducted despite the increasing burden of foodborne diseases, which increases as demand for food increases.

Considering the high prevalence rates of respiratory and gastroenteric infections globally and locally, this study tends to select *rotavirus* (RV) for study and to fill the knowledge gap existing in *rotavirus*-related infections among the food handlers. Moreover, comparative studies on other enteric viral agents can also be conducted to cover a wider scope of viral-related gastroenteric infections.

Recent research has revealed a variety of enteric viruses present in food and the surrounding environment, despite viral detection being underappreciated. Therefore, this study proposes using meat cuts (beef and pork) and handlers' fecal samples collected from four different abattoirs in Nairobi. Meat cuts (beef and pork) will be preferable since most of these enteric viruses are associated with cases of zoonotic transmission occurs via the ingestion of raw or inadequately cooked contaminated meat or its products [11] [25]. Beef and pork cuts will be the preferred meat type considering the high consumption rates per capita by inhabitants of Nairobi County. Fecal samples from meat handlers will be required, considering the main transmission route of most food-borne diseases is through fecal-oral. Viral transmission by fecal-oral routes depends on high viral shedding rates with low infectious doses in symptomatic and asymptomatic individuals. This is the most important clinical sample type required during food handling examination exercises [11].

Additional research has been conducted on *rotavirus* in neonates, which is a prevalent contributor to gastrointestinal infections among children under five years old. The lack of recognition of *rotavirus* in adults is also a cause for alarm considering there's limited knowledge on the source of rotaviral infection in children.

The study was expected to examine and evaluate the prevalence of *rotavirus* infections in fecal samples and meat cuts. The findings of this study will help food establishments design relevant preventive measures required to eliminate any possible transmission of viral infections to the public through food.

2. Materials and Methodology

2.1. Study Site and Design

A cross-sectional study was carried out in Nairobi, focusing on the four primary abattoirs for beef and pork. The selection criteria for these four zones were centered on both formal and informal operations, with every two sites being representative of either beef or pork. These four sites were the study's most preferred and relevant sites.

The study involved two sample types: stool and meat cuts. The subjects included handlers of pork and beef.

2.2. Sample Collection

During the period from February to August 2023, 302 stool samples and 165 meat cuts were collected resulting in a total of 467 samples for the study. Simple random sampling techniques were used for the random selection of meat cuts and participants in the 4 Study sites. Data on beef/pork handlers were collected qualitatively and quantitatively using questionnaires. Dry sterile leakproof stool collections container was used to collect fecal samples. In the informal, 50 g of fresh beef/pork cuts sections were randomly collected from different body parts of the carcasses, while in the formal setup, the same quantity of meat cuts/products were randomly selected from the production site. The 50 g of beef/pork cuts sections and fecal samples were then packaged in sterile sample packaging bags or sampling containers and placed carefully in different sterile cooler boxes with ice packs for transportation and storage. These samples were transported to KEMRI-CVR labs at temperatures between 2˚C and 8˚C for up to 5 hours after collection.

Table 1 and Table 2 show the distribution of sampling from the selected abattoirs.

Table 1. Sample distribution from different establishments.

Abattoir	Number of stool samples from handlers	Meat type	Number of Meat cuts	Location of Study Site
Site 1	76	Pork	41	Kahawa West
Site 2	75	Beef	41	Kahawa West
Site 3	75	Beef	41	Makadara
Site 4	76	Pork	42	Lower Kabete

Table 2. Sampling distribution of meat cuts/products collected from the abattoirs.

Abattoir	Name of product/section from animal carcasses	Number of Meat cuts
Site 1	Pork leg	3
	Sausages (5 different types)	15
	Bacons	3
	Pork belly	3
	Liver	3
	Pork frankfurters	3
	Pork neck fillet	3
	Polony	2
	Sandwich hams	3
	Pork loin	3
	Sandwich beefs	6

Continued

Site 2	Smokies	6
	beef chipolatas	6
	Beef brawns	6
	beef sausages (3 different types)	17
	Shank	7
Site 3	Round cut	7
	Rump cup	7
	Chuck	7
	Rib Steak	6
	T-borne steak	7
Site 4	Boston Butt	11
	Loin	10
	Ham	10
	Picnic shoulder	11

2.3. Sample Preparation and RV detection

2.3.1. Meat Cuts Sample Preparation

Beef/pork cuts were defrosted and homogenized, and 1 g of the 50 g punched beef/pork sample were collected and macerated in 1 ml of amino acid-rich bench stable minimum essential medium (MEM, pH 7.0). The combinations were vortexed for approximately 10 seconds and centrifuged for 5 min at 10,000 rpm before Trizol RNA extraction.

2.3.2. Stool Sample Preparation

The collected stool samples were diluted in (1:10) tenfold phosphate-buffered solution (pH 7.4) by adding 1 g of a stool specimen to the phosphate-buffered saline solution (PBS). Alternatively, 1 ml of loose stool samples were added to 9 ml of PBS in case samples were retrieved from those with diarrheal symptoms. The prepared suspensions were centrifuged at 3000 rpm for 30 min before *rotavirus* identification using immunoassays.

2.3.3. *Rotavirus* Identification by Immunoassay

The prepared suspensions of diluted stool samples were subjected to indirect sandwich ELISA-serotyping using a commercial enzyme immunoassay (EIA) in accordance with the manufacturer's instructions (Meridian Bioscience™ Immuno-Card™ STAT! *Rotavirus* Test Kit, Rotaclone, Cincinnati, USA).

2.3.4. RNA Extraction and RT-PCR

The EIA positive stool samples and all homogenized meat suspensions underwent

the procedure for nucleic acid extraction using Qiagen and Trizol RNA extraction kits respectively. The extraction procedures were conducted according to the manufacturer's specification with some little modifications required. Detection of the RVAs dsRNA was performed by Two Step RT-PCR using ReverTrace and KOD PLUS Kits. The dsRNA was denatured to ssRNA at 97c for 2 min, the resulting ssRNA product was reverse transcribed at 42c for 30 min, 97c for 5 min, and 4c for 5 min using ReverTrace kit for complementary DNA synthesis. The resulting product, complementary DNA, was then used for primary PCR, to amplify the fragments VP4 and VP7 segments of RVA using KOD-PLUS kit. Amplification was done on a Thermocycler using the following thermocycling conditions: 95c for 2 min, (94c for 30 sec, 48c for 30 sec, 72c for 1 min) 30 cycles, 72c for 7 min, and 4c for infinity. The primary PCR products were ultimately analyzed using 1.2% agarose gel electrophoresis and then visualized using trans-illuminator device.

2.3.5. VP7 and VP4 Genotyping

Multiplexed Semi-Nested RT-PCR

The primary PCR products positive for VP7 and VP4 were to be subjected to G and P genotyping using different sets of VP7 2nd and VP4 2nd primers respectively. PCR reactions were performed using a Thermocycler with the following thermocycling conditions—95c for 5 min, (94c for 30 sec, 48c for 30 sec, 72c for 1 min) 35 cycles, 72c for 7 min, and 4c for infinity (Table 3).

Table 3. List of primers used to detect *rotavirus* RV.

VP7	Primer Code	Sequence (5'-3')	Product Length (bp)
First PCR	T31 + Sense; 5		1 - 28
	T32 – Sense; 3		1039 - 1062
Second PCR (Genotyping)	T32 – Sense; 3		1039 - 1062
G1	T33 + Sense	CAAGTACTCAAATCAATGATGG	748
G2	T34 + Sense	GACTACAATGATATTACTAC	656
G3	T50 + Sense	GACGCGACGTTGCAATTG	581
G4	T51 + Sense	TCAAACGACAAATACAGCTA	393
G8	T38 + Sense	GTCACACCATTTGTAAATTCG	884
G9	T39 + Sense	CTAGATGTAACTACAACTAC	305

Continued

VP4	Primer Code	Sequence (5'-3')	Product Length (bp)
First PCR	PCR4-5-1 + Sense; 5		11 - 37
	3 PCR4 – Sense; 3		1072 - 1094
Second PCR (Genotyping)	PCR4-5-1+ Sense; 5		11 - 32
P[8]	P1PCR4 – Sense	ATATTCCTACGAGTTTAGTATC	497
P[4]	P2PCR4 – Sense	ACTAACATGTGGTTCAACTGCGAT	337
P[6]	P3PCR4 – Sense	CTGAGCACGTTGATAAGTCAC	742
P[9]	P4PCR4 – Sense	CGTATATTGATAGTTCATGGG	910

2.4. Data Analysis

Data analysis was conducted using the Power BI statistical software application. The results from laboratory tests and questionnaire responses were tabulated, coded, and analyzed by employing frequency distribution tables and percentages. Descriptive statistics was also used to provide a clear image of background variables. The Chi-square was to be employed to associate *rotavirus* with meat handlers' hygienic practices. Eppicollect5 was used to collect and store the socio-demographic data from the questionnaire. Finally stored data in Epicollect5 was accompanied by manual documentation of A4 hard copies as backups before storage in a locked cabinet.

3. Results

467 samples were analyzed, including 302 stool samples, and 165 meat cuts sourced from four different abattoirs. Enzyme-linked immunoassay (Indirect Sandwich ELISA) and two-step RT-PCR methods were used to analyze stool and meat samples respectively, to show handlers and meat cuts that are positive or negative.

Table 4 and Table 5 shows the prevalence of *rotavirus* in stool and meat cuts.

3.1. The Prevalence of *Rotavirus* among Beef/Pork Handlers at the 4 Study Sites

The prevalence of *rotavirus* among beef/pork handlers was 0% (n = 302), 95%CI: The Indirect Sandwich ELISA results for the stool samples analyzed were all non-reactive in the 4 study sites as shown in Table 5 below.

3.2. The Prevalence of *Rotavirus* in Beef/Pork Cuts from the 4 study Sites

Additionally, the prevalence of *rotavirus* in meat cuts was also 0.00% (n=165),

95%CI. The Two-Step RT PCR results for Meat cuts from the 4 study sites were all non-reactive as shown in Table 5 below.

Table 4. Indirect sandwich ELISA results.

Abattoir	Gender		Age Mean	Number of stool samples analysed	Results	
	M	F			Pos	Neg
Site 1	56	20	35.11	76	0	76
Site 2	67	8	35.07	75	0	75
Site 3	46	29	36.99	75	0	75
Site 4	63	13	35.61	76	0	76

Table 5. 2-Step RT-PCR results.

Abattoir	Meat type	Number of Meat cuts analysed	Results	
			Pos	Neg
Site 1	Pork	41	0	41
Site 2	Beef	41	0	41
Site 3	Beef	41	0	41
Site 4	Pork	42	0	42

3.3. Demographic Details of Participants and Their Questionnaire Responses from Various Abattoirs

The study included 302 beef and pork handlers. The demographic characteristics examined included gender, age, education level, and marital status, as detailed in Table 5. Their average age was 35.69 years old across all 4 abattoirs. Regarding the education level of the personnel involved in the study, the highest attained level was tertiary (university/college). In the formal establishments, most participants had attained tertiary (university/college) level education with few participants having lower levels of education. In contrast, the informal establishments had a more diverse range of education levels among their participants. While the highest level of education was also tertiary, many of the participants in the informal abattoirs had lower levels of education, unlike the formal establishments. Additionally, in formal settings, most participants, including those with tertiary education, received comprehensive hygiene training. The emergence of COVID-19 significantly increased the demand for such training, ensuring that individuals working in formal abattoirs were well-equipped with essential hygiene knowledge and practices. This heightened focus on hygiene has been crucial in maintaining health standards and preventing disease transmission within these environments [26].

However, the situation was markedly different in informal establishments. While participants with tertiary-level education in informal abattoirs did receive some

hygiene training, those with lower levels of education were often left without adequate training. This disparity in access to hygiene training based on educational background raises concerns, as it highlights a significant gap in knowledge and practices among employees. Unlike in formal abattoirs, where hygiene training was consistently implemented across all employee groups, informal establishments exhibited a troubling inconsistency that could jeopardize health and safety standards.

In the informal establishments, most of the meat handlers were observed to be working without the appropriate personal protective equipment. Many were seen wearing torn dust coats, and were missing essential PPE items such as gloves, gumboots, hair nets, and masks. This was the case despite the inherently unhygienic environment in which they were operating.

In stark contrast, the meat handlers in the formal establishments were provided with the necessary PPE to ensure their safety and maintain proper hygiene standards. The formal abattoirs ensured that their employees were equipped with the appropriate protective gear, including intact dust coats, gloves, gumboots, hair nets, and masks, enabling them to work in a more hygienic and safe manner. It was observed that the majority of participants did not exhibit symptoms of diarrhea, vomiting, or abdominal pain, with the exception of a few individuals who experienced non-rotaviral stomach complications and presented with abdominal pain.

Table 6. Demographic details of participants and their questionnaire responses from various abattoirs.

(a)

Abattoir	Gender		Age	Marital Status			Level of Education		
	M	F	Mean	Y	N	O	P	S	T
Site 1	56	20	35.11	62	14	0	0	35	41
Site 2	67	8	35.07	64	8	3	3	28	44
Site 3	46	29	36.99	53	16	6	16	45	14
Site 4	63	13	35.61	68	7	1	17	39	20

(b)

Abattoir	Hygiene Training		Use of PPEs		GIT complications		Abdominal pain		Vomiting	
	Y	N	Y	N	Y	N	Y	N	Y	N
Site 1	76	0	75	0	17	59	17	0	2	15
Site 2	75	0	75	0	7	68	7	0	0	7
Site 3	10	65	68	7	5	70	5	0	0	5
Site 4	41	35	75	1	2	74	2	0	1	1

Y—Yes, N—No, O—Other, P—Primary, S—Secondary, T—Tertiary.

The findings showed that 36 (11.9%) had primary or lower level of education, 145 (48.1%) had secondary level education while 121 (40.0%) of the study respondents had tertiary level education. Analysis of marital status revealed that 55 (18.21%) of the patients were single while 247 (81.79%) were married as shown in Table 6.

4. Discussion

4.1. Prevalence of RV

The absence of RV in 467 samples (302 stool samples and 166 meat cuts) from the 4 selected abattoirs in Nairobi, Kenya, indicates a low risk associated with the consumption of these products. Globally, the primary sources of foodborne viral diseases are fish, fruits, and vegetables, which are often linked to water transmission [27] [28]. However, this study contributes to the limited research on viral detection in animal-derived products in Kenya, particularly fresh meat products.

Rotavirus (RV) can be transmitted between animals and humans through contaminated food, posing a public health risk. While infections are often self-limiting, studying foodborne viruses in animal products is crucial within the One Health framework. Therefore, this research aids in understanding transmission dynamics and informing public health interventions [13].

However, the lack of detection of *Rotavirus* A (RVA) in beef and pork cuts does not necessarily indicate a public health concern, despite the capacity of these microorganisms to survive on various surfaces under diverse environmental conditions, including low humidity, ambient temperatures, and refrigeration [11] [28]. Recent data indicate that RVA was responsible for 3.1% of foodborne outbreaks in Brazil in the past few years [14]. Furthermore, *rotavirus* is recognized as a significant pathogen associated with neonatal diarrhea on a global scale [29]. This study tends to screen RVA in stool samples from symptomatic and asymptomatic participants of adult age, working in abattoirs. The study findings support the rationale for the increased prevalence of the identified etiological agent in neonates with acute gastroenteritis (AGE) compared to adults, despite adult meat handlers working in environments that are more susceptible to zoonotic diseases.

4.2. Risk Factors Associated with the Spread of RV Gastroenteritis

Despite the absence of documented direct links between contaminated products and outbreaks of *rotavirus* (RV) in the population, infections typically occur via the fecal-oral route, person-to-person contact, or through contaminated food [30] [31]. RV is recognized as an enteric virus that serves as an indicator of environmental contamination during food handling processes and can help assess the sanitary quality of water used in these procedures. This indicates that the transmission of these pathogens can happen in food-handling environments, particularly through handlers or contaminated water sources [27].

Furthermore, certain viruses can lead to cross-contamination in both commercial and domestic settings due to their resistance to cleaning and sanitizing methods

[28]. These viruses exist as small, non-enveloped virions, lacking lipid bilayers, with outer protein layers (capsids) that confer greater resistance to environmental factors, disinfectants, and common sanitizers. Notably, RVs form highly stable and resilient viral particles in the environment due to their triple-layered capsid structure [18].

In Kenya, environmental monitoring studies have been conducted to assess the presence of enteric viruses in food, even in the absence of specific legislation. Recent evaluations revealed no detection of RV in the samples analysed [24] [32]. However, this finding does not necessarily indicate optimal hygiene conditions for products handled and sold, particularly in informal settlements. While the quantification and verification of the infectivity of viral particles were not feasible, the amplification of extracted genetic material was achieved.

The results of this study hold significant implications for health inspection and surveillance agencies, suggesting that meat products available in Nairobi pose minimal risk to consumer health. During the study, beef and pork samples showed a 0% frequency of RV detection, which is reassuring given the high consumption rates of these products in Nairobi. Nevertheless, the potential risks associated with improper handling of these products in home environments warrant consideration. Although these meats are generally not consumed raw, there are reports indicating that consumers often struggle with proper handling and storage, which could increase the risk of RV transmission in domestic settings [33].

The negative findings regarding RV may also reflect the positive impact of vaccination programs introduced by Kenya's national immunization program in 2014. The introduction of a two-dose monovalent vaccine, Rotarix and a three-dose pentavalent vaccine, Rotateq offered an opportunity to mitigate the spread of acute rotaviral gastroenteritis [34]. This intervention is expected to reduce a substantial amount of childhood morbidity and mortality, which could likely contribute to the reduced prevalence of viral infections.

Collectively, these factors contribute to a lower risk of contamination in meat products, thereby supporting public health outcomes in the region [35] [36].

4.3. Study Limitations and Further Research

This study aimed to identify a specific virus; however, it is imperative to expand the research scope to encompass additional pathogens. Due to current funding constraints in our country, our investigation was limited to the aforementioned virus. Future research efforts will aim to expand the focus to include the identification of other significant viruses, including norovirus, adenovirus, hepatitis E virus, coronavirus, rhinovirus, astrovirus, and hepatitis A virus. Additionally, the research was limited to a single geographical area, which restricts our ability to evaluate the wider epidemiological context. Nonetheless, we highlight that this is the first study conducted in the selected city. Future investigations will aim to encompass multiple counties across Kenya to offer a more thorough assessment of viral presence in food sources and among their handlers.

5. Conclusion

In this study, *rotavirus* antigen was found non-reactive in all stool samples and meat cut from animal carcass in the 4 abattoirs in Nairobi. Particular attention was paid to cleanliness and hygiene rules in the sampling areas (ground, floor and cutting surfaces) and equipment used in these slaughterhouses. It was observed that the equipment and surfaces in 2 slaughterhouses from formal regions were treated, and cutting surfaces were made of either stainless steel or wood when compared to abattoirs from informal areas. In addition, it could be concluded that whether employees receive hygiene training, or they generally use gloves during working could be effective in the protection of employees against *rotavirus* or any other gastroenteric infections, viral or non-viral.

Recommendations

We advocate for a comprehensive analysis of the contributions of various enteric viruses, including astroviruses, coronaviruses, hepatitis E virus (HEV), hepatitis A virus (HAV), adenoviruses, and norovirus, to outbreaks of acute gastroenteritis by integrating their testing as potential viral agents.

It is also imperative to delineate the specific roles of food handlers in the transmission dynamics of foodborne diseases across Kenya. Strengthening the food safety regulatory framework is vital for implementing policies that restrict symptomatic food workers from engaging in food handling and mandate a minimum of 48 hours off work following the resolution of symptoms. This approach effectively mitigates disease transmission risks.

Furthermore, comprehensive food safety training programs should be established in the study area, focusing on enhancing awareness of enteric diseases, understanding modes of foodborne disease transmission, and implementing effective prevention strategies, particularly emphasizing rigorous hand hygiene practices.

Additionally, thorough investigations of gastroenteritis outbreaks in the region are essential, with *rotavirus* considered a potential etiological agent among other pathogens. This multifaceted approach aims to enhance public health outcomes and reduce the burden of foodborne illnesses.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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