Research Paper

Water, sanitation, and hygiene risk factors of acute diarrhea among children under five years in the Gaza Strip

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ABSTRACT

This cross-sectional community household-based study aims to evaluate the water, sanitation, and hygiene facilities in the Gaza Strip and to investigate their associations with the occurrence of acute diarrhea among children under five years. A survey using a structured questionnaire was conducted on 1,857 households with an child under five years from August 2017 to June 2018. About 69.7% of heads of households reported a diarrheal episode among their children during the two months preceding the survey. Multivariable logistic regression showed that sewage water observed around the households was associated with an increased risk of acute diarrhea (AOR = 2.45; P < 0.001; 95% CI: 1.83–3.27). Nevertheless, the allocation of a special water tank for desalinated drinking water at home (AOR = 0.3; P = 0.02; 95% CI: 0.1–0.8), the connection of households to a closed sewerage system (AOR = 0.56; P < 0.001; 95% CI: 0.43–0.73), and handwashing practices before and after eating (AOR = 0.42; P = 0.003; 95% CI: 0.24–0.74 and AOR = 0.50; P = 0.03; 95% CI: 0.26–0.94, respectively), as well as using desalinated water sources for drinking purposes, were inversely associated with the incidence of acute diarrhea among children under five. Further improvements in the existing sewerage system and the intensification of sanitation and hygiene promotion programs at the household levels may reduce the risk of acute diarrhea among children under five years in the Gaza Strip.

Key words | acute diarrhea, children, households, hygiene, sanitation, water

doi: 10.2166/washdev.2019.072
INTRODUCTION

Diarrhea is the fifth leading cause of childhood mortality and responsible for the annual deaths of 446,000 children around the world (Troeger et al. 2018). Moreover, diarrhea has multiple burdens; causing about 72.8 million disability-adjusted life years, and due to its adverse effects on the physical and cognitive activities of children, it worsens the adjusted life years, and due to its adverse effects on the economic situation of families and the healthcare system (Guerrant et al. 1999; Aikins et al. 2010; Gakidou et al. 2017). Symptoms such as nausea, vomiting, abdominal cramping, malnutrition, and dehydration often accompany diarrhea (Thielman & Guerrant 2004; Ansari et al. 2012). In developing countries, it has been estimated that 1.8 million people die annually due to diarrheal diseases and more than 80% of them are children aged under five years, mainly due to poor water, sanitation, and hygiene (WASH) conditions in the households (Hodge et al. 2016; Bakir et al. 2017).

To mitigate morbidity and mortality due to diarrheal diseases, it is necessary to direct global attention to improving access to safe drinking water and enhance the sanitation and hygiene conditions among vulnerable communities (Montgomery & Elimelech 2007; Prüss-Ustün et al. 2019). Conducting country-based studies to recognize risk factors of diarrheal diseases and their likely threat to public health is crucial in order to take appropriate action, which might vary depending on the environmental conditions (Kumar & Subita 2012).

In the Gaza Strip, the high population density combined with a severe poverty rate creates a high-risk environment for the spread of diseases. The area has been classified by the Organization for Economic Co-operation and Development (OECD) as a ‘highly fragile’ region. Israel has imposed a crippling blockade on the Gaza Strip since 2007 after Palestinian group Hamas seized control of the strip from its rival group Fatah, a situation that severely affects WASH conditions as well as the healthcare, economic, and political sovereignty (OECD 2016; AlFar et al. 2017). Furthermore, a severe shortage of the fuel required to power wastewater has caused raw sewage to flood into residential neighborhoods. This, combined with the ineffective sewage management, makes the Gaza Strip the worst-case scenario in respect of WASH-related diseases (Shira et al. 2018; Abuzerr et al. 2019a, 2019b, 2019c).

Desalination of brackish has been introduced as a promising option to improve groundwater quality – the only source of water in the Gaza Strip. Notwithstanding, microbiological contamination of desalinated water has been detected mainly because of the non-hygienic transportation and storage practices (Aish 2013; Zaqoot et al. 2016; Abuzerr et al. 2019a, 2019b, 2019c).

Nowadays, the coverage rate of the life-saving Rotavirus vaccine in the Gaza Strip has reached 95% of babies, which were made through strenuous efforts on the part of the Rostropovich Vishneskaya Foundation (RVF). The Palestinian Ministry of Health (MOH) and the United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA) have made efforts since 2016 to support and assist the primary healthcare providers in the Gaza Strip. These efforts are directed toward the implementation and sustaining of the RVF’s Rotavirus immunization program (RVF 2019). Nonetheless, acute diarrhea in Gaza is one of the most common childhood illnesses and the main reason for outpatient clinic visits and hospitalizations (MOH 2016a). The situation is particularly worrying as the UNRWA epidemiological bulletin reports between 2009 and 2012 indicated that the incidence rate of diarrhea among children had increased markedly, almost doubling (UNRWA 2009). The incidence rate of diarrhea was 4,017.1 cases per 100,000 individuals in 2009 and continuously increased to 6,909.1 cases per 100,000 individuals in 2012. Furthermore, there was a slight decrease in 2015, with about 6,448.2 cases per 100,000 individuals. Therefore, the identification of the causes of the elevated occurrence rate of diarrhea should be the first step in preventive and control measures, which would alleviate the burden of diarrheal diseases among children under five years.

Hence, this study was conducted to assess the situations related to water supply, hygiene practices, and sanitation facilities in the Gaza Strip households and investigate their association with acute diarrhea among children under five years. Outcomes may help health policymakers and program managers in the development of WASH-related
interventions for the prevention of acute diarrheal disease in the Gaza Strip.

METHODS

Study design, period, and area

The present study is a cross-sectional community household survey conducted in the Gaza Strip governorates from 1 August 2017 to 28 June 2018. Data collection was carried out from 3 September 2017 to 25 March 2018. The Gaza Strip is a narrow Palestinian strip with a surface area of 365 km² located in a transitional zone between the arid desert climate of the Sinai Peninsula and the temperate and semi-humid Mediterranean climate along the coast. The Gaza Strip borders Egypt in the southwest and occupied Palestinian Territories in the north and east at a coordinate of 31° 27.54’ N and 34° 27.03’ E. The average rainfall ranges between 400 mm/yr in the north and 230 mm/yr in the south (PCBS 2009; Alslaibi et al. 2017). As of 2016, Gaza’s population was 1,912,267 people, making a population density of about 5,239 inhabitants per square kilometer, and ranks third globally in terms of the most densely populated countries (PCBS 2016). It consists of five governorates, namely Rafah governorate, Khan Younis, Middle area, Gaza, and North Gaza governorate.

Tools of the study

The demographic and socio-economic, diarrheal illness, and WASH data were collected through a validated paper-based questionnaire developed by previous studies (UNICEF & PHG 2010; UNICEF 2017). In this study, the demographic and socio-economic section contains a list of 10 items. The diarrheal illness section comprises 12 items, while the water section includes seven items. In the sanitation section, there are three items, whereas the hygiene section contains seven items. The content validity of the questionnaire was checked by six specialists in the fields of environmental health, public health, biostatistics, and allied medical professions. We first conducted a pilot study on 45 households. Afterwards, minor modifications were made to the questionnaire according to the results of the pilot study.

In this study, the occurrence of an episode of acute diarrhea in a two-month old child before the survey was considered to be the dependent (outcome) variable and WASH factors as independent (exposure) variables.

Sample size and sampling

The representative sample size in the current study was determined using the following formula (Charan & Biswas 2013).

\[
\text{Sample size (} n \text{)} = \frac{Z_{1-\alpha/2}^2 P(1-P)}{d^2} = \frac{(1.96)^2(0.50)(1 - 0.50)}{(0.05)^2} = 384
\]

where \(Z_{1-\alpha/2}\) is the standard normal variate (Z value is 1.96 for a 95% confidence level), \(p\) is the response distribution (50%), and \(d\) is the margin of error (5%).

The calculated sample size was 384 households. Unexpectedly, after we finished the data collection, there were some items of the sociodemographic characteristics and drinking water-related variables that were of zero frequency at the sample size of 384 households. To make up for this shortfall, we increased the sample size by recalculating it by decreasing the margin of error to (2.274%) which increased the level of study representation and validity as well as getting a narrower confidence interval (CI) (Amin 2005).

Finally, the sample size calculated by the same equation with an adjusted margin of error was 1,857 households. After that, a second round of surveying was conducted to reach this number of households. Thereafter, a second round of the survey was conducted to reach the number of 1,857 households by following the earlier sampling method.

\[
\text{Sample size (} n \text{)} = \frac{Z_{1-\alpha/2}^2 P(1-P)}{d^2} = \frac{(1.96)^2(0.50)(1 - 0.50)}{(0.02274)^2} = 1,857
\]
the five governorates of the Gaza Strip based on the number of households in each of them as follows: 316 households from Rafah, 477 households from Khan Younis, 472 households from the Middle area, 466 households from Gaza, and 126 households from the North Gaza governorate. The survey was carried out simultaneously in all five governorates by four qualified interviewers.

Eligibility criteria

The interviews were carried out among households that have a child under the age of five. However, in cases where more than one child is present in the household, the child who has recently experienced diarrheal episodes was considered eligible.

Variable definitions

Acute diarrhea in this study was defined according to the World Health Organization (WHO) as the passage of three or more abnormally loose, watery, or liquid stools over a 24-h period and lasts no longer than 14 days, whereas chronic or persistent diarrhea is defined as an episode that lasts longer than 14 days (WHO 2005). Private water well indicates an improved water source received from private groundwater wells. The municipal water network refers to improved water, which is supplied to households using underground pipes; the source of water is the aquifer. The house reverse osmosis (RO) unit is a water purification process inside households that uses a partially permeable membrane to remove ions, unwanted molecules, and larger particles from water. Desalinated trucked water refers to improved potable water intended for human consumption that is conveyed from small-scale desalination plants into households via tanker trucks. Water vendor shops are designated shops where improved desalinated water by small-scale vendors for drinking use is sold. NGO desalination plants denote small-scale desalination plants owned by NGOs, which often supply people with improved desalinated water for free.

Sit-down and squat toilets with water flush represent improved toilets that dispose of human excreta by using water to flush it through a drainpipe to another location for disposal, thus maintaining a separation between humans and their excreta.

A pit latrine, also known as pit toilet or long drop, is a type of toilet that collects human feces in a hole on the ground. Urine and feces enter the pit through a drop hole to the floor, which might be connected to a toilet seat or squatting pan for user comfort. A pit latrine without slab/open pit is an unimproved type of toilet that collects human feces in a hole in the ground. Urine and feces enter the pit through a drop hole in the floor. A dry toilet is an unimproved toilet that operates without flush water, unlike a flush toilet. The dry toilet may have a raised pedestal on which the user can sit or a squat pan over which the user squats in the case of a squat toilet.

Ethical consideration

The study protocol was approved by the Ethics Committee of Tehran University of Medical Sciences (Code: IR. TUMS.REC.1396.3917) and by the Helsinki Ethical Committee in the Gaza Strip (Code: PHRC/HC/288/17). Also, permission was obtained from the General Directorate of Human Resources Development at the Palestinian Ministry of Health. The household heads who agreed to participate in the study were asked to sign a written informed consent attached to the questionnaire.

Data analysis

Each completed questionnaire was manually checked in order to ensure the quality of the data in the matter of completeness, clarity, and uniformity. The Statistical Package for Social Science (SPSS) version 22 (IBM Corp., Armonk, NY, USA) was used for data analysis. Descriptive statistics were used to calculate the frequencies and percentages of the variables. Pearson’s chi-square test was applied for all dependent variables that had two or more categories.

Univariate logistic regression analysis was used to estimate the crude odds ratio and to identify variables associated with the incidence of acute diarrhea at \( p < 0.05 \) and 95% CI without controlling confounders, whereas multivariable logistic regression analysis was used to examine the adjusted odds ratio and to find the association between WASH factors and acute diarrhea in children.
aged less than five years by controlling for potential confounding factors. Variables scored $p < 0.05$ in the univariate analysis were inserted into the model.

**RESULTS AND DISCUSSION**

**Demographic and socio-economic characteristics of households**

A total of 1,857 households with children under five years participated in this current study. The distribution of interviewed households has been taken into account to cover all neighborhoods and municipal areas in each governorate in order to preclude any risk of selection bias (Table 1). A predominant number of the participating households (47.7%) were refugee camp inhabitants, and the majority were living in single-family houses (42.0%). About 87.3% of household heads surveyed were males, 52.1% were university graduates, 73.6% were employed, and 43.4% and 43.2% worked as businessmen and public

| Table 1 | continued |
|---|---|
| **Demographic and socio-economic characteristics** | **Frequency** ($n$) | **Percentage (%)** |
| Asbestos | 706 | 38.0 |
| Tent or shack | 37 | 2.0 |
| Total | 1,857 | 100.0 |
| **Gender of the household head** | | |
| Male | 1,621 | 87.3 |
| Female | 236 | 12.7 |
| Total | 1,857 | 100.0 |
| **Educational level of the household head** | | |
| Illiterate | 124 | 6.7 |
| Elementary | 259 | 13.9 |
| Secondary | 507 | 27.3 |
| University | 967 | 52.1 |
| Total | 1,857 | 100.0 |
| **Employment status of the household head** | | |
| Employed | 1,566 | 73.6 |
| Unemployed | 491 | 26.4 |
| Total | 1,857 | 100.0 |
| **If employed, please specify the career** | | |
| Shepherd | 44 | 3.2 |
| Farmer | 139 | 10.2 |
| Businessman/men | 593 | 43.4 |
| Public servant | 591 | 43.2 |
| Total | 1,567 | 100 |
| **Number of family members** | | |
| <5 | 675 | 36.3 |
| 5–7 | 744 | 40.1 |
| >7 | 438 | 23.6 |
| Total | 1,857 | 100.0 |
| **Number of children <5 years at household** | | |
| 1 | 993 | 53.5 |
| 2 | 804 | 43.3 |
| 3 | 60 | 3.2 |
| Total | 1,857 | 100.0 |
| **Average monthly income of the household (NIS)** | | |
| <1,000 | 484 | 26.1 |
| 1,000–2,000 | 468 | 25.3 |
| 2,001–3,000 | 724 | 39.1 |
| >3,000 | 177 | 9.6 |
| Total | 1,857 | 100.0 |

1 USD ≈ 3.5 NIS.
servants, respectively. Most of the households (40.1%) consisted of five to seven members, and 53.5% and 43.3% of the households included one and at least two children below five years old, respectively. Approximately 51.4% of the households earned a monthly average income less than 2,000 New Israeli Shekel (NIS), equivalent to almost 571.4 US dollars. It is pertinent to mention that in 2017, the poverty line and deep poverty line for a reference household of five individuals (two adults and three children) were 2,470 NIS (705.7 US dollars) and 1,974 NIS (564 US dollars), respectively (PCBS 2017), indicating that half of the study households live below the poverty line.

**Acute diarrhea illness among children under five years**

Our findings showed that 9.1% of the study participants revealed that their children had developed diarrhea within the two weeks before the survey, whereas 69.7% of household heads reported the occurrence of acute diarrhea among their children within the two months preceding the interview. Of them, about 88.6% reported the duration of diarrhea to be less than or equal to one week, and 68.7% testified that the frequency of defecations in 24 h was between four and six times. Around 29.9% and 39.8% of household heads indicated that their children complained of having bloody diarrhea and watery diarrhea as the primary symptom, respectively. Nearly half of the participants (49.9%) revealed that their children received health care for diarrheal disease treatment in public hospitals or clinics, whereas 31.8% did not seek treatment anywhere. Several reasons were mentioned for not seeking treatment. Medical treatment was prescribed for only 44.7% of those who visited healthcare facilities; only 39.2% underwent stool analysis. A total of 54.4% household heads did not know the results of stool analysis, while 19.5% revealed the bacterial infection. Finally, 44.7% of the participants revealed that their children had received a medical prescription for the treatment of acute diarrhea. The highest incidence of diarrhea was among children aged 4–5 years (33.1%) followed by those aged 3–4 years (24.1%) (Table 2). This outcome may be explained by the idea that older children have more contact with the surrounding environment than the younger ones, making them more vulnerable to contaminants.

### Table 2 | Acute diarrheal illness characteristics among children under five years in the Gaza Strip

| Acute diarrheal illness characteristics | Frequency (n) | Percentage (%) |
|----------------------------------------|--------------|----------------|
| Reported acute diarrheal disease within the previous two months | | |
| Yes | 1,272 | 69.7 |
| No | 585 | 30.3 |
| Total | 1,857 | 100.0 |
| If yes, please specify when did this incident occur | | |
| ≤2 weeks ago | 115 | 9.1 |
| >2 and ≤4 weeks ago | 313 | 24.7 |
| >4 and ≤6 weeks ago | 427 | 33.7 |
| >6 and ≤8 weeks ago | 413 | 32.6 |
| Total | 1,268 | 100.0 |
| Age of getting diarrhea based on a 2-month recall period | | |
| <1 year | 178 | 14.0 |
| 1–2 years | 134 | 10.5 |
| >2–3 years | 233 | 18.3 |
| >3–4 years | 306 | 24.1 |
| >4–5 years | 421 | 33.1 |
| Total | 1,272 | 100.0 |
| Duration of an acute diarrheal episode | | |
| <7 days | 1,122 | 88.6 |
| 7–14 days | 145 | 11.4 |
| Total | 1,267 | 100.0 |
| Defecation frequency per 24 h | | |
| ≤3 times | 238 | 18.8 |
| 4–6 times | 871 | 68.7 |
| >6 times | 158 | 12.5 |
| Total | 1,267 | 100.0 |
| Bloody diarrhea symptom | | |
| Yes | 379 | 29.9 |
| No | 889 | 70.1 |
| Total | 1,268 | 100.0 |
| Watery diarrhea symptom | | |
| Yes | 504 | 39.8 |
| No | 763 | 60.2 |
| Total | 1,267 | 100.0 |
| Healthcare provider | | |
| None | 403 | 31.8 |
| Public hospital/clinic | 633 | 49.9 |
| Private hospital/clinic | 106 | 8.4 |

(continued)
The acute diarrhea occurrence in our study is similar to a report by the United Nations Children’s Emergency Fund in 2010, where 20% of Gaza Strip households that had at least one child under five years of age suffered from diarrhea in the month preceding the survey (UNICEF & PHG 2010). Our study with a 4-week illness recall revealed that 24.7% of household heads reported the occurrence of acute diarrhea among their children. Another study conducted one month after the 2014 Israel–Gaza conflict reported a high occurrence of diarrhea (46.1%) among the same age group of our study using an one-month illness recall (Kanoa et al. 2017). The higher occurrence rate of acute diarrhea in the study of Kanoa and colleagues than ours might be ascribed to poor WASH conditions during the conflict and subsequent periods.

WASH factors associated with acute diarrhea in the univariate analysis

The univariate logistic regression model and Pearson’s chi-square test were applied to determine the association between the incidence of acute diarrhea and WASH factors. The strength of association was attained using the crude odds ratio (COR) at 95% CI. Several water-related factors were found to be significant protective factors with acute diarrhea incidence, for instance, using a separated water tank for the storage of desalinated water for drinking purposes and using an improved water source for drinking, cooking, and domestic purposes. However, no significant association was found for the other water-related factors (Table 3).

The presence of sewage water around the household was significantly associated with acute diarrhea (COR = 4.2; 95% CI: 3.3–5.3). On the contrary, the connection of households to the sewerage system (COR = 0.3; 95% CI: 0.3–0.4) would reduce the likelihood of diarrheal disease occurrence among children in our univariate analysis. Nevertheless, no significant association was recognized for the type of toilet (Table 4).

Some hygiene variables were significantly associated with acute diarrhea in univariate analyses. Handwashing practices such as before (COR = 0.4; 95% CI: 0.3–0.6) and after (COR = 0.5; 95% CI: 0.4–0.7) eating, before bedtime (COR = 0.5; 95% CI: 0.4–0.7), before cooking (COR = 0.4; 95% CI: 0.4–0.6), after using a toilet (COR = 0.5; 95% CI: 0.4–0.7), and taking a shower four times or more per week (COR = 0.8; 95% CI: 0.6–1.2) were found to be significantly associated with and protective against the risk of diarrheal disease incidence (Table 5). However, children’s contact with household pets, eating ground beef, and drinking unpasteurized milk were not statistically significant at $p < 0.05$.

WASH factors associated with acute diarrhea in a multiple logistic regression model

In this study, the multiple logistic regression model was used to evaluate the association between WASH factors and the
The recall period for acute diarrhea is two months.

Filling of drinking water storage tank 0.102 6.2
Monthly 378 163 Ref. 0.661
Weekly 11 0 0.740 5.9 0.001
Every 2 weeks 290 133 0.126 2.45; 95% CI: 1.83–4.4
Every 3 weeks 593 289 0.103 0.746 0.001
Source of water for drinking uses 0.03 0.001
Private well 135 1 Ref. 610.3
Municipal network 454 20 0.168 0.126 (0.22–1.264) 0.168
RO filter (household unit) 14 31 0.003 0.003
Tanker-truck 337 487 0.005 0.005
Vendor shops 127 24 0.039 0.039
NGO plants 205 22 0.069 0.069
Source of water for cooking uses 0.028 0.001
Private well 142 1 Ref. 273.5
Municipal network 667 240 0.02 0.001
RO filter (household unit) 4 10 0.003 0.001
Tanker-truck 272 318 0.006 0.001
NGO plants 187 16 0.082 0.016
Source of water for domestic uses (e.g. bathing, washing clothes and dishes, brushing your teeth, and watering the garden) 0.001
Private well 136 1 Ref. 71.2
Municipal network 1,130 576 0.014 0.001
RO filter (household unit) 2 6 0.002 0.001
Tanker-truck 4 2 0.015 0.001
Children had swum in the sea previous week of illness 0.745
No 1,018 6 Ref. 0.106
Yes 241 1 0.7 0.746 0.001

Table 4 | Univariate analysis of sanitation factors and acute diarrhea among children under five years in the Gaza Strip

| Sanitation factors | Acute diarrhea | Statistical tests |
|--------------------|----------------|------------------|
|                   | Yes (n) | No (n) | COR (95%CI) | P | $\chi^2$ |
| Type of toilet     |          |          |             |    |        |
| Sit-down toilet    | 361      | 177     | Ref.        | 0.240 4.2 | 0.001 |
| Squat toilet       | 682      | 322     | 1.0 (0.8–1.3) | 0.740 |
| Pit latrine without slab/open pit | 173 | 60 | 1.4 (1.01–2.0) | 0.049 |
| Dry toilet         | 56       | 26      | 1.1 (0.6–1.7) | 0.830 |
| Presence of sewage water around the household | <0.001 |
| No                 | 682      | 485     | Ref.        | 147.2 |
| Yes                | 590      | 100     | 4.2 (3.3–5.3) | <0.001 |
| Connection of households to the sewerage system | <0.001 |
| No                 | 702      | 175     | Ref.        | 102.7 |
| Yes                | 570      | 410     | 0.3 (0.3–0.4) | <0.001 |

COR, crude odds ratio using 95% CI in univariate logistic regression analysis. The recall period for acute diarrhea is two months.

occurrence of diarrheal diseases in children less than five years of age in the Gaza Strip. Variables that scored $p < 0.05$ in the univariate analysis were inserted into the model. Although several variables were significantly associated with acute diarrhea in univariate analyses, they lost their significance in multivariable analysis when adjusting for all probable confounders.

Among all analyzed variables, we found that the collection of sewage water around households was associated with an increased risk of acute diarrhea ($\text{AOR} = 2.45; 95\% CI: 1.83–3.27$). The presence of sewage water in Gaza Strip neighborhoods is mainly due to inadequate sewer infrastructure (Tubail et al. 2004; Sharif 2015). This is a consistent finding in the cross-sectional study of 477 households in Nekemte Town, western Ethiopia, where the existence of feces nearby the household cesspool was shown to be an essential determinant of acute diarrhea among children (Regassa et al. 2008). Also, several studies reported that the disposal of garbage and sewage close to homes was significantly associated with acute diarrhea morbidity (Owolabi 2012; Collinet-Adler et al. 2015; Baker et al. 2016; Bancalari & Martinez 2018).
Table 5 | Univariate analysis of hygiene factors and acute diarrhea among children under five years in the Gaza Strip

| Hygiene factors | Yes (n) | No (n) | COR (95% CI) | P | χ² |
|-----------------|---------|--------|--------------|---|----|
| Practices of handwashing with soap | | | | | |
| At the ablution | | | | | |
| Yes | 1,272 | 585 | – | – | – |
| No | 0 | 0 | – | – | – |
| Before eating | | | <0.001 | 41.2 | |
| No | 356 | 84 | Ref. | – | – |
| Yes | 916 | 501 | 0.4 (0.3–0.6) | <0.001 | |
| After eating | | | <0.001 | |
| No | 240 | 63 | Ref. | 19.3 | |
| Yes | 1,032 | 522 | 0.5 (0.4–0.7) | <0.001 | |
| Before bedtime | | | <0.001 | 53.1 | |
| No | 1,039 | 388 | Ref. | – | – |
| Yes | 233 | 197 | 0.5 (0.4–0.7) | <0.001 | |
| Before cooking | | | <0.001 | |
| No | 296 | 78 | Ref. | 24.6 | |
| Yes | 976 | 507 | 0.4 (0.4–0.6) | <0.001 | |
| After toilet | | | <0.001 | |
| No | 766 | 299 | Ref. | 13.6 | |
| Yes | 506 | 286 | 0.5 (0.4–0.7) | <0.001 | |
| Shower times | | | <0.001 | 52.5 | |
| Every day | 102 | 57 | Ref. | – | – |
| Four times or more per week | 358 | 237 | 0.8 (0.6–1.2) | 0.361 | |
| At least once a week | 690 | 277 | 1.4 (1.0–2.0) | 0.066 | |
| Less often | 122 | 14 | 4.9 (2.6–9.2) | <0.001 | |

COR: crude odds ratio using 95% CI in univariate logistic regression analysis. The recall period for acute diarrhea is two months.

Table 6 | Multiple logistic regression analysis of WASH factors and acute diarrhea among children under five years in the Gaza Strip

| WASH factors | B | SE | Wald | P | AOR (95% CI) |
|--------------|---|----|------|---|-------------|
| Presence of desalinated water storage tank | –1.2 | 0.5 | 5.3 | 0.022 | 0.303 (0.109–0.841) |
| Source of drinking water | | | | | |
| Municipal network | –1.5 | 1.0 | 2.0 | 0.153 | 0.227 (0.03–1.734) |
| RO filter (household unit) | –4.9 | 1.1 | 21.2 | <0.001 | 0.007 (0.001–0.059) |
| Tanker-truck | –4.4 | 1.0 | 19.2 | <0.001 | 0.012 (0.002–0.086) |
| Vendor shops | –2.3 | 1.0 | 5.0 | 0.026 | 0.099 (0.013–0.755) |
| NGO plants | –2.1 | 1.0 | 4.0 | 0.045 | 0.126 (0.016–0.955) |
| Presence of sewage water around the household | | | | | |
| 0.9 | 0.1 | 36.6 | <0.001 | 2.445 (1.831–3.266) |
| Connection of households to the sewerage system | | | | | |
| –0.6 | 0.1 | 18.1 | <0.001 | 0.556 (0.425–0.729) |
| Handwashing with soap before eating | | | | | |
| –0.9 | 0.3 | 9.0 | 0.003 | 0.423 (0.241–0.741) |
| Handwashing with soap after eating | | | | | |
| –0.7 | 0.3 | 4.6 | 0.032 | 0.497 (0.262–0.943) |
| Constant | 7.1 | 1.1 | 38.5 | <0.001 | |

AOR, adjusted odds ratio using 95% CI in multivariable logistic regression analysis; B, slope; CI, confidence interval.

Our study also showed that using a separated water tank for the storage of desalinated water for drinking purpose in the household was a protective factor for childhood diarrhea (AOR = 0.5; 95% CI: 0.1–0.8), which supports the notion that drinking of desalinated water is protective for getting diarrheal disease among children. Also, the likelihood of children developing acute diarrhea in households using a municipal network for drinking purposes (AOR = 0.2; 95% CI: 0.03–1.73), RO household filter (AOR = 0.01; 95% CI: 0.001–0.06), tanker-truck (AOR = 0.01; 95% CI: 0.002–0.09), vendor shops (AOR = 0.10; 95% CI: 0.01–0.76), and NGO plants (AOR = 0.13; 95% CI: 0.02–0.96) was lower than for those in households which rely on private wells (Table 6).

Consistent with our findings, several recent global and local studies recognized that access to an improved water source for drinking purpose reduces the morbidity related to diarrheal diseases (Majuru et al. 2011; Shrestha et al. 2015; Cha et al. 2015; Komarulzaman et al. 2017). In the Gaza Strip, diarrhea is strongly associated with the source of drinking water (Mourad 2004), as it is more prevalent among citizens who are relying on non-improved water sources than those using improved water sources for drinking (Abu Mayla & Abu Amr 2010). Moreover, a growing body of evidence suggests a dramatic decline in the quality and quantity of Gaza’s water (Shomar 2006; Shomar et al. 2008). In contrast to our findings, a case–control study...
among hospitalized children in the Gaza Strip indicated that no relationship exists between the source of drinking water and the incidence of diarrhea (Alnawajha et al. 2015). This incompatible result may be either due to the heterogeneity of the study sample or perhaps because of the effect of seasonal variations as their data were collected in June and July, while ours were obtained between September and March. Nonetheless, there is a growing body of evidence suggesting that improved sources of water are not utterly safe (Bain et al. 2014, Boakye-Ansah et al. 2016).

Alnawajha et al. (2015) also revealed that children who were residing in Gaza Strip refugee camps had higher odds of getting diarrhea than those who were living in residential tower areas. Perhaps this is due to refugee camps having a higher rate of inadequate access to sanitary facilities and safe sewage disposal. Also, Abuzerr and his research team indicated that Gazans who were living in urban areas had lower odds of developing diarrheal disease than those who were residing in rural regions (Abuzerr et al. 2019a, 2019b, 2019c).

The outcome of our study is similar to other studies conducted in the Gaza Strip, suggesting that poor water quality, sanitary facilities, and hygiene practices are risk factors for acute diarrhea (UNRWA 2009; UNICEF & PHG 2010; MOH 2016b). We also found that the connection of households to the sewerage system (AOR = 0.56; 95% CI: 0.43–0.73) and handwashing practices before and after eating (AOR = 0.42; 95% CI: 0.24–0.74 and AOR = 0.50; 95% CI: 0.26–0.94, respectively) were inversely associated with the incidence of diarrhea and remained in the final model. Our finding is supported by previous studies that showed the effectiveness of handwashing in preventing childhood gastrointestinal parasitic infections (Ejemot-Nwadiaro et al. 2008; Curtis et al. 2009; Owolabi 2012; Hirai et al. 2017).

In general, several studies which were carried out in developing communities suggest an association between childhood diarrhea and poor different WASH conditions (Uwizeye et al. 2014; Hongxing et al. 2016; Kalakheti et al. 2016; Adane et al. 2017). Hence, future investigations that consider other WASH variables that were not included in this study are recommended.

Our results should be interpreted in light of certain limitations. To begin with, the reporting of handwashing behavior and practices are perhaps prone to social desirability bias. Also, the child’s history of diarrhea was collected by the subjective reporting of the household head on any episode of diarrhea in the last two months before the collection of the data. This might have introduced recall bias (Arnold et al. 2013; Overbey et al. 2019). Besides, the estimates provided in this study did not account for the seasonal variation in diarrhea. Evidence has shown that diarrheal diseases vary by season. Therefore, we encourage further studies to investigate the seasonal trend of diarrhea cases. Moreover, the study was cross-sectional in design, limiting the causal inference. Finally, several possible confounding variables of the diarrheal disease were not considered in the present study, such as the time of weaning and dietary practices of children. Hence, future studies with adjustment for other potential confounding factors are suggested.

CONCLUSIONS

The high population density combined with severe poverty and ineffective sewage management in the Gaza Strip continues to make the region the worst-case scenario in respect of WASH-related diseases. Therefore, this study aimed to evaluate the WASH facilities in the Gaza Strip and to investigate their associations with the occurrence of acute diarrhea among children under five. A survey was conducted on 1,857 households with at least one child under five years. This study found that the collection of sewage water around the household was the main factor associated with acute diarrhea among children under five in the Gaza Strip. Notwithstanding, the allocation of a special water tank for desalinated drinking water at home, the connection of households to a closed sewerage system, handwashing practices before and after eating, and using improved water sources for drinking purposes were found to be protective factors for acute diarrheal disease. In view of the fact that half of the study households live below the poverty line, the study suggests that government and competent authorities should do their utmost to improve the existing sewerage system and ensure adequate improved sanitary services. Also, the water supply infrastructure would benefit from an overall improvement. Lastly, sanitation and hygiene
education programs at household levels in the Gaza Strip may reduce the risk of acute diarrhea among children under five.

ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to the Tehran University of Medical Sciences – International Campus and the Palestinian Ministry of Health for their support to conduct the study. The Palestine-Québec Science Bridge is appreciated as well for facilitating carrying out this work. We are also grateful to Mr Waliu Jawula Salisu for editing the language of the final version of the manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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First received 11 May 2019; accepted in revised form 19 November 2019. Available online 10 December 2019.