RESEARCH ARTICLE

Quantification of microbial risk associated with fecal exposure in a nomadic lifestyle; case study of Turbi ward, Marsabit County [version 1; peer review: awaiting peer review]

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Abstract

Background: Water, Sanitation and Hygiene (WASH) is the cornerstone for health and growth at all stages of life in helping to maintain health and increase in life span. Poor sanitation as lead to disease causing microorganisms such as E. coli to be on the rise. This study aimed to determine water and milk contamination of E. coli from nomadic community.

Methods: A cross-sectional study was conducted on water and milk samples using most probable number method to determine contamination as a result of poor sanitation in this community.

Results: The dominant exposure pathway in this study was water pathway with high E. coli positivity, 20% (n=50) for dam water sampled, 20% (n=50) for pan and borehole feed water tanks 20% (n=50). Dam water sources analyzed had presence of 1.05 x 10^7 CFU/ml and pan water sources 1.93 x 10^4 CFU/ml, which is above acceptable E. coli level in water for consumption is (10-40 CFU/ml)

Conclusions: Microbial contamination noted from this study indicates that there is poor sanitation in nomadic lifestyle. This study reaffirms the need for elaborate sanitation model tailored to the need of pastoralist community to reduce perennial faecal contamination of water sources for the community of Turbi ward. Elaborate sanitation model tailored to the need of pastoralist community to reduce perennial fecal contamination of water sources for the community of Turbi ward.

Keywords
sanitation, E. coli, colony forming units
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Author roles: Jaro B: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Writing – Original Draft Preparation, Writing – Review & Editing; Wandili S: Supervision, Validation; Gakii G: Supervision, Validation; Karani C: Conceptualization, Methodology, Supervision

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Introduction

Sanitation and water management is one of the ways to reduce the spread of enteric pathogens in the urban, peri-urban and rural environmental set up. The most affected are children, women and elderly people especially in a rural set up. The approach of a community to sanitation includes factors such as the perception, feelings and practices involved in defecation and urination, and the disposal of this waste. Their attitude is a result of interconnected factors of cognition as a result of knowledge, perception together with feeling and behaviour that leads to action (Rosenzweig et al. 1962). Sanitation solutions such as flush toilet, piped sewer system, ventilated pit latrines, etc., that prevent direct contact with human excrements are considered improved, while others such as bucket latrines, hanging toilets, and open defecation are not (WHO/UNICEF 2010).

The goal of SDG 6.2 is to provide access to adequate, equitable sanitation and hygiene for all and put an end to open defecation especially for girls, women and the vulnerable in the society by 2030 (World Bank 2016). Between 2015 and 2020, the population with safely managed sanitation increased from 47 per cent to 54 per cent and the population with access to handwashing facilities with soap and water in the home increased from 67 per cent to 71 per cent. Rates of progress for these basic services would need to quadruple for universal coverage to be reached by 2030.

Water, sanitation and hygiene (WASH) is the cornerstone for health and growth at all stages of life in helping to maintain health and increase in life span. Epidemiological studies has associated poor hygiene practices and lack of water with adverse health outcomes that includes diarrhoeal diseases caused by microorganisms such as E. coli leading to enteric malfunctions that leads to stunted growth. (Pruss-Ustun et al. 2014).

These exposure pathways can be through water bodies, food, utensils, storage tanks, sewerage system, open drains galleys or seepage. Tens of millions of people across the world, most of them children, die of sanitation related illness (WHO/UNICEF 2019).

Methods

Ethical consideration

Permission was sought through the board of postgraduate studies of Meru University of science and technology, The Meru University of Science and Technology Institutional Research Ethics Review Committee (MIRERC) and County government of Marsabit.

Study area

The study was carried out in the Turbi ward, North Sub-County of Marsabit County, Kenya, with a population of 23,978 (Kenya National Bureau of Statistics 2019). The populations are mostly Cushitic community practicing a pure nomadic lifestyle. The area has land mass of 10,821 km², and is located at longitude 38°22’.25”00’E, latitude 3°20’.51”00’N. Has tropical dry savanna climate. Map for Turbi ward in Northhorr sub county (Figure 1).

Study design and population

The study employed a cross-sectional study design with an aspect of laboratory analysis. Samples for analysis were collected from dams, pans, camel milk and swabs from milk holding containers. The samples were then transported to the laboratory for analysis. Consent to collect water samples from dams, pans and boreholes was obtained by village elders while milk and swabs from containers consent was given by household heads.

Sampling procedure

Simple random sampling was conducted to select one village from each center totaling to five villages. Water from dams, pans and boreholes were collected while milk samples were collected from the selected households.

Sample processing

Preparation and analysis of water and milk in the laboratory

Water and milk analysis for most probable number required sterile bottles with MacConkey broth, and Durham tubes for gas collection. Each bottle with sample was appropriately labelled. The water was mixed thoroughly by inverting the bottle many times. The cap of the bottle was removed and the mouth of the bottle flame. The water samples were then inoculated. After inoculation, the bottles were incubated at 44°C for 24 hours the samples were examined for color change and gas formation.
Figure 1. Shows sampled area of Turbi Ward.

Figure 2. CFUs from different sampled areas in Turbi Ward.
Positive isolates were subjected to biochemical identification using Indole test for *E. coli*. The test organism was inoculated in a bijou bottle containing 3 mL Tryptone water and incubated at 37°C for 24 hours.

**Enumeration of *E. coli* CFU using colony counter**

All samples that were confirmed to have *E. coli* were subjected to enumeration in order to calculate the colony forming unit. A serial dilution was performed up to $10^5$ for *E. coli*. Then 100 μL were transferred into plate count agar plates arranged from $10^0$ to $10^5$ respectively. They were incubated for 24 hours at 37°C. The plate that had grown distinct colonies were subjected to counting and colony forming unit calculated. Selected plate was placed on a counting chamber and a colony pointer was used to touch the surface where the colony was had grown on the media and all the colonies will be counted. Colony forming unit was obtained by multiplying number of colonies counted times the dilution factor.

**Table 1. No of colonies of *E. coli* per water source.**

<table>
<thead>
<tr>
<th>Manyatta</th>
<th>Water sources</th>
<th>No. of colonies</th>
<th>% negative (N=50)</th>
<th>% positives (N=50)</th>
<th>CFU/mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Okolla</td>
<td>Pan</td>
<td>193</td>
<td>1 (2%)</td>
<td>4 (8%)</td>
<td>$1.93 \times 10^4$</td>
</tr>
<tr>
<td>Shurr</td>
<td>Trough</td>
<td>61</td>
<td>3 (6%)</td>
<td>2 (4%)</td>
<td>$6.1 \times 10^4$</td>
</tr>
<tr>
<td></td>
<td>Household items</td>
<td>46</td>
<td>3 (6%)</td>
<td>2 (4%)</td>
<td>$4.6 \times 10^4$</td>
</tr>
<tr>
<td></td>
<td>Tank (borehole water)</td>
<td>41</td>
<td>0 (0%)</td>
<td>5 (10%)</td>
<td>$4.1 \times 10^3$</td>
</tr>
<tr>
<td>Dekuku</td>
<td>Tank (borehole water)</td>
<td>55</td>
<td>0 (0%)</td>
<td>5 (10%)</td>
<td>$5.5 \times 10^4$</td>
</tr>
<tr>
<td></td>
<td>Trough</td>
<td>69</td>
<td>0 (0%)</td>
<td>5 (10%)</td>
<td>$6.9 \times 10^5$</td>
</tr>
<tr>
<td>Kambi Nyoka</td>
<td>Trough</td>
<td>281</td>
<td>0 (0%)</td>
<td>5 (10%)</td>
<td>$2.81 \times 10^3$</td>
</tr>
<tr>
<td></td>
<td>Dam</td>
<td>40</td>
<td>0 (0%)</td>
<td>5 (10%)</td>
<td>$4.0 \times 10^4$</td>
</tr>
<tr>
<td>Turbi</td>
<td>Pan</td>
<td>34</td>
<td>0 (0%)</td>
<td>5 (10%)</td>
<td>$3.4 \times 10^3$</td>
</tr>
<tr>
<td></td>
<td>Dam</td>
<td>105</td>
<td>0 (0%)</td>
<td>5 (10%)</td>
<td>$1.05 \times 10^7$</td>
</tr>
</tbody>
</table>
Table 2. No of colonies of *E. coli* per milk source.

<table>
<thead>
<tr>
<th>Name of villages</th>
<th>No. of colonies</th>
<th>% positives (N=37)</th>
<th>CFU/mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shurr</td>
<td>220</td>
<td>7 (19%)</td>
<td>2.20×10⁵</td>
</tr>
<tr>
<td>Okolla</td>
<td>100</td>
<td>4 (11%)</td>
<td>1.00×10⁵</td>
</tr>
<tr>
<td>Dekuku</td>
<td>20</td>
<td>2 (5%)</td>
<td>2.0×10⁴</td>
</tr>
<tr>
<td>Turbi</td>
<td>86</td>
<td>8 (21%)</td>
<td>8.6×10⁴</td>
</tr>
<tr>
<td>Kambi Nyoka</td>
<td>260</td>
<td>4 (11%)</td>
<td>2.60×10⁴</td>
</tr>
</tbody>
</table>

Data analysis and presentation
Data are presented using tables and bars graphs to compare microbial contamination in different villages.

Results

**Microbial analysis of water pathways**
All the samples taken from all sampled villages had high *E. coli* bacteria, indicating extent of faecal contamination in water sources used for domestic purposes. Surface water from dams 20% (n=50) and borehole feed water tanks 20% (n=50) had high positivity of *E. coli* colonies. Table 1 shows the CFU of water samples. Only three samples tested negative for *E. coli*; these were in Okola. Turbi dam and Okola pan had high *E. coli* counts colonies both having high positivity of 10% and 8% (n=50) respectively (Table 1).

**Microbial analysis of milk pathway**
*E. coli* was positively identified in milk from Turbi 21%, (n=37), Shurr 19%, (n=37) (Table 2). The lowest burden was Dekuku 5% (n=37) *manyattas* (small settlements). Out of the 37 samples analysed, 12 tested negative for *E. coli* (Table 2).

Discussion

**Microbial analysis of various pathways**
The principle finding of this study is predominance of *E. coli* in all sources; dam, pan and borehole fed water tanks. Environmental samples collected from the water pathways predominately were from dam, pan, trough, borehole, about 86% (n=50) of samples test positive for *E. coli*, an indicator of bacteria in faecal contamination. Dam, borehole fed water tanks and pans had positivity of 20% (n=50) showing high presence of *E. coli* colonies (Table 1). Turbi dam and Okolla pan had high *E. coli* colony numbers, both having high positivity of 1.05×10⁷ and 1.93×10⁴ CFU/mL, respectively, (Table 1); the acceptable *E. coli* in water for consumption is 10–40 CFU/mL (WHO 2020).

The high presence of *E. coli* detected in these sources used by Turbi, Okolla, and Kambi Nyoka villages could be attributed to that the fact that the research was conducted during the raining season and, during these periods, pastoralist communities depend solely on surface runoff water that feed the dams and pans. Water from boreholes which is retrieved by pumping appliances, such as the one in the Shurr village, are rarely contaminated, but due to poor management of storage tanks and poor hygiene during household water storage processes, tends to increase the likelihood of *E. coli* exposure in these source of water.

The results of this study also concur with related study done by Suraja and Raja (2020) on faecal exposure pathways, conducted in low income urban and peri-urban areas that identified contact with open drain water and produce to be the main pathways for exposure both for adults and children. There is limited information and research conducted on exposure pathways among communities that practice a nomadic lifestyle. Due to their mobile lifestyle, the nomadic community lacks basic amenities, such as toilets and safe drinking water (Mohamed 2020). Contamination of water bodies and environment by faecal matter exposes children and adults to water-borne diseases, such as cholera and dysentery.

Milk and milk products are basic foods consumed by people practicing a pastoralist way of life. Milk and milk products are also good media for bacterial growth. Any contamination to these food products affects health and general wellbeing of the population that depend on these food products. Milk samples collected from all *manyattas* showed contamination with evidence of *E. coli*. This contamination could be due to use of contaminated water to clean milking utensils and lack of hand washing before milking animals.
The consumption of raw milk is accepted in some pastoralist communities is associated with cultural beliefs and preference (Tumwine et al. 2015). A study conducted by Samuel Majalija et al. (2020) in Nakasogola, Uganda, observed that 67.8% respondents reported never or rarely washed hands before milking animals. A related study conducted in India by Lingathurai and Vellathurai (2010) reported high presence of E. coli of $1.25 \times 10^7$ CFU/mL in milk samples collected from farmers. This was linked to poor hygiene, handling, transportation and storage that affects quality of raw milk.

Conclusion

Microbial contamination noted from this study indicates that there is poor sanitation in a nomadic lifestyle. This study reaffirms the need for an elaborate sanitation model tailored to the need of pastoralist community to reduce perennial faecal contamination of water sources for the community of the Turbi ward.

Recommendation

This study reaffirms the need for elaborate sanitation model tailored to the need of pastoralist community to reduce perennial fecal contamination of water sources for the community of Turbi ward.

Author’s contribution

BJ: Developed the concept, wrote the project proposal, collected the research data, analyzed the data, and wrote the thesis.

SW: Corrected the concept, provided necessary guidance, and corrections at the proposal writing, data analysis, and thesis writing.

GK: Corrected the concept, provided necessary guidance, and corrections at the proposal writing, data analysis, and thesis writing

CK: Mentorship guidance in writing and corrections

Data availability

Underlying data


Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

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I thank the Almighty God for bringing me this far. My utmost gratitude is to my immediate family members with special emphasis to my husband for his continuous support and encouragement during my study. I appreciate my lecturers who have paved way during my coursework that has enabled me to accomplish my study. I would like to thank my colleague students and all people who in their own special ways made this research thesis a success.

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