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Research Article

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Drinking Water Quality and Potential Health Risks in Emergency Shelters in Northern Gaza: Evidence from Humanitarian Crisis Conditions1

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Abstract

Background: *Clean drinking water is critical for public well-being. Water scarcity, infrastructural damage, and dependence on temporary water distribution have led to significant risks of waterborne diseases in the displaced populations of North Gaza.*

Objectives: *This study aims at evaluation of water quality, identification of contamination channels, and formulation of evidence-based recommendations to reduce health risks.*

Methods: *The study uses a cross-sectional descriptive design integrating two datasets: the database of the Ministry of Health containing data of 753 samples tested in laboratories (Feb 2025-Feb 2026) and the prospective field campaign collecting data of 89 samples from both household water storage and distribution points reinforced with the questionnaire data obtained from 100 interviewed households.*

Results: *According to data, 61% of inhabitants depend on tanker water. The quality of water has degraded in the course of distribution, with average free residual chlorine dropping from 0.34 mg/L to 0.16 mg/L and with the share of samples with values below the emergency level of 0.2 mg/L climbing from 18% to 47%. E. coli positivity rose from 15% to 38% in the same timeframe. Statistical modeling proved that chlorine levels lower than 0.2 mg/L are associated with a 3.8 times higher likelihood of detection of E. coli. In addition, out of households using water for different purposes, the number of households having point of use treatment is 4%, while 76% of them report incidents of getting ill due to water-related diseases.*

Conclusion: *The main problem that is being encountered in order to ensure safety of drinking water is microbial safety of water at all stages of the supply chain and household use. Actions that should be taken first include the restoration of levels of free residual chlorine and improvement of the hygiene rules for tanker usage.*

Keywords: Internally Displaced Persons, Wash, Escherichia Coli, Residual Chlorine, Waterborne Diseases.

1. Introduction

The availability of clean and dependable drinking water is well-known to be a fundamental human right and an important factor in public health. At the moment, the Gaza Strip faces serious and ongoing water difficulties, including the high population density, political challenges, damaged infrastructure, and a lack of natural water sources [1]. The coastal aquifer, which is the main water source, has been extensively depleted and dangerously polluted with high levels of salt, nitrate, and dangerous microorganisms. As a result, more than 96% of the groundwater in Gaza fails to meet safety standards for population consumption [2,3]. Therefore, the population has to rely on desalinated water or uncontrolled private tankers.

This problem is especially important in emergency shelters that accommodate internally displaced persons (IDPs) during repeated conflicts. They rely on temporary and often very poor water supply options, lacking sufficient treatment, disturbance in chlorination process, and restrictive quality control. In addition, the above-mentioned facilities normally do not have proper sanitation and all the prerequisites for the spread of pathogenic agents that can be transmitted with water. This exposes population living in the shelters to high chances of developing water-induced diseases, including diarrhea, typhoid fever, and hepatitis According to recent research, 31.5% of IDPs exhibit symptoms of waterborne diseases [4].

In spite of a wealth of humanitarian initiatives, there is an evident lack of systematic and evidence-based data on the quality of water provided at emergency shelters and the consequent implications for health. The shortcoming in complete assessment of ways through which water gets contaminant makes any interventions less effective and does not allow for the establishment of durable water safety management systems.

This research is focused on measuring the quality of drinking water in emergency shelters in the Northern Gaza Strip and determining the health risks related to it. In particular, the researchers will study the physical, chemical and microbiological properties of water so that they can evaluate it according to standards of the World Health Organization (WHO) and the Palestinian Water Authority (PWA) [5]. They will also study the possible sources of contamination of water, the correlation between the measured properties of water and the number of people suffering from water-borne diseases, and develop suggestions related to improvement of water quality management in emergency settings.

2. Methodology

2.1. Study Design and Setting

This study employed a descriptive cross-sectional, mixed-methods design to evaluate drinking water quality and associated health risks. The research was conducted in the Northern Gaza Strip (north of Wadi Gaza) over a five-month period (August–December 2025), targeting emergency shelters hosting internally displaced persons (IDPs). Eleven zones were selected to capture heterogeneity in supply modalities, including desalinated water, trucked deliveries, and intermittent network supply (Figure 1).



Figure 1: Study area map and georeferenced sampling zones in the Northern Gaza strip

2.2. Data Sources and Sampling

The study integrated two primary datasets:

- Surveillance Dataset: A retrospective database obtained from the Palestinian Ministry of Health, comprising 753 laboratory-tested drinking water samples collected between February 22, 2025, and February 22, 2026. This dataset monitored free residual chlorine, turbidity, pH, total dissolved solids (TDS), and Escherichia coli (E. coli) across three operational phases (pre-escalation, escalation, and post-escalation recovery).

- Primary Field Sampling: A prospective field campaign that collected 89 water samples from multiple nodes along the supply chain, including communal distribution tanks and household point-of-use containers (jerrycans). The field sampling was implemented in two phases (64 samples in Phase I and 25 samples in Phase II).

2.3. Household Questionnaire

A bilingual questionnaire was published to the 100 households in the sampled emergency shelters for the purposes of supplementing the water quality information collected. The questionnaire included behavioral and exposure variables such as water acquisition methods, containers used for storage, cleaning frequency of the storage containers, household water treatment procedures, and incidence of water-related diseases reported by households during the last three months.

2.4. Laboratory Analysis

The tools used for measurement included hand held, calibrated meters for electrical conductivity (EC)/TDS, pH and turbidity, and DPD colorimetric kits for free residual chlorine detection. Microbial sampling was performed in sterile sample containers treated with thiosulfate, and samples were transported through cold chain to the Ministry of Health laboratory for E. coli and total coliforms analysis using membrane filtration methods as per standards of the World Health Organization (WHO) [5].

2.5. Statistical Analysis and Ethical Approval

The data collected underwent cleaning and analytical procedure using SPSS software. The compliance proportions were then calculated and compared to WHO and PWA criteria in this process (Technical Instructions 108/2023) [2,3]. The connection between the cause variables of microbiological non-compliance (e.g. residual chlorine, types of storage) and the unique variable was verified with the help of Chi-square tests and multiple logistic regression analysis. The analysis of qualitative data collected with the help of the questionnaires was performed to illustrate contamination routes. The research methodology was agreed by the Research Ethics Committee at Islamic University of Gaza and informed consent was received from the respondents.

2.6. Data Management and Statistical Analysis

Quantitative data were processed in SPSS (version 21) to obtain descriptive statistics, compliance rates, and preliminary relations between water quality elements and incidence of diseases. The qualitative data analysis was done through NVivo software (version 17). The results of both quantitative and qualitative data were integrated using triangulation to identify potential routes of pollution and key aspects of management interventions. Statistical significance was accepted at $p < 0.05$.

2.7. Quality Assurance and Ethical Approval

Quality assurance and quality control processes had to do calibration checking, chain of custody documentation, temperature control in accordance with guidelines that were implemented in order to ensure safe transport of microbiological materials. Approvals pertaining to ethical issues and procedures had been secured prior to commencement of work. Participation in the study adhered to the principles of voluntary co-operation of participants who had been made aware of their obligations during the course of the research.

3. Results

Considerable differences in water quality indicators were apparent in the examined emergency shelters and study sites (Figure 2). Microbiological non-compliance was widespread, with one in three samples failing to meet the standards set by the World Health Organization (WHO) [5]. The percentage of household tanks contaminated by Escherichia coli (E. coli) was found to be 28%, while this number was 24% for the communal tanks and distribution centers (Table 1).

Indicator	Guideline/standard	Study finding (North Gaza shelters)
E. coli	**0 CFU/100 mL**	**Detected in 28% of household containers; 24% of communal/ distribution tanks.**
Residual free chlorine	**≥0.2–0.5 mg/L at point-of-use**	**Below 0.5 mg/L in 40% of samples; some locations recorded 0 mg/L.**
Turbidity	**<5 NTU**	**Exceeded 5 NTU in 18% of samples.**
pH	**6.2–8.5**	**Outside range in 12% of samples.**

Table 1: Summary of Key Drinking-Water Quality Indicators Observed in North Gaza Emergency Shelters

Physicochemical parameters also revealed notable deficiencies. Approximately 40% of the tested samples exhibited residual free chlorine concentrations below the required threshold of 0.5 mg/L (with some locations recording 0 mg/L), while 18% of samples had turbidity levels exceeding WHO guidelines (Figure 2).

Household handling practices contributed substantially to secondary contamination risks. Survey results indicated that 45% of households transferred water using open and uncovered containers, and 30% received less than 50 L/person/day during the study period (Figure 2). Consequently, 42% of respondents reported experiencing symptoms of gastrointestinal illness in the month preceding the study, correlating directly with the presence of microbial pathogens and low chlorine residuals in stored water [6].

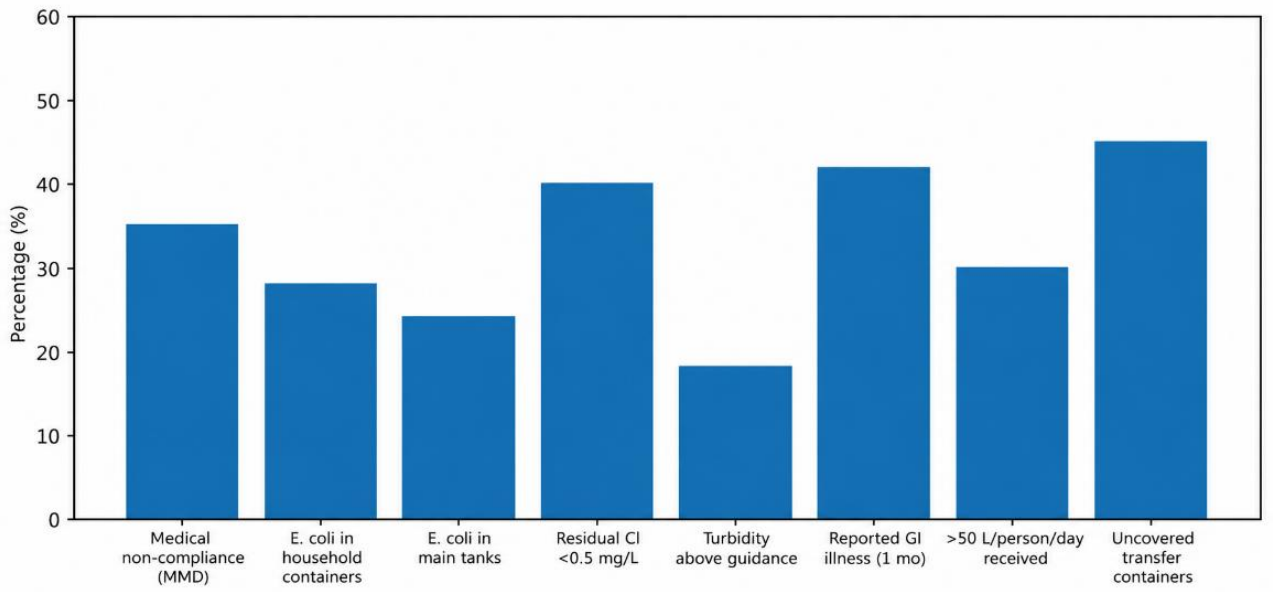


Figure 2: Summary of key water-quality, handling, and health-risk indicators measured in North Gaza emergency shelters

4. Discussion

This study finds that huge vulnerabilities exist in drinking water quality along the supply-storage chain in emergency shelters in Northern Gaza Strip. The considerable rate of microbiological violations, especially the presence of E. coli in the communal tanks as well as home containers shows that a considerable microbial barrier malfunction has taken place. While the water fulfills the minimum specifications at the time of its manufacture (for example small-scale desalination plants), it is subject to secondary contamination subject to secondary contamination during unprotected transport through water tankers and lengthy storage in households under difficult war and displacement conditions.

The lack of enough free residual chlorine is mainly responsible for this problem, as many samples tested low in this respect. Shortages of fuel as well as damage to both pumping stations and water treatment facilities have made it very difficult for aid organizations to ensure continuous chlorination of water. Displaced communities have no choice but to depend on irregular and unpredictable supplies while almost half of respondents used unprotected vessels to store their water, Furthermore, the statistical modeling in this study confirms that chlorine levels dropping below the emergency threshold of 0.2 mg/L significantly amplify public health risks, increasing the likelihood of E. coli detection by several-fold. These findings align with broader humanitarian water safety assessments emphasizing that secondary contamination during transport and extended household storage in displaced settings severely undermines primary treatment efforts [5-7].

Moreover, the excessive occurrence of gastrointestinal diseases in shelters correlates with the intake of microbially polluted and improperly cleaned water. Problems like the overcrowding of the shelter, the limited per capita supply of water (most of the residents receive less water than the minimum requirements in emergencies), and poor sanitation systems aggravates the public health issue [7]. Solving these problems requires a new approach, from focusing on only the production of water, to an all-inclusive management of water safety.

5. Conclusions and Recommendations

Conclusions

This research shows how unsafe drinking water has become an issue in emergency shelters in North Gaza. Due to ongoing contamination, particularly the high detection rates of E. coli bacteria in containers used for water storage and distribution, together with the lack of free residual chlorine and improper handling of the water in the shelter by IDPs, the residents are exposed to various health risks. Results indicate that locally produced water does not suffice alone; it is important to have precautionary measures against contamination throughout the disinfection process, during transportation, and at the storage site.

Recommendations

Based on these findings, the following priority interventions are recommended for humanitarian WASH operations:

- Reinforce Residual Chlorination: Restore and maintain free residual chlorine levels (≥ 0.2--0.5 mg/L) at all supply points, communal tanks, and distribution nodes, ensuring regular verification at the point of use.
- Improve Transport and Storage Hygiene: Promote hygienic water transport and safe covered storage by distributing secure water containers to households and conducting routine cleaning protocols for community tanks.
- Target Infrastructure Repairs: Prioritize emergency repairs to severely damaged distribution networks and storage facilities, while implementing feasible quality assurance and quality control (QA/QC) procedures under constrained laboratory capacities.

- Strengthen Surveillance and Risk Communication: Enhance routine monitoring of critical control points and establish rapid communication channels with shelter management and households to address microbial contamination promptly.
- Expand Per-Capita Availability: Increase daily per-capita water availability toward minimum emergency humanitarian benchmarks through coordinated contingency supply planning and fuel allocation for pumping stations.

Declarations

Funding

This research received no specific grant from any funding agency.

Conflict of Interest

The authors declare no conflict of interest.

Ethical Approval

The study protocol was approved by the Research Ethics Committee at the Islamic University of Gaza (Approval No.: 02, Date: 11-2025).

Author Contributions

Conceptualization, methodology, formal analysis, investigation, and writing—original draft preparation, A.M.M. and S.M.M.; supervision, review, and editing, H.A.

Data Availability Statement

The data presented in this study are available upon request directly from the corresponding author.

AI Usage Statement

The authors declare that generative AI tools were used solely for language editing and grammatical refinement of the manuscript.

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