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Modifiable diarrhoea risk factors in Egyptian children aged <5 years

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SUMMARY

By conducting a case-control study in two university hospitals, we explored the association between modifiable risk behaviours and diarrhoea. Children aged <5 years attending outpatient clinics for diarrhoea were matched by age and sex with controls. Data were collected on family demographics, socioeconomic indicators, and risk behaviour practices. Two rectal swabs and a stool specimen were collected from cases and controls. Samples were cultured for bacterial pathogens using standard techniques and tested by ELISA to detect rotavirus and *Cryptosporidium* spp. Four hundred cases and controls were enrolled between 2007 and 2009. The strongest independent risk factors for diarrhoea were: presence of another household member with diarrhoea [matched odds ratio (mOR) 4·9, 95% CI 2·8–8·4] in the week preceding the survey, introduction to a new kind of food (mOR 3, 95% CI 1·7–5·4), and the child being cared for outside home (mOR 2·6, 95% CI 1·3–5·2). While these risk factors are not identifiable, in some age groups more easily modifiable risk factors were identified including: having no soap for handwashing (mOR 6·3, 95% CI 1·2–33·9) for children aged 7–12 months, and pacifier use (mOR 1·9, 95% CI 1·0–3·5) in children aged 0–6 months. In total, the findings of this study suggest that community-based interventions to improve practices related to sanitation and hygiene, handwashing and food could be utilized to reduce the burden of diarrhoea in Egyptian children aged <5 years.

Key word: Diarrhoea.

INTRODUCTION

Diarrhoea remains one of the leading causes of childhood morbidity and mortality, mainly in children aged <5 years living in developing countries. It is estimated that globally, 1·236 million children die because of diarrhoea each year, representing 15% of the total of <5-year-old child mortality [1]. Death due to diarrhoea has decreased significantly from 13·6/1000 to 4·9/1000 over the past three decades [2]. However, the incidence of diarrhoea in children aged <5 years

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in developing countries is still high, with an average of 3·2 episodes per child per year [3]. In Egypt, the diarrhoea incidence of 5·5 episodes per child per year is higher than the global average [4]. Many epidemiological studies have identified risk factors that have lead to low cost, simple and practical intervention measures to decrease the burden of diarrhoea; an intensive hand hygiene campaign for children in elementary schools in Cairo decreased the absence rate from school by 30% compared to controls. Another water quality intervention study in Bolivia showed that point-of-use water disinfection, safe water storage and community education decreased diarrhoea episodes by 44% in an intervention group compared to controls [5–11]. Sanitation and improved water supply are major and costly infrastructural changes that are needed for the prevention of diarrhoea, but these are long-term solutions at best for most of the world, and thus efforts are needed to identify and implement low-cost solutions [12]. Diarrhoea risk factors vary across populations according to geographical distribution and cultural practices, age and pathogens detected [5, 13]. In this case-control study we aimed to identify modifiable risk factors associated with diarrhoea in children sged <5 years seeking treatment for diarrhoea in outpatient clinics at two university children's hospitals in Cairo, Egypt.

SUBJECTS AND METHODS

The study population was recruited from October 2007 to October 2009 from two children's hospitals located in two different universities which are referral hospitals that receive many diarrhoeal cases as well as other illnesses. Cairo University Children's Hospital serves most of Cairo and many other neighboring urban and rural areas, while Ain Shams University Children's Hospital serves East Cairo and neighbouring communities.

Cases were children aged <5 years seeking treatment for acute diarrhoea (i.e. lasting <14 days) at the outpatient clinics of the hospitals, from Saturday to Thursday, 09:00 to 14:00 hours. Diarrhoea was defined as the passage of $\geqslant 3$ loose or liquid stools in a 24-h period, or two loose or liquid stools in a 24-h period in addition to one or more associated symptom(s)/signs, including fever (oral temperature $\geqslant 38{\cdot}2\,°C$, dysentery (gross blood in diarrhoeal stool) or abdominal pain/cramps temporally related to the diarrhoeal episode.

A control was selected for each case by selecting the next child in the clinic's admission registry from children presenting to the clinic with a chief complaint other than acute diarrhoeal illness, who had not experienced acute diarrhoeal illness during the preceding 30 days and did not present with a fever of unknown origin. Controls were identified and enrolled within 48 h of the matched case. The controls were matched for age and gender (6 months interval) with cases. If a potential control declined to participate, the next patient meeting the criteria for enrolment was approached regarding study entry.

After obtaining written informed consent, a paediatrician and a social worker interviewed the parents and/or guardians of both cases and controls. The questionnaire included information on family demographics such as: age, date of birth, gender, residence, date of hospitalization and questions about exposures related to the period before the onset of diarrhoea (or acute illness for control subjects). Other exposures included daycare situation, breastfeeding, use and handling of baby bottles and their contents, and consumption of foods and drinks with documentation of manner of preparation and storage. Queries related to household conditions included the number of people and rooms in the household and the presence of household members with diarrhoea before the onset of the child's illness. Queries related to hygiene included availability of running water and taps, water storage and handling practices, type of toilet and the availability of handwashing facilities. Also assessed were the caregiver's handwashing practices and the presence or absence of animals within and outside the house. Finally, the questionnaire measured socioeconomic indicators, such as parental education, occupation and ownership of the house and its contents.

Two rectal swabs and a stool specimen were collected from every case and control. One swab was placed in a clear plastic tube containing Cary–Blair transport medium, and a second was placed in a clear plastic tube containing Campy Thio Broth (CTB) transport medium. The rectal swabs and stool specimens were stored in a refrigerator at both sites and transferred in a cool box to United States Naval Medical Research Unit No.3 (NAMRU-3) no more than 3 days from collection. All the samples were processed at NAMRU-3, Cairo.

Upon arrival at NAMRU-3 the faecal swab samples were cultured for routine enteric pathogens using standard methods for *Campylobacter*, *Salmonella*, and *Shigella*. Additional characterizations of

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isolated *Escherichia coli*-like colonies were tested for enterotoxigenic *E. coli* (ETEC). ETEC colonies producing toxin were further tested for colonization factors using an immunodot-blot assay [14]. Stool aliquots were screened for the presence of rotavirus and *Cryptosporidium* by commercial enzyme-linked immunosorbent assay kits (Premier Rotaclone®, Meridian Bioscience, USA and Techlab, USA) according to the manufacturers' instructions.

Statistical analysis

The primary outcome variable was increased risk of acute diarrhoeal illness as measured by odds of exposure in cases compared to odds of exposure in controls. In addition to predictor variables such as family demographics and socioeconomic indicators, risk behaviour practices focusing specifically on drinking water treatment and storage, food preparation and storage, childcare, and hygiene practices of the caregiver were also examined. Univariate analyses were performed for all categorical variables and the strength of association between the behavioural factors and diarrhoea were estimated by calculation of odds ratios (OR) with 95% confidence intervals (CI). The McNemar test was used to determine the statistical difference in categorical variables between matched cases and controls and paired *t* test or Wilcoxon's matched-pairs signed-rank test were used for parametric and non-parametric testing, respectively, of continuous variables depending on normality assumptions. Variables with $P<0{\cdot}2$ in the univariate analysis were included in a multivariable conditional logistic regression analysis. Variables that were not significant in the univariate analysis were eliminated in an effort to include the maximum number of subjects in the final regression modelling. Interactions between primary exposure and other predictor variables were considered. All statistical analyses were performed with SAS version 9.1 (SAS Institute Inc., USA).

The variable of standard of living was used as a surrogate for socioeconomic status (SES). It was calculated based on assigning one point to any ownership of an asset that the head of household possessed (as assessed in the SES section of the questionnaire), such as a car, television, refrigerator, etc. The total score for each household was determined and the median for all scores was set as the cut-off value. Accordingly, those with a household value above that cut-off value were considered to have a high standard of living and below that value were considered to have a low standard of living.

Sample size was estimated from a range of risk-factor prevalence estimates previously published [5]. Taking the estimates and logistical factors into consideration, the appropriate sample size was 400 cases and 400 controls from all study sites.

RESULTS

As the study was minimal risk, after initial screening the response rate in eligible cases was high and moderate in controls. The main reason for non-participation of cases was lack of interest in the study while the time required waiting until the child provided a stool sample was the main reason for controls refusing to participate. There were 400 cases and 400 controls enrolled in the study. Forty-seven per cent of cases were aged 0–6 months, 31% were aged 7–12 months, 16% were aged 13–24 months, and 7% were aged 25–59 months. Cairo University Children's Hospital had 223 pairs of cases and controls enrolled with 177 pairs from Ain Shams University Children's Hospital. Males constituted 59% of the participants with 51% of hospital visits during the summer season, from May to October (Table 1).

There were no significant differences between cases enrolled from the two sites with regards to age ($P=0{\cdot}2$), gender ($P=0{\cdot}1$), SES ($P=0{\cdot}6$) or season of enrolment ($P=0{\cdot}9$). However, there were differences regarding the clinical presentation of diarrhoeal disease. Cases from Ain Shams University Children's Hospital were more likely to be dehydrated, have blood in stool, vomiting and fever ($P=0{\cdot}0001$), and were more likely to be hospitalized ($P=0{\cdot}0001$) than the Cairo University Children's Hospital cases (Table 1).

Cases presenting clinically with diarrhoea were also associated with fever (80%), vomiting (62%), blood in stool (35%), and dehydration (53%). Median duration of illness was 4 days [interquartile range (IQR) 3–7 days] and the maximum number of loose stools was seven per day (IQR 5–10). Since the start of the latest diarrhoea episode, 82% received treatment for the current diarrhoea episode including 42% who received antibiotics. Of all enrolled cases, 37% were hospitalized; 35% received intravenous fluids, and 48% received oral rehydration therapy (ORT) at the hospital. Additionally, 79% were prescribed ORT to be used at home (Table 1).

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Table 1. *Demographic and clinical characteristics of children seeking medical care for diarrhoea (cases) at Cairo University (CU) and Ain Shams University (ASU) paediatric hospitals, Cairo, Egypt, 2004–2009*

Characteristics	All cases ($n=400$) n (%)	Site: CU ($n=223$) n (%)	Site: ASU ($n=177$) n (%)	P value
Age (months)				
0–6	187 (47)	109 (49)	78 (44)	0·07
7–12	124 (31)	63 (28)	61 (34)	
13–24	63 (16)	41 (18)	22 (12)	
25–59	26 (7)	10 (4)	16 (9)	
Median age (IQR)	7 (3–11)	7 (3–12)	8 (4–12)	0·2
Male gender	237 (59)	124 (56)	113 (64)	0·1
Low income	128 (32)	110 (49)	92 (52)	0·6
Warm season	202 (51)	72 (32)	56 (32)	0·9
Currently on breastfeeding	280 (72)	153 (72)	127(72)	0·5
⩽6 months on exclusive breastfeeding	75 (19)	38 (18)	37 (21)	0·2
>6 months on partial breastfeeding	126 (32)	66 (31)	60 (34)	0·5
Duration of diarrhoeal illness in days, median (IQR)	4 (3–7)	4 (3–7)	4 (3–5)	0·002
Max no. of stools in 24 h, median (IQR)	7 (5–10)	8 (6–10)	6 (5–7)	<0·0001
Vomiting	244 (62)	107 (49)	137 (77)	<0·0001
Blood in stool	138 (35)	44 (20)	94 (53)	<0·0001
Dehydration	210 (53)	60 (13)	150 (42)	<0·0001
Fever	314 (80)	155 (71)	159 (90)	<0·0001
Mucous in stool	178 (46)	134 (62)	44 (25)	<0·0001
Received treatment for current diarrhoea episode	300 (82)	133 (60)	167 (94)	<0·0001
Use of antibiotics	163 (42)	64 (30)	99 (56)	<0·0001
ORT at hospital	187 (48)	41 (13)	146 (83)	<0·0001
ORT taken at home	305 (79)	176 (84)	129 (74)	0·2
Intravenous fluids	129 (35)	11 (6)	118 (68)	<0·0001
Hospitalization	127 (37)	5 (3)	122 (71)	<0·0001

IQR, Interquartile range; ORT, oral rehydration therapy.

Univariate analysis (Tables 2–4) indicated several risk factors that were significantly associated with diarrhoeal illness including the presence of a family member with diarrhoea within 2 weeks before the child's diarrhoea began (OR 4·4, 95% CI 2·8–6·7, $P<0{\cdot}0001$), introduction of a new food that had never been eaten in the 7 days prior to the interview (OR 4·1, 95% CI 2·4–7) and childcare outside the home on any day during the 7 days preceding the survey (OR 2·1, 95% CI 1·2–3·6). Of household characteristics, three characteristics appeared more frequently in cases than controls. Cases (21%) used shared bathrooms, more often than controls (15%) (OR 1·6, 95% CI 1·1–2·3). Additionally, 15% of cases had no soap available in the bathroom compared to 11% of controls (OR 1·6, 95% CI 1·0–2·6), and 22% of cases had no towel available in the bathroom compared to 16% of controls (OR 1·6, 95% CI 1·1–2·3).

Differences in demographic characteristics (paternal education and occupation, maternal education and occupation, and SES) between cases and controls were not significant ($P<0{\cdot}05$).

Other feeding and hygiene practices also showed no statistical difference between cases and controls. These included breastfeeding status, bottle use and bottle cleaning practices, type of drink consumed during the week before the interview (i.e. cow's milk, homemade juice, tea, herbal drink, unboiled water), pacifier use, more than four family members living in the same household, presence of another child aged <5 years at home, and at least three persons sleeping in the same room (Table 3 and 5).

Upon stratifying by age (0–6, 7–12, ⩾13 months) (Table 2), univariate analyses showed that risk factors associated with diarrhoeal illness for the 0–6 months age group included the presence of a family member with diarrhoea within 2 weeks before the child's diarrhoea began (OR 3·3, 95% CI 1·8–5·8), introduction of new food not eaten in the 7 days prior to the interview (OR 5·0, 95% CI 2·1–12) and childcare outside

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Table 2. *Demographic characteristics suggested to be associated with diarrhoeal illness in matched pairs of children aged <5 years stratified by sites* [*Cairo University* (*CU*) *and Ain Shams University* (*ASU*) *paediatric hospitals*], *Cairo, Egypt, 2004–2009*

Demographic characteristics	CU		mOR (95% CI), *P* value	ASU		OR (95% CI), *P* value
	Cases	Controls		Cases	Controls	
Father's education						
Illiterate	73 (33)	77 (35)	1·0 (0·6–1·5), 0·9	75 (43)	52 (30)	1·7 (1·0–2·9), 0·07
Incomplete secondary or less	45 (20)	43 (19)	1·0 (0·6–1·7), 0·8	57 (32)	69 (40)	1·0 (0·6–1·8), 0·9
Complete secondary and higher	103 (47)	103 (46)	1 (ref.)	44 (25)	53 (30)	1 (ref.)
Mother's education						
Illiterate	80 (36)	80 (36)	1·2 (0·8–1·8), 0·5	80 (46)	63 (37)	1·9 (1·0–3·3), 0·04
Incomplete secondary or less	46 (29)	53 (24)	1·4 (0·9–2·3), 0·2	60 (34)	61 (35)	1·5 (0·8–2·6), 0·2
Complete secondary and higher	77 (35)	90 (40)	1 (ref.)	34 (20)	48 (28)	1 (ref.)
Father's occupation						
Not working	8 (4)	4 (2)	1·9 (0·6–6·5), 0·3	3 (2)	7 (4)	0·4 (0·1–1·7), 0·2
Driver	2 (1)	0 (0)	n.a.	11 (6)	13 (7)	1·0 (0·4–2·5), 0·9
Farmer/manual worker	74 (34)	87 (39)	0·8 (0·5–1·3), 0·3	37 (21)	27 (16)	1·1 (0·5–2·0), 0·9
Casual worker	6 (3)	5 (2)	1·2 (0·3–4·6), 0·8	11 (6)	4 (2)	2·2 (0·7–7·2), 0·2
Other	16 (7)	16 (7)	1·0 (0·5–2·2),0·9	20 (11)	12 (7)	1·3 (0·5–3·1), 0·6
Sales/clerical/security	32 (15)	27 (12)	1·2 (0·6–2·2), 0·6	22 (13)	48 (28)	0·4 (0·2–0·7), 0·005
Professional	81 (37)	83 (37)	1 (ref.)	71 (41)	63 (36)	1 (ref.)
Mother's occupation						
Not working/housewife	208 (94)	210 (95)	1·0 (0·1–7·1), 1·0	168 (95)	151 (86)	2·0 (0·4–10·9), 0·4
Farmer/manual worker	3 (1)	4 (2)	0·8 (0·1–10·1), 0·9	0 (0)	3 (2)	n.a.
Sales/clerical	5 (2)	2 (1)	2·4 (0·2–31·7), 0·5	4 (2)	14 (8)	0·5 (0·1–3·8), 0·5
Other	4 (2)	4 (2)	1·0 (0·1–11·0), 1·0	2 (1)	3 (2)	1·3 (0·1–15·7), 0·8
Professional	2 (1)	2 (1)	1 (ref)	2 (1)	4 (2)	1 (ref)
Socioeconomic status						
Low	72 (32)	75 (34)	0·9 (0·6–1·4), 0·7	56 (32)	62 (35)	0·8 (0·5–1·4), 0·5
High	151 (68)	148 (66)	1 (ref.)	121 (68)	115 (65)	1 (ref.)

mOR, Matched odds ratio; CI, confidence interval; ref. reference category; n.a., not available.

the home on any day during the 7 days preceding the survey (OR 3·3, 95% CI 1·4–7·7) (Table 6).

For the 7–12 months age group, risk factors were: the presence of a family member with diarrhoea within 2 weeks before the child's diarrhoea began (OR 7·8, 95% CI 2·7–22); the child began eating a food he/she had never eaten before in the 7 days prior to the interview (OR 2·6, 95% CI 1·2–5·5), no soap in the bathroom (OR5, 95% CI 1·7–14·6) and no towels in the bathroom (OR 2·8, 95% CI 1·2–6·2) (Table 6).

For the 1–5 years age group, risk factors were: the presence of a family member with diarrhoea within 2 weeks before the child's diarrhoea began (OR 4·8, 95% CI 2·0–11·6); the child having eaten a food not previously eaten in the 7 days prior to the interview (OR 8·5, 95% CI 2·0–36·8), lack of caregiver hand-washing after cleaning the child after defecation (OR 3·3, 95% CI 1·1–10) and the presence of pets at home (OR 2·1, 95% CI 1·0–4·3) (Table 6).

An identified pathogen was isolated from 34% ($n = 134$) of cases *vs.* 13% ($n = 52$) of controls. A bacterial pathogen was isolated from 13% of diarrhoea stool samples *vs.* 12% of controls, with no significant difference between them. ETEC and *Campylobacter* spp. were isolated from 8% and 4% of cases *vs.* 9% and 2% of controls respectively, while *Shigella* spp., *Salmonella* spp. and mixed infections were $\leqslant 1\%$ for both cases and controls. On the other hand, rotavirus, the only enteric virus tested for, was detected in 20% of cases *vs.* 13% of the 30 stool samples tested from controls. Additionally, *Cryptosporidium* was detected in 5% of cases *vs.* 3% of the 29 stool samples tested from controls (Table 7).

Univariate analysis of suggested risk factors associated with diarrhoea and mainly ETEC and

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Table 3. *Feeding characteristics, number of children and family members within household suggested to be associated with diarrhoeal illness in matched pairs of children aged <5 years seeking medical care at Cairo University (CU) and Ain Shams University (ASU) paediatric hospitals, Cairo, Egypt, 2004–2009*

	Cases ($n=400$) n (%)	Controls ($n=400$) n (%)	mOR (95% CI)	P value
Currently breastfeeding	284 (71)	293 (74)	0·8 (0·6–1·2)	0·3
Bottle use	122 (31)	122 (31)	1·0 (0·7–1·4)	0·9
Bottle cleaning				
Soap and water	26 (22)	21 (18)	1·2 (0·4–4·1)	0·9
Only water	23 (19)	19 (16)	1·4 (0·3–6·2)	0·8
Boiling/boiling and soap	70 (59)	77 (66)	1 (ref.)	
Type of drink during the past week before interview				
Cow's milk	144 (47)	144 (47)	1·0 (0·7–1·5)	0·9
Homemade juice	192 (59)	194 (59)	1·0 (0·7–1·7)	0·7
Tea/herbal drinks	195 (61)	224 (66)	0·8 (0·5–1·2)	0·3
Unboiled water	232 (70)	243 (72)	0·8 (0·5–1·3)	0·4
Child uses pacifier	107 (28)	89 (23)	1·4 (0·9–1·9)	0·1
Experiencing new food/drink a week prior to survey	159 (46)	113 (32)	4·1 (2·4–7·0)	<0·0001
No. of family members >4	169 (43)	160 (40)	1·1 (0·8–1·4)	0·6
Presence of child aged <5 years	177 (44)	179 (45)	1·0 (0·8–1·3)	0·9
At least three persons sleeping in the same room	167 (42)	169 (43)	1·0 (0·7–1·4)	0·9
Presence of family member with diarrhoea	137 (35)	46 (12)	4·4 (2·8–6·7)	<0·0001
Childcare outside home ⩾4 days during the week preceding the survey	117 (70)	94 (24)	2·1 (1·2–3·6)	0·008

mOR, Matched odds ratio; CI, confidence interval; ref. reference category.

Campylobacter spp. were performed (Table 8). ETEC was significantly associated with diarrhoea during the warm season and children experiencing new food in the 7 days preceding the interview was also associated with ETEC diarrhoea. Additionally, children living in houses where garabage was not collected on daily basis and where the waste water was collected in the streets of their living area tended to have ETEC-associated diarrhoea ($P=0·06$). For *Campylobacter* spp.-associated diarrhoea the risk increased in the warm season but was not associated with any other suggested risk factor.

Multivariate conditional logistic regression (Table 9) showed three independent risk factors for overall diarrhoea: if the child had eaten any food not previously eaten in the 7 days prior to the interview (OR 3, 95% CI 1·7–5·4), presence of a family member with diarrhoea (OR 4·9, 95% CI 2·8–8·4), and childcare outside the home for ⩾4 days during the week preceding the survey (OR 2·6, 95% CI 1·3–5·2). Attributable fractions for these risk factors were 0·16, 0·17 and 0·18, respectively.

Risk factors identified by multiple logistic regressions for the 0–6 months age group were: introduction of new food (OR 3·9, 95% CI 1·5–10·4), presence of a family member with diarrhoea (OR 2·9, 95% CI 1·4–6·3), and the child's use of a pacifier (OR 1·9, 95% CI 1·0–3·5). For the 7 months to <1 year age group, independent risk factors identified were: presence of a family member with diarrhoea (OR 9·4, 95% CI 2·3–38·4) and absence of soap in the bathroom (OR 6·3, 95% CI 1·2–33·9). However, there was one protective factor: consumption of tea and/or herbal drinks in the week preceding the interview (OR 0·2, 95% CI 0·02–0·6).

Finally, for the 1 to <5 years age group, identified risk factors were introduction to a new food (OR 7·7, 95% CI 1·0–61) and the presence of a family member with diarrhoea (OR 7·9, 95% CI 2·4–26·3).

DISCUSSION

A combination of environmental, microbiological, social and host immune statuses together determine the risk associated with the human burden of diarrhoea [5, 15]. Sanitation and safe/clean water supplies are needed for the prevention of diarrhoea within a society but are not sufficient unless paired with changes in modifiable risk behaviours. Protective measures like improved sanitation and establishing

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Table 4. *Comparison between cases and controls according to risk factors related to house conditions of children aged <5 years with (cases) and without (controls) diarrhoea seeking medical care at Cairo University and Ain Shams University paediatric hospitals, Cairo, Egypt, 2004–2009*

Variable	Cases ($n=400$) *n* (%)	Controls ($n=400$) *n* (%)	mOR (95% CI)	*P* value
Water source other than piped	68 (17)	54 (14)	1·4 (0·9–2·1)	0·1
Family has no refrigerator at home	30 (8)	32 (8)	0·9 (0·6–1·6)	0·8
Family have only one water tap	41 (11)	41 (11)	1·0 (0·6–1·6)	0·9
Do not use public collection for sewage disposal	85 (21)	69 (17)	1·4 (0·9–2·2)	0·1
Garbage presence only outside house	158 (40)	152 (38)	1·1 (0·8–1·5)	0·6
Garbage not collected on daily basis	259 (66)	253 (63)	1·1 (0·8–1·5)	0·5
All garbage not covered	187 (48)	212 (54)	0·7 (0·5–2·0)	0·06
Have waste water in streets	96 (24)	81 (20)	1·3 (0·9–1·8)	0·2
Share toilet with other households	85 (21)	60 (15)	1·6 (1·1–2·3)	0·02
Have no flush toilet	62 (16)	50 (13)	1·4 (0·9–2·2)	0·2
Have no toilet paper in toilet	371 (94)	372 (94)	1·0 (0·5–1·7)	0·9
Have no soap in toilet for handwashing	60 (15)	42 (11)	1·6 (1·0–2·6)	0·04
Have no towels in bathroom	86 (22)	62 (16)	1·6 (1·1–2·3)	0·02
Handwash after defecation				
Never/sometimes	44 (11)	32 (8)	1·6 (0·9–2·9)	0·1
Handwash before defecation (all)				
Never/sometimes	347 (88)	341 (86)	1·3 (0·8–2·0)	0·3
Handwash after changing child's diapers				
Never/sometimes	34 (9)	29 (7)	1·3 (0·7–2·4)	0·4
Handwash before preparation of food				
Never/sometimes	30 (8)	35 (9)	1·0 (0·7–1·5)	0·9
Presence of pets at house	118 (30)	97 (25)	1·3 (0·9–1·8)	0·2
Have only one room for sleeping	118 (30)	132 (33)	0·8 (0·5–1·2)	0·2

mOR, Matched odds ratio; CI, confidence interval.

a microbiologically and chemically safe water supply can be implemented by governments, but these efforts require considerable time and effort and are costly. Alternatively, modifying risk behaviours can also reduce the burden of diarrhoeal diseases to affected segments of the population, offering protection that is more readily implemented [10, 11].

Of the demographic epidemiological characteristics studied, the presence of a family member with diarrhoea had the highest impact on diarrhoea burden. A child who had a family member with diarrhoea was five times more likely to have diarrhoea compared to those without a family member with diarrhoea; additionally this risk factor had an attributable fraction of 0·17. This finding was also observed in other studies [5, 16]. Although an unidentified shared exposure may have led to diarrhoea in household members, the effect of this risk factor on all age groups studied suggests a high rate of intrahousehold transmission and the need for specific measures to minimize this transmission. Many infectious agents are able to cause diarrhoeal disease through faecal–oral transmission and in small inocula, such as *Shigella* spp. Other microbes require larger inocula, but close contact with an infected person has led to the spread of other microbes such as enterohemorrhagic *E. coli*, *Campylobacter* spp., norovirus, rotavirus, *Giardia lamblia*, *Cryptosporidium parvum*, and *Entamoeba histolytica* [17]. Pathogens detected in the current study were mainly observed in children aged <1 year, with rotavirus the most common pathogen detected. Blake *et al.*, showed that the presence of a household member with diarrhoea preceding the case's illness was the risk factor with the highest OR for children aged <1 year [16]. This finding was further confirmed by Sobel *et al.*, who added that the presence of an infected household member was strongly associated with rotavirus infection [5]. Studies have shown that improvement in hygiene practice, sanitation and handwashing may effectively decrease diarrhoea morbidity in general [12, 18].

Exposure of the child to a new food/drink in the 7 days prior to interview was also a risk factor for

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Table 5. *Feeding characteristics stratified by age of children aged <5 years with (cases) and without (controls) diarrhoea seeking medical care at Cairo University and Ain Shams University paediatric hospitals, Cairo, Egypt, 2004–2009*

	Age 0–6 months ($n=187$ for both cases and controls)			Age 7–12 months ($n=124$ for both cases and controls)			Age ⩾13 months ($n=89$ for both cases and controls)		
Characteristics	Cases	Controls	mOR (95% CI), *P* value	Cases	Controls	mOR (95% CI), *P* value	Cases	Controls	mOR (95% CI), *P* value
Currently breastfeeding	149 (80)	151 (81)	0·9 (0·6–1·6), 0·8	92 (74)	100 (81)	0·7 (0·4–1·3), 0·3	43 (48)	42 (49)	0·8 (0·4–1·6), 0·6
Type of drink during the past week before interview									
Cow's milk	40 (30)	28 (22)	1·6 (0·8–3·2), 0·1	53 (55)	55 (54)	1·1 (0·6–2·0), 0·9	51 (68)	61 (80)	0·5 (0·2–1·1), 0·07
Homemade juice	42 (31)	40 (30)	1·1 (0·6–2·3), 0·7	82 (75)	78 (68)	1·7 (0·8–3·6), 0·1	68 (83)	76 (92)	0·4 (0·1–1·2), 0·1
Tea/herbal drinks	72 (47)	80 (49)	1·0 (0·5–1·7), 0·9	61 (66)	80 (76)	0·5 (0·2–1·2), 0·1	62 (84)	64 (89)	0·8 (0·3–2·7), 0·8
Unboiled water	13 (11)	16 (14)	0·6 (0·2–1·7), 0·3	31 (41)	27 (34)	2·0 (0·8–5·3), 0·2	16 (29)	20 (36)	1·0 (0·3–3·1), 0·99
Exclusive breastfeeding	50 (30)	60 (36)	0·7 (0·4–1·2), 0·2	13 (11)	12 (10)	1·2 (0·5–2·8), 0·7	3 (3)	1 (1)	3·0 (0·3–28·8), 0·3

mOR, Matched odds ratio; CI, confidence interval.

diarrhoea. The effect of the introduction of a new food was evident in all age groups in the primary analysis; however, in multivariate analysis the effect was evident only for age groups 0–6 months and 13 months to <5 years. In the 7–12 months age group there may not have been sufficient power to detect a significant difference. The 0–6 months and 13 months to <5 years age groups differed in feeding practices, mobility, and immunity; the mechanism of how a new food is introduced in these two age groups is likely to be different. The impact of the introduction of a new food was higher in children aged >1 year (OR 7·7) compared to children agred <6 months (OR 4). This finding may be linked to the observation that in general, children aged >1 year start to experience a greater variety of food types compared to younger children. However, for the 7–12 months age group, drinking herbal tea in the 7 days prior to interview may be a protective factor against diarrhoea (OR 0·2). Along the lines of this observation, several studies have shown that specific types of food may increase or decrease the burden of diarrhoea. One study from Uganda showed that consumption of raw chicken eggs was significantly ($P<0·01$) and strongly (OR 99) associated with diarrhoea in residents of Kampala district [19]. Consumption of homemade fruit juice was associated with diarrhoea in a study from Brazil [5] and in another study from Mexico, asymptomatic heat labile-ETEC infection increased 400% in children who received oat gruel (hazard rate 4·01, 95% CI 2·77–5·24), while drinking a herbal tea reduced the hazard of symptomatic infection by 90% [20]. Breastfeeding was not protective against diarrhoea in our study, similar to other studies [5, 20], but contrasting with other studies that have shown breastfeeding to be protective during infancy [21–23]. Breastfeeding has also been reported to have limited protection against rotavirus diarrhoea after the first months of infancy [24]. The reason why breastfeeding was not protective for individual pathogens causing diarrhoea in our study was not clear. However, possible reasons include: pathogen detection was limited to only a few pathogens which may not be protected by breastfeeding, perhaps a significant number of children used antibiotics before sample collection and/or a limited number of samples were collected from controls for viral and parasitic isolation. Studies have shown that consumption of contaminated food, mainly in the weaning period, is associated with diarrhoea. Thus, improvement of food safety through community-based education

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Table 6. *Risk and protective factors significantly associated with diarrhoeal illness in matched cases and controls aged <5 years seeking medical care at Cairo University and Ain Shams University paediatric hospitals, Cairo, Egypt, 2004–2009*

Age category	Exposure	Cases *n* (%)	Controls *n* (%)	mOR (95% CI)	*P*
0–6 months	Experiencing new food/drink in week prior to survey	53 (36)	36 (24)	5·0 (2·1–12)	0·0003
	Presence of family member with diarrhoea	63 (34)	25 (14)	3·3 (1·8–6)	0·0001
	Childcare outside home ⩾4 days during the week preceding the survey	58 (32)	42 (23)	3·3 (1·4–8)	0·006
7–12 month	Experiencing new food/drink in week prior to survey	62 (54)	46 (40)	2·6 (1·2–5·5)	0·02
	Presence of family member with diarrhoea	39 (32)	10 (9)	7·8 (2·7–22)	0·0001
	Having no soap for handwashing	28 (23)	12 (10)	5·0 (1·7–15)	0·003
	Having no towels in bathroom	31 (25)	17 (14)	2·8 (1·2–6)	0·01
13–59 months	Experiencing new food/drink in week prior to survey	44 (52)	31 (36)	8·5 (2·0–37)	0·004
	Presence of family member with diarrhoea	35 (40)	11 (13)	4·8 (2·0–12)	0·0004
	Handwash after defecation (never/sometimes)	16 (18)	7 (8)	3·3 (1·1–10)	0·04

mOR, Matched odds ratio; CI, confidence interval.

Table 7. *Distribution of pathogens stratified by age detected in cases and controls seeking medical care at Cairo University and Ain Shams University paediatric hospitals, Cairo, Egypt, 2004–2009*

	Age 0–6 months		Age 7–12 months		Age ⩾13 months	
Pathogen detected	Cases	Controls	Cases	Controls	Cases	Controls
ETEC	11 (6)	13 (7)	9 (7)	14 (11)	10 (11)	6 (7)
Campylobacter	4 (2)	5 (3)	6 (5)	2 (2)	5 (6)	2 (2)
Shigella	0 (0)	0 (0)	1 (1)	0 (0)	1 (1)	2 (2)
Salmonella	3 (2)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)
Mixed	2 (1)	0 (0)	1 (1)	0 (0)	0 (0)	3 (3)
Undiagnosed	167 (89)	169 (90)	107 (86)	108 (87)	73 (82)	75 (84)

ETEC, Enterotoxigenic *Escherichia coli*.

programmes may be an effective tool to decrease the burden of diarrhoea in this population [25, 26].

Another hygiene practice identified as an independent risk factor for diarrhoea in the 0–6 months age group was pacifier use. Infants who used pacifiers were twice as likely to have diarrhoea than controls. Other studies have reported the same finding from developed and developing countries [27–29]. In one study, use of pacifiers by infants aged <6 months not only increased the risk for diarrhoea but also increased risk of early weaning [27]. In another study, pacifiers were linked not only to diarrhoea, but also to respiratory illnesses [29].

A related hygiene variable that was recognized as an independent risk factor for diarrhoea was childcare outside the home (daycare) for ⩾4 days in the 7 days prior to the survey (OR 2·6). Association of daycare with diarrhoea has been reported in many studies from developed and developing countries; in developing countries, studies have shown that care of the child at home during the week preceding the illness was protective and that informal daycare in private homes was a significant risk factor for diarrhoeal illness [5, 16, 30]. In developed countries, studies have shown that any household daycare is safer than formal daycare [5, 31, 32]. Other studies from developing countries have indicated that children attending daycare centres may be exposed to diarrhoeal epidemics [33, 34]. Additionally, improving hygiene practices was found to be the only intervention in the childcare centre environment that had good potential to reduce diarrhoea in attendees [35].

Absence of soap in the bathroom for handwashing was a further risk factor for diarrhoea for children aged 7–12 months (OR 6·3). Association between poor hygienic conditions and diarrhoea has been

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Table 8. *Pathogen distribution according to demographics and some selected risk factor in diarrhoea cases and their matched controls seeking medical care at Cairo University and Ain Shams University paediatric hospitals, Cairo, Egypt, 2004–2009*

Characteristics	ETEC Cases (*n*=22)	ETEC Controls (*n*=33)	*P* value	*Campylobacter* Cases (*n*=15)	*Campylobacter* Controls (*n*=9)	*P* value
Age, months						
0–6	9 (41)	13 (39)	0·9	4 (27)	5 (56)	0·2
7–12	4 (14)	14 (42)	0·06	6 (40)	2 (22)	0·7
⩾13	9 (41)	6 (18)	0·06	5 (33)	2 (22)	0·6
Warm season	11 (50)	0 (0)	<0·0001	6 (40)	0 (0)	0·05
Currently breastfeeding	16 (73)	27 (82)	0·4	12 (80)	7 (78)	0·9
Exclusive breastfeeding	3 (16)	4 (13)	0·7	2 (15)	2 (25)	0·6
Type of drinks during the past week before interview						
Cow's milk	8 (53)	15 (52)	0·9	2 (22)	1 (17)	0·7
Homemade juice	2 (17)	4 (22)	0·7	1 (14)	1 (20)	0·7
Tea/herbal drinks	10 (67)	21 (70)	0·8	10 (83)	5 (62)	0·3
Unboiled water	16 (80)	17 (63)	0·2	14 (93)	6 (75)	0·3
Bottle use	5 (23)	10 (30)	0·5	4 (27)	3 (33)	0·8
Bottle cleaning						
Soap and water	0 (0)	1 (10)	0·7	0 (0)	0 (0)	n.a.
Only water	2 (40)	1 (10)	0·2	0 (0)	1 (33)	0·5
Boiling/boiling and soap	3 (60)	8 (80)	0·6	3 (100)	2 (66)	0·5
Number of family members >4	11 (50)	12 (36)	0·3	7 (47)	4 (44)	0·9
Presence of child aged <5 years	15 (68)	20 (61)	0·6	9 (60)	4 (44)	0·7
Child uses pacifier	2 (9)	7 (22)	0·2	4 (29)	2 (22)	0·8
Experiencing new food/drink in week prior to survey	15 (75)	9 (31)	0·003	7 (54)	2 (25)	0·4
Presence of family member with diarrhoea	8 (36)	9 (27)	0·5	8 (53)	3 (33)	0·3
At least three persons sleeping in the same room	11 (50)	156 (48)	0·9	11 (73)	7 (78)	0·8
Family has no refrigerator at home	2 (9)	3 (9)	1·0	2 (13)	2 (22)	0·6
Having no toilet paper in toilet	20 (91)	30 (91)	1·0	11 (73)	7 (78)	0·8
Childcare outside home during the past 4 days preceding the survey	7 (31)	8 (24)	0·5	2 (13)	0 (0)	0·5
Water source other than piped	3 (14)	8 (24)	0·5	2 (13)	4 (44)	0·09
Does not use public collection for sewage disposal	6 (27)	6 (18)	0·4	4 (27)	3 (33)	0·8
Garbage presence only outside house	7 (32)	8 (24)	0·5	8 (53)	4 (44)	0·7
Garbage not collected on daily basis	15 (68)	14 (42)	0·06	4 (27)	3 (33)	0·8
All garbage not covered	12 (55)	21 (64)	0·5	10 (67)	8 (89)	0·4
Having wastewater in streets	8 (36)	5 (15)	0·06	5 (33)	1 (11)	0·4
Share toilet with other households	6 (27)	5 (15)	0·3	7 (47)	3 (33)	0·5
Having no flush toilet	4 (18)	4 (12)	0·7	3 (20)	3 (33)	0·6
Having no soap in toilet	3 (14)	4 (12)	0·9	5 (33)	1 (11)	0·4
Having no towels in bathroom	5 (23)	7 (21)	0·9	8 (53)	1 (11)	0·08
Handwash after defecation						
Never/sometimes	3 (14)	2 (6)	0·4	2 (13)	2 (22)	0·6
Handwash after changing child's diapers						
Never/sometimes	2 (9)	1 (3)	0·6	3 (20)	0 (0)	0·3
Handwash before defecation (all)						
Never/sometimes	19 (86)	28 (85)	0·9	12 (86)	7 (78)	0·6
Handwash before preparation of food						
Never/sometimes	0 (0)	1 (3)	0·4	2 (13)	0 (0)	0·5
Presence of pets at house	4 (18)	10 (31)	0·3	5 (33)	2 (22)	0·7
Having only one room for sleep	7 (32)	14 (42)	0·4	6 (40)	5 (56)	0·7

ETEC, Enterotoxigenic *Escherichia coli*.

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Table 9. *Predictors of diarrhoeal illness on multivariate analysis in children aged <5 years seeking medical care at Cairo University and Ain Shams University paediatric hospitals, Cairo, Egypt, 2004–2009*

Age category	Variables	mOR (95% CI)	*P* value
All	Experiencing new food/drink in week prior to survey	3·0 (1·7–5·4)	0·0003
	Presence of a family member with diarrhoea	4·9 (2·8–8·4)	<0·0001
	Childcare outside home in week preceding the survey	2·6 (1·3–5·2)	0·007
0–6 months	Pacifier use	1·9 (1·0–3·5)	0·05
	Experiencing new food/drink in week prior to survey	3·9 (1·5–10·4)	0·006
	Presence of a family member with diarrhoea	2·9 (1·4–6·3)	0·006
7–12 months	Drinking tea in the week preceding the interview	0·2 (0·02–0·6)	0·004
	Presence of a family member with diarrhoea	9·4 (2·3–38·4)	0·001
	Having no soap for handwashing	6·3 (1·2–33·9)	0·03
13–59 months	Experiencing new food/drink in week prior to survey	7·7 (0·96–61·4)	0·05
	Presence of a family member with diarrhoea	7·9 (2·4– 26·3)	0·0007

mOR, Matched odds ratio; CI, confidence interval.

reported in many studies [7, 36]. One study reported that the most immediate preventive impact can be achieved by promoting handwashing with soap [37]. Another study reported that handwashing with soap decreased diarrhoea by 48% [12]. On the other hand, one study reported that handwashing itself either with or without soap after eating, defecation, or cleaning the child can reduce subsequent diarrhoea [38].

Limitations of our study include recall bias of the caregivers, which may have had an effect on the study results. However, we attempted to limit the time of recall to a narrow period (1–2 weeks prior to the survey). The stratification of cases and controls by ages (three age categories) may also have influenced the risk factors detected for each age group, due in part to the smaller population in each stratum. Additionally, this may have decreased the power because the study was conducted in outpatient clinics, the number of stool samples collected from the controls was low, potentially affecting the detection of viral and parasitic pathogens in controls, and possibly affecting the ability to detect pathogen-specific risk factors.

In summary, this study provides useful data which needs further exploration. While we found that the presence of another household member with diarrhoea, introduction to new foods, and having childcare outside the home increased risk, these are not in and of themselves easily modifiable. They do suggest that further study is needed to evaluate what modifiable behaviours such as handwashing, increased peri-domestic sanitation, and food safety practices in the home might have on reduction of disease in these populations. Given that major improvements in sanitation, access to clean water, and vaccines to prevent diarrhoea are decades away from availability, all that can be done, should be done now to decrease the burden of diarrhoeal diseases worldwide.

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DECLARATION OF INTEREST

The authors had no potential, perceived, or real conflict of interest. The study sponsor had no involvement in (1) study design; (2) the collection, analysis, and interpretation of data; (3) the writing of the report; nor (4) the decision to submit the manuscript for publication.

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