Environmental risk factors for diarrhoea among male schoolchildren in Jeddah City, Saudi Arabia

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ABSTRACT

Diarrhoeal disease is still one of the major causes of mortality and morbidity of children in developing countries. Our objective was to assess the prevalence of diarrhoeal disease among male schoolchildren in Jeddah and to identify the associated risk factors, especially those related to drinking water and sanitation disposal. This cross-sectional study was conducted randomly where self-administered questionnaires were issued to parents through the schools. The data were collected from 1,064 respondents indicating that 14.9% of the children had diarrhoea during the previous month. The main risk factors were: the number of children under five years living in the same house (OR per child 1.34, 95% confidence intervals 1.15–1.56), being of Saudi nationality (OR 1.75, 1.08–2.84), reporting sewage spillage near the home (OR 1.69, 1.14–2.53), eating out after school hours (OR 1.74, 1.16–2.60), not drying hands after washing them (OR 1.66, 1.10–2.51), using reusable cloths or sponges to dry dishes (OR 1.70, 1.14–2.52).

Key words | children, diarrhoea, drinking water, environment, risk factors, Saudi Arabia

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INTRODUCTION

Diarrhoea is still an important public health issue in developing countries and continues to be a leading cause of morbidity and mortality among children (Gurrant *et al.* 1990; Bern *et al.* 1992; Black & Lantana 1995; Rautanen *et al.* 1998; Kosek *et al.* 2003).

Diarrhoeal diseases claim the lives of nearly 2 million children every year and have killed more children in the last decade of the last century than all people lost to armed conflict since the Second World War (UNICEF 2000). Furthermore, over 99% of deaths of children less than 14 years of age occur in developing countries (WHO 1999). Although there has been a decline in mortality, morbidity has remained high over the last four decades (Kosek *et al.* 2003).

Globally, the main factors responsible for diarrhoeal disease are inadequate drinking water, sanitation and hygiene practices (Ashbolt 2004; Fewtrell *et al.* 2005; Marino 2007; Pruss-Ustun *et al.* 2008). In particular, diarrhoeal disease due to inadequate water and sanitation is one of the two most important factors in childhood mortality in low-income countries (Pruss-Ustun *et al.* 2008). Food hygiene is also assumed to play a major role in the epidemiology of diarrhoeal diseases, especially in developed countries (WHO 1984; Motarjemi *et al.* 1993). It has been estimated that, in the United States, foodborne microbiological hazards may be responsible for as many as 76 million cases of illness, 324,000 hospitalizations and 5,200 deaths in the United States each year (Mead *et al.* 2000). Unhygienic food preparation occurs both in developing countries and in industrialized countries. It has been suggested that a substantial proportion of foodborne illness is attributable to improper in-home food handling preparation, and consumption practices by consumers, including inadequate cooking and storage of foods,

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cross-contamination of raw and cooked foods, inadequate personal hygiene such as hand washing, and consumption of raw, uncooked or unsafe foods (Doyle *et al.* 2000; Medeiros *et al.* 2001; Redmond & Griffith 2003). However, a recent systematic review of the impact of kitchen hygiene on diarrhoeal disease in developed country settings was unable to find strong epidemiological evidence of a link (Stenberg *et al.* 2008). Nevertheless, a review of hygiene interventions did find that hygiene interventions in low-income countries were generally effective at reducing diarrhoeal disease (Aiello & Larson 2002).

Although there have been many epidemiological studies of self-reported diarrhoeal disease reported worldwide, most have been concerned with simply estimating prevalence or identifying the aetiological agents. In a systematic review, mentioned above, the authors identified 19 observational studies worldwide of the impact of hygiene behaviours on risk of diarrhoea from January 1980 to June 2001 (Aiello & Larson 2002). Most of these studies were on young children under five years old and all were in developing countries, often in very poor situations. Diarrhoea in older children, though not as lethal as it is in very young children, remains an important cause of morbidity. It is also likely that risk factors for older children differ from children under five as they start school and begin to experience life away from their immediate family.

To the authors' knowledge, there have been no studies to associate drinking water, food sources and practices, and personal hygiene to diarrhoeal disease in Saudi Arabia. Most of the published studies have been limited to consideration of the microbial aetiology and/or prevalence (Al-Abbad & Bella 1990; Qadri *et al.* 1991; Milaat & Elassouli 1995; El-Sheikh & El-Assouli 2001; Al-Braikan *et al.* 2003; Ghazi *et al.* 2005) or demographic and socioeconomic factors only (Al-Abbad & Bella 1990; Al-Mazrou *et al.* 1991; El-Sheikh & El-Assouli 2001; Bani *et al.* 2002). Therefore, many factors considered in this study have not already been adequately examined in the country for this age group.

The aim of this study was to assess the prevalence of diarrhoeal disease among schoolchildren in Jeddah boys' primary public schools aged 7–12 years and to identify the associated socio-demographic and environmental factors.

MATERIALS AND METHODS

Study area

Jeddah city, located on the west coast of Saudi Arabia, is the largest city in the Western Province and the second major city after the capital (it is located in the most densely populated province in the country, Makkah Al-Mukarramah). Jeddah is a very good example of a typical Saudi urban area with a complex population structure, incorporating different origins. In 2001, the population reached 2.9 million, representing 14% of the total population of Saudi Arabia, and is increasing at a rate of 4% per year (Municipality of Jeddah 2006).

Drinking water and sewage system

Due to the shortage of water sources in the country, the population is entirely dependent on desalination plants for drinking water for such large cities. Desalinated water is then chemically treated prior to being pumped into the distribution network. Properties are provided with drinking water once or twice per week only. Each property has a private underground tank where the water is settled for couple of days. The water is then pumped to the roof tank, and from there to water facilities in the property as needed. Cesspool systems are still used in many areas for domestic and commercial wastewater disposal and in such areas most underground water supply tanks are built next to or very close to the cesspools. The long term use of cesspool systems has caused the ground water table to rise rapidly in many areas of the city (Mohorjy 1997). Currently, the level of ground water in Jeddah is rising. Between 1998 and 2002, this rise has been estimated to be 0.41 m. Consequently, the area of the city considered to be at risk from the elevation has increased from 56% in 1998 to 61% in 2002, an area of 915 km^2. This represents a yearly increase of about 1.25% and 18.75 km^2 of the city area (Basamad 2003). Therefore, the risk of water contamination in some parts of the city is high (Mohorjy 2001).

Study design

The study was conducted in boys' public schools serving children aged 7–12 years. Jeddah City is divided into four

sectors (North, South, East and Central) by the Ministry of Education. Each sector is further divided into districts and six districts were randomly chosen from each sector using the select cases function within SPSS™. Within each district, one school was chosen at random also using the select cases function. This led to 24 schools being selected for inclusion in this study. Following local practice for such studies, the study was approved by the regional Ministry of Education which reviewed the study design to ensure that it did not conflict with Saudi culture. The study was restricted to schools catering for boys only because of cultural and governmental difficulties in gaining access to girls' schools.

The study was conducted from October 2004 to February 2005, which is the winter season in Jeddah. Data on children were collected from parents and guardians by a self-administered questionnaire. The questionnaire requested mainly demographic, socioeconomic and environmental data for households and their children as well as diarrhoea episodes for children during the last month and last year. Demographic and socioeconomic variables include nationality, education level, age group, family income, house type, number of people sharing the child's bedroom, and toilet. Environmental variables include the source of drinking water and practices inside the house, sanitary system type and spillover, child health status and diarrhoea episodes and personal hygiene, food safety behaviour and practices. Most of the questions were one of two types: yes/no questions, which offer a dichotomous choice; and multiple choice questions offering several fixed alternatives. The questionnaire was reviewed for comprehension and tested on a group of households from different districts of the city and the results of the test were used to modify the questionnaire. The piloting of the questionnaires sought comments on the clarity of questions and language, their applicability to the actual situation of the child's environment, the time taken to complete the questionnaire and whether the questions were considered too intrusive. The results of this feedback were used to revise the final questionnaire.

In each school, 70 questionnaires were distributed to the parents through their children. Children were randomly chosen in the school irrespective of age, nationality or academic achievement. At each age level, if there were more than one class, only one was chosen at random as described above. Children in that class were chosen from the odd numbers of the attendance register and received an envelope containing a copy of the questionnaire to submit to their parents for completion. In total, 1,680 questionnaires were distributed to the parents. Where there was more than one child selected from the same household the questionnaire was directed at the youngest. Instructions on how to complete the questionnaire were included for the parents, together with an introductory letter explaining the purpose of the study.

Data analysis

The data entry was performed by using EpiInfo software (Version 3.3.2, Centre for Disease Control and Prevention, Atlanta, Georgia). Analysis and tabulation were conducted by using SPSS software Version12 (SPSS Inc., Chicago, Illinois).

The data were summarized by using descriptive statistics, including frequencies and percentages for all variables. Means and standard deviation were calculated for continuous variables only.

The chi-squared test was used to test the association between socio-demographic, environmental factors and diarrhoea episodes at 95% level of significance. Variables that were positively or negatively associated with illness ($p < 0.2$) were included in a logistic regression model. Diarrhoea episodes were considered as the dependent variable whereas the others were independent variables. The least significant variable was then removed from the model and the model re-run. This was repeated until all variables in the model were significant at the $p < 0.2$ level. This was then deemed to be the final model.

RESULTS

Completed questionnaires were received from a total of 1,190 parents (71% response rate). Of these 126 were rejected as they were inadequately completed or duplicates, in that 50% or more questions were unanswered or were unintelligible. Therefore, 1,064 questionnaires were included in the analyses.

Tables 1 and 2 give the demographic data of the families responding to the questionnaire. The majority of respondents (95.4%) reported that their children were in good health. Some 14.9% of children had diarrhoea in the previous month, 76.2% of children with diarrhoea reported abdominal pain, 43.0% vomiting, 33.8% fever, and only 1.3% bloody diarrhoea. The duration of illness for patients was less than 24 hours for 19%, 1–3 days for 70.8%, and 4–7 days for 8.0%. Only 2.2% reported that their children were admitted to the hospital and 49.7% reported that the children were off school because of the illness.

All potential predictor variables for diarrhoea in the previous month were tested against the dependent variable by the *t*-test for scalar variables, chi-square test for nominal and chi-square test for trend for ordinal variables. All variables with a p value < 0.2 are shown in Table 3 and were included in a binary logistic regression model.

This final model is shown in Table 4. From this final model, it would appear that the main risk factors for diarrhoea in the previous month were: the number of children under five years living in the same house (OR 1.34, 95% confidence interval: 1.14, 1.56), being of Saudi nationality (OR 1.75, 95% CI: 1.08, 2.84), reporting sewage spillage near the home (OR 1.69, 95% CI: 1.14, 2.53), eating out after school hours (OR 1.74, 95% CI: 1.16, 2.60), not drying hands after washing them (OR 1.66, 95% CI: 1.10, 2.52), reusing a cloth towel, rag or sponge to dry dishes (OR 1.70, 95% CI: 1.14, 2.52).

Table 1 | Characteristics of children and their households ($n = 1,064$)

Variable	Mean	Standard deviation
Child's age	9.76	1.74
Number of people living at your house		
Aged less than 5 years	1.06	1.13
Aged 5–15 years	2.54	1.97
Aged over 15 years	2.02	1.83
Number of years you have been in this house	8.44	6.49
Number of rooms in house	4.72	1.65
Number of bedrooms in house	2.51	0.95
Number of people share the bedroom with child	2.37	1.36
Number of people use the same toilet as child	4.42	2.15

DISCUSSION

The findings in this study are based on self-reported diarrhoea, and as such the study does not have the advantage of a microbiological diagnosis. On the other hand, alternative study designs may give a more accurate diagnosis but suffer from major under-ascertainment of illness. This is particularly marked when having to rely on physician reported surveillance (Wheeler *et al.* 1999), but is also seen in the steep decline in reporting with time after recruitment in prospective studies (Colford *et al.* 2005). It is also likely that having to collect stool samples in many cultures would act as a strong disincentive to report diarrhoeal disease. Consequently, we would argue that the study design that we have adopted gives a more accurate estimate of population prevalence of diarrhoeal disease than alternative study designs.

The reported 1-month incidence of diarrhoea in the present study is 14.2 cases per 100 children, which is similar to that found in another Saudi study (12.5) (Al-Abbad & Bella 1990). In Arab countries, diarrhoea prevalence was found to be 23.6% in Egypt (El-Gelany & Hammad 2005) and 13.7% among family members in the Nuseirat Refugee Camp, Gaza Strip (Abu Mourad 2004). In Latin America, diarrhoea among children less than two years of age in poor area is 21.2% in Brazil (Rego *et al.* 2005). Bolivia has some of the highest reports of morbidity and mortality due to diarrhoeal disease among children less than five years old with an estimated 500,000 cases and 7,900 deaths, and a prevalence of 30% (Clasen *et al.* 2004). A study conducted in East Africa reported that diarrhoea prevalence was found to be 18% in Kenya, 21% in Uganda and 8% in Tanzania (Tumwine *et al.* 2002).

Many of the most significant risk factor findings in this study are not surprising and are consistent with results from most other studies. The association between the presence of children in the home under 5 years old and diarrhoea has been identified before in Saudi Arabia (Al-Abbad & Bella 1990). The same findings were confirmed regionally (El-Gelany & Hammad 2005) and globally (Letrilliart *et al.* 1997). A study of sporadic cryptosporidiosis in England

Table 2 | Demographic and socioeconomic characteristics for children and their households

Variable		Number	(%)
Child's house	Rented flat	558	52.4
	Owned flat	179	16.8
	Rented villa	23	2.2
	Owned villa	139	13.1
	Rented traditional house	91	8.6
	Owned traditional house	53	5.0
Nationality	Saudi	748	70.3
	Non-Saudi	314	29.5
Relationship to the child of person completing questionnaire	Father	800	75.2
	Mother	196	18.4
	Brother/Sister	42	4.0
Marital status of person completing questionnaire	Married	974	91.5
	Not married	74	7.0
Age group of person completing questionnaire	15–24	43	4.0
	25–34	239	22.5
	35–44	508	47.7
	45–54	189	17.8
	55–64	54	5.1
	Over 64	11	1.0
Education level	Low	156	14.7
	Middle	520	48.9
	High	378	35.5
Occupation	Looking for job	31	2.9
	Housewife	19	1.8
	Private employee	324	30.5
	Governmental employee	465	43.7
	Self-employed	128	12.0
	Retired	73	6.9
Monthly income (£1 ≈ 7.0 SR)	Low (<3,000 SR)	300	28.2
	Middle (3,000–8,000 SR)	478	44.9
	High (>8,000 SR)	257	24.2

and Wales also found the presence of young children as a risk factor for human but not bovine genotypes (Hunter *et al.* 2004). Clearly young children are more at risk of diarrhoea themselves and act as a source of infection for older children in households. The lack of an association with illness in other family members suggests that children under five can act as a source of infection even when asymptomatic themselves as already suggested by Hunter *et al.* (2004).

The increased risk seen in Saudi nationals compared with those with non-Saudi nationality is surprising as it would be expected that newcomers into a community would be at greater risk. However, this finding is consistent with the latest data presented by the Saudi Ministry of Health (MOH) in which about 19% of diarrhoea cases treated in government primary health care centres (PHCC) and hospitals in Jeddah city in 2006 were non-Saudi (MOH 2007), while about 30% of the population of Jeddah city are

Table 3 | Single variable analysis of associations with self-reported diarrhoea in past month

Variable	Not ill	Ill	Odds ratio	95% CI*	*p* value
Number of people at house less than 5 years old (mean)	1.0	1.41	1.328	1.158–1.522	<0.001
Nationality					
Non-Saudi	268	33	1.0		0.021
Saudi	592	118	1.619	1.072–2.444	
Occupation of head of family					
Governmental employee	366	76	1.0		0.109
Housewife	17	1	0.283	0.037–2.161	
Looking for job	21	7	1.605	0.659–3.910	
Private employee	268	42	0.755	0.502–1.135	
Retired	61	8	0.632	0.290–1.374	
Self-employed	111	12	0.521	0.273–0.992	
Any problems observed in public water network at home					
No	514	75	1.0		0.036
Yes	324	69	1.460	1.023–2.082	
Colour problem in public network					
No	744	124	1.0		0.153
Yes	116	27	1.397	0.882–2.212	
Taste problem in public network					
No	726	117	1.0		0.035
Yes	134	34	1.574	1.030–2.406	
How frequently problems in public network observed					
Never	514	75	1.0		0.020†
Rarely	29	6	1.418	0.570–3.526	
Sometimes	134	28	1.443	0.898–2.318	
Mostly	65	14	1.523	0.813–2.853	
Always	73	18	1.690	0.956–2.988	
Complaint from child about school water					
No	620	105	1.0		0.100
Yes	183	43	1.387	0.938–2.052	
Colour problem in school water					
No	817	137	1.0		0.036
Yes	43	14	1.942	1.034–3.644	
Any spill of sewage around the house					
No	398	51	1.0		0.005
Yes	410	90	1.700	1.174–2.462	
Sewage spill does often happen					
Never	395	51	1.0		0.001†
Rarely	42	6	1.106	0.448–2.732	
Sometimes	195	37	1.470	0.931–2.320	
Mostly	61	16	2.032	1.090–3.788	
Always	99	27	2.112	1.261–3.538	
Wash hands before eating					
Always	529	83	1.0		0.041†
Mostly	162	28	1.102	0.693–1.750	
Sometimes	131	31	1.508	0.957–2.377	
Never/rarely	29	8	1.758	0.777–3.977	

Table 3 | (*continued*)

Variable	Not ill	Ill	Odds ratio	95% CI*	*p* value
Wash hands after toilet					
Always	613	46	1.0		0.055†
Mostly	97	23	1.514	0.916–2.504	
Sometimes	90	23	1.632	0.984–2.706	
Never/rarely	35	7	1.277	0.552–2.957	
Wash hands when coming from outside					
Always	295	46	1.0		0.037†
Mostly	155	24	0.993	0.584–1.688	
Sometimes	247	41	1.065	0.676–1.676	
Never/rarely	131	37	1.811	1.122–2.925	
Dry his hands after washing them					
Yes	617	97	1.0		0.025
No	193	47	1.549	1.055–2.274	
Eats out after school					
No	416	53	1.0		0.001
Yes	416	95	1.792	1.247–2.576	
How often eats out after school					
Never	416	53	1.0		<0.001†
Once a week	125	27	1.695	1.023–2.808	
2–3 times a week	142	29	1.603	0.981–2.620	
4–5 times a week	48	13	2.126	1.081–4.180	
Every day	56	20	2.803	1.561–5.032	
Buy from street vendors					
Never	40	7	1.0		<0.001†
Rarely	499	68	0.779	0.335–1.807	
Sometimes	226	49	1.239	0.524–2.929	
Mostly	20	6	1.714	0.508–5.780	
Always	15	9	3.429	1.083–10.85	
Have a servant					
No	502	76	1.0		0.059
Yes	355	75	1.395	0.987–1.974	
Uses reusable cloths or sponges to dry dishes					
No	421	54	1.0		0.003
Yes	426	94	1.720	1.199–2.468	
How often do family buy and eat food from outside house					
$<$ once a week	17	4	1.0		0.175†
Once a week	504	80	0.675	0.221–2.056	
2–3 times a week	219	45	0.873	0.281–2.718	
$>$ 3 times a week	35	9	1.093	0.294–4.061	
Family buy and eat food in traditional restaurants					
No	90	9	1.0		0.086
Yes	770	142	0.542	0.267–1.101	

*CI, confidence interval.
†Chi-square for trend.

non-Saudi based on this survey. However, this finding may be biased by the policy of the MOH which asks certain groups of non-Saudis to visit private PHCCs and hospitals rather than government ones.

Regarding water and sanitation, the only significant factor is reports of sewage spillage near the home (OR 1.69). The association between diarrhoea and wastewater contact or inadequate sanitation provision is one that has been made previously (Blumenthal *et al.* 2001; Fewtrell *et al.* 2005). Sites where stagnant water accumulates would support microbial growth and could become reservoirs of infection (Tanner 2002). Other study findings indicate that species that grow under these conditions are a greater risk to vulnerable groups, such as children, pregnant women, the elderly and those with immune suppressive illnesses, than to other family members (Wolf 1995; Bloomfield 2001).

One of the surprising findings was that hand washing was not more strongly associated with reduced risk. In the univariable analyses, the association had only borderline significance (0.041, 0.055 and 0.037), and none of the three hand washing variables was included in the final model. This is in contrast to previous studies where hand washing with soap is shown to be an important intervention (Aiello & Larson 2002). In part, this could be cultural and due to the high proportion of children who are reported to wash their hands in the study. Alternatively this could be because our study was in slightly older children and most other studies have been dominated by children under five years old, who do indeed experience most diarrhoea. Some studies suggested that the availability of water could have an impact on hand washing, simply because when water is closer, hand washing is more frequent and this encourages better hygiene in general (Cairncross 1997; Curtis *et al.* 2000; Jensen *et al.* 2004). After reviewing many studies regarding water and hand washing, Esrey *et al.* (1991) concluded that water availability was probably more important than water quality, though this view has been contradicted by recent systematic reviews (Clasen *et al.* 2007). This seems to be the situation in Jeddah where water is available through the public network most of the time. However, the intermittency of the public network water supply is one of the main causes for using bottled water among respondents. In addition, it is confirmed that public network tariffs are among the lowest in the world, and Saudis consume twice as much water as UK residents. Of particular interest, however, is the finding that not drying hands was associated with a significant increase in risk of illness. This would make sense, as children with wet hands are likely to wipe

Table 4 | Final model for binary logistic regression analysis of diarrhoea in past month

Variable*		Odds ratio	Confidence interval	*p* value
Children in home under 5 years	For each additional child	1.339†	1.146–1.564	0.0002
Nationality	Non-Saudi	1.0		0.022
	Saudi	1.754	1.083–2.843	
Any sewage spill around house	No	1.0		0.010
	Yes	1.694	1.136–2.527	
Eats out after school hours	No	1.0		0.007
	Yes	1.736	1.160–2.598	
Dries hands after washing them	No	1.664	1.100–2.518	0.016
	Yes	1.0		
Uses reusable cloths or sponges to dry dishes	No	1.0		0.009
	Yes	1.695	1.140–2.521	
Eats in traditional restaurants	No	1.00		0.095
	Yes	0.533	0.254–1.116	
Number of bedrooms	For each additional bedroom	0.828	0.657–1.043	0.109

*Model estimated from 863 observations.
†Per additional child http://www.bmj.com/cgi/content/full/313/7061/862#R4

them on their clothes, possibly leading to recontamination of the hands after washing. This observation is worthy of further study.

The association with eating from outside after the school day (OR 1.7) is consistent with other studies. It is reported that 44% of food poisoning outbreaks are associated with restaurants, hotels and other catering establishments (POST 1997). Owing to the rapid socio-economic development in Saudi Arabia, especially during the last three decades, there has been a rapid increase in the number of fast food businesses owned by immigrants from developing countries who have not had adequate training in food hygiene (Yagob & Al-Mazrou 2004). Unfortunately, few studies have been published on food poisoning from such sources. In one local study, a popular local fast food outlet was found to be responsible for a large number of salmonellosis outbreaks from chicken shawarma (Al-Azeri *et al.* 2002). This type of dish has great potential for food poisoning, because the meat is cooked very slowly by direct heat from a distance which does not raise its temperature to an extent that can kill the bacteria present in the chicken. These popular sandwiches were repeatedly implicated (Jarallah *et al.* 1993). In another study in Abha city, an outbreak of gastroenteritis occurred among customers of a restaurant that specialized in fried chicken. Of the 10 food items served, only mayonnaise and minced garlic were associated with cases, which indicated unsafe storage for these items. Salmonella was isolated from 84% of persons with symptoms of food poisoning (Al-Ahmadi *et al.* 1998). The association between illness and eating out was not found when the family as a whole ate out, suggesting that children eating by themselves may purchase their food from poorer quality sources such as cafeterias compared with their parents. They may also be less careful about personal hygiene when eating out by themselves than when their parents are there to remind them. Bentham & Langford (2001) stated that the increase in eating outside the home could be one of the factors that play a role in increasing food poisoning incidences.

Another important observation was the increased risk of illness in those families who dry their dishes with materials used more than once, such as tea towels, sponges and cloths. This would suggest that pathogens contaminate the cloths during their use and repeated use spreads these pathogens onto newly washed dishes. It is known that pathogens can survive on dishes during washing and can contaminate kitchen cloths used to dry them (Mattick *et al.* 2003). Our findings may support the case for health education about the importance of using disposable materials to dry dishes or even just to leave dishes to dry naturally. This could be a highly cost-effective intervention to reduce diarrhoea.

As well as the important significant associations discussed above, there were some expected associations that were not confirmed in this study. The first was that we did not find an association with illness in other family members (OR = 1.17). Most studies of diarrhoeal disease find such an association. The second was that the drinking water source was not associated with either an increased or a decreased risk of illness, also suggesting that waterborne transmission was not an important source of infection in this group or that both tap and bottled water carried similar risks (drinks tap water vs. bottled water: OR = 1.08). In fact, there have been two studies involving drinking water as a risk factor for diarrhoea; the first one was by Mahfouz *et al.* (1995) who found that children under 5 years of age whose households were not using chlorinated water had twice the risk of diarrhoea (OR = 1.98, $p = 0.047$). Also he reported that use of chlorinated water was associated with a 48% reduction in diarrhoea. His study was in a rural area where the wells are heavily contaminated with bacteria. In a more recent study, Al-Braikan (2004) collected 130 serum samples from adults in Jeddah city to identify the sero-prevalence of cryptosporidiosis infection and to determine the factors associated with increased risk of infection. Tap water consumption was the only factor significantly associated with seropositivity to cryptosporidiosis infection (OR = 37.33, $p < 0.001$).

The reported prevalence of diarrhoea in the present study (14.9 cases per 100 children per month) and the risk factors identified here differ from those reported in other local studies making it difficult to compare our findings with them. In part, this difference may be because we restricted our study to male school children aged between 7 and 12 years. Any study that recruits children of all ages will be strongly biased towards children under 5 where most illness occurs. It is highly likely in our view that risk factors in school children will differ from those in pre-school children

and such studies are likely to miss potentially important risk factors in older children. In addition to that, even though Saudi Arabia is categorized as a developing country, the environmental and public health infrastructure is more advanced than in many other countries: for example, according to World Health Organization statistics, infant mortality rate (IMR) was 22 in 2004, 21 in 2005 (WHO 2007) and 18.5 in 2006 according to the Saudi Ministry of Health (MOH 2007).

CONCLUSIONS

This study has demonstrated a number of independent risk factors for childhood diarrhoea in male schoolchildren. Despite the intermittent nature of the Jeddah water distribution network, we did not find that drinking water was linked to risk, though this may be because the alternative bottled water was equally likely to be a risk factor. However, problems with sanitation especially sewage spills near the house from septic tanks was an important risk factor. Improving the emptying of septic tanks to avoid spills and advising children to stay away from such spills could be a worthwhile public health intervention. Other interventions that could help reduce the prevalence of diarrhoeal illness include discouraging children from buying food after school from potentially risky sources, encouraging them to wash and dry their hands properly, and not using re-usable cloths to dry dishes in the home kitchen.

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