Infantile diarrhoea due to water complementation of breast and bottle feeding

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SUMMARY This study investigated the prevalence of unusual infant feeding practices among 204 mothers of infants aged 1–12 months, who were admitted with acute diarrhoea to the only two national hospitals in Kuwait. Ninety per cent of the mothers boiled water to prepare a powdered milk formula, but only 15% boiled water for drinking.

Thirty nine infants (19%) were admitted more than once. Better family state in terms of socioeconomic class, maternal education, and breast feeding gave some protection against re-admission, though this was not significant. It seems that the condition of drinking water is an important cause of diarrhoea and hence of re-admission. The number of re-admissions was twice as high among infants drinking unboiled (unfiltered or mineral) water than among those drinking boiled or unboiled but filtered water. Breast feeding is protective if no extra water is given.

Kuwait is a small country situated at the head of the Arabian Gulf with a population of 1.3 million and with 50 000 live births every year. The water supply in Kuwait is derived from distillation of sea water; some areas are supplied through pipes, others by water tankers. The water is usually muddy, and most houses have filters to clear it. Some families use mineral water, and at least 35 types are imported to Kuwait. In a recent study it was claimed that 55% of 'mineral water' imported to Qatar was tap water. (Kotb A. Personal communication.) Although many mothers prepare formula feeds with boiled, cooled water, they tend to give additional drinking water to the infants from any source.¹ In hot weather infants probably drink more water than breast milk or formula.

The aim of this study was to ascertain if there was an association between the types of water used and the frequency of admission due to acute infantile diarrhoea.

Patients and methods

A total of 204 mothers of infants aged 1–12 months were interviewed when their infants were admitted with acute diarrhoea to Al-Sabah and Al-Ameri Hospitals (the only two national hospitals in Kuwait), during four months between early March and the end of June 1981. The population studied was multi-national, comprising many Arab and

Asian countries. The interviews (carried out by S P-S and two trained social workers) included details of: living area, referring clinic, birth place, age, sex, nationality, weight at birth, weight on admission, the mother's education and occupation, and father's social class (I, II, III, IV, or V, classified according to the general registrar classification of occupation for the United Kingdom).

Each mother was asked how she defined diarrhoea, the number of attacks of diarrhoea at home since the baby's birth, and the remedies used; the number of attendances at paediatric clinics because of diarrhoea; the number of admissions to hospital because of diarrhoea; the type of feeding (breast or bottle, or both) being used on admission to hospital; and the duration of breast feeding. The brand of milk being used on admission and the number of bottles and teats and the method of sterilisation employed were also ascertained. It was also determined whether water was administered to the infant other than as milk, the source of drinking water, whether it was boiled or unboiled (filtered, unfiltered, or mineral) and whether water was given during each episode of fever, diarrhoea, or vomiting.

Stool culture and microscopic examination were undertaken at least three times after admission, but virological investigation was not possible. Infants with chronic diarrhoea—that is, lasting more than 10 days, infants weighing less than 2.5 kg or requiring

incubator care at birth, and infants showing developmental delay or anomalies were excluded from analysis of the results.

The questionnaires were analysed by computer and included tabulations and χ^2 analysis.

Results

Sex, age group, and type of feeding. Two hundred and four infants were admitted (124 boys and 80 girls), of whom 59 (29%) were breast fed, 115 (56%) artificially fed, and 30 (15%) were on mixed feeding (breast and artificial) at the time of admission. Forty five (22%) were aged 1–3 months, 49 (24%) were aged 3–6 months, 56 (27%) were aged 6–9 months, and 54 (27%) were aged 9–12 months.

Infants from all age groups were admitted in equal ratios. More boys than girls were admitted in each group, but the difference was not significant. There was no association between type of feeding and age groups or sex.

Type of drinking water given between feeds. In all, 199 (98%) mothers gave water between feeds, with only five giving none. Among those who gave water, 30 (15%) gave water after boiling, 97 (49%) gave filtered (unboiled) water, 51 (26%) gave unfiltered (unboiled) water, and 21 (11%) gave unboiled mineral water.

The difference in water use among mothers with different feeding practices was significant. Only five infants did not receive any extra drinking water, and all of these were breast fed and aged between 2 and 6 months. The use of boiled water was four times more prevalent among bottle than breast fed infants (breast fed 5%, bottle fed 20%, and mixed feeding 13.5%). Filtered water was used in similar percentages of infants on the different types of feeding (breast fed 51%, bottled fed 48%, and mixed feeding 40%). The unfiltered water was used in various percentages (breast fed 29%, bottle fed 19%, and mixed feeding 40%). The mineral water was used more often in infants who were bottle fed (13%) than in infants who were breast fed (7%) or on mixed feeding (6.5%).

Socioeconomic class of father. Breast feeding has been shown to be significantly higher among infants of social classes IV and V than of social classes I, II, and III ($p<0.001$).¹

The difference in water used among different social classes was significant ($p<0.001$), except for the use of filtered water, which was similar in each class (range 41–57%). Of 36 infants from social classes I and II, 10 (28%) received mineral water, nine (25%) received boiled water, only one received

unfiltered water, and one received no water at all. Of 82 infants from social class III, 18 (22%) received boiled water, nine (11%) received mineral water, and eight (10%) received unfiltered water. Of 86 infants from social classes IV and V, however, 42 (49%) received unfiltered water, three (3%) received boiled water, two (2%) received mineral water, and four (5%) infants received no water.

Maternal education. The difference in water use among mothers with varying levels of education (grouped as illiterate, primary, secondary, or university) was significant ($p<0.001$). It was broadly similar to the social class distribution. Mothers from each group give filtered water in nearly equal percentages (range 44–48%). Of 108 mothers classed as illiterate, however, 48 (44%) gave unfiltered water, seven (6%) gave boiled water, four (4%) gave no water, and only one gave mineral water. Of 48 mothers with some education (primary or intermediate), 11 (23%) gave boiled water, seven (15%) gave mineral water, and three (6%) gave unfiltered water to their infants. Of 48 mothers with higher education (secondary or university), all gave some water, 13 (27%) gave mineral water, 12 (25%) gave boiled water, and no one gave unfiltered water.

Amount of water given during episodes of fever, vomiting, or diarrhoea. Although most mothers gave water on most days, only 58 (29%) considered it necessary to give water 'always' during episodes of fever, vomiting, or diarrhoea, 85 (42%) gave water 'sometimes', and 61 (30%) did not give any extra water. The difference in water use during episodes of fever, diarrhoea, or vomiting among mothers with different feeding practices was significant ($p<0.001$). Twenty five (42%) of the breast feeding mothers gave no extra water during an attack compared with 26 (23%) of mothers who bottle fed and 10 (33%) of those giving mixed feeds. Some mothers thought water would aggravate vomiting or diarrhoea.

Re-admitted infants. Thirty nine (19%) infants had more than one re-admission to hospital. No association was found between re-admission and age group or sex. Some association between re-admission and type of feeding, however, was apparent, though this was not significant. Nine (15%) breast fed infants, 27 (23%) bottle fed infants, and three (10%) infants on mixed feeding were re-admitted to hospital.

An association between social class and re-admission was noted, though again this did not reach significance. Five (14%) of the 36 infants in social classes I and II, 18 (22%) of the 82 in social

Table Re-admission rates among infants receiving different types of feeding and water

	No (re-admission %) of infants classed according to type of water received					Total No (re-admission %) of infants (n=204)
	No water	Boiled	Filtered	Unfiltered	Mineral	
Breast	5 (0)	3 (0)	30 (13)	17 (18)	4 (50)	59 (15)
Bottle	—	23 (22)	55 (15)	22 (46)	15 (27)	115 (24)
Breast + bottle	—	4 (0)	12 (8)	12 (17)	2 (0)	30 (10)
Total	5 (0)	30 (17)	97 (14)	51 (30)	21 (29)	204 (19)

class III, and 16 (19%) of the 86 infants in social classes IV and V were re-admitted.

There was no association between maternal education and re-admission. Twenty two (20%) infants of mothers classed as illiterate, nine (19%) infants of mothers classed as of primary or intermediate education, and eight (17%) infants of mothers classed as of secondary or university education were re-admitted.

Type of drinking water and re-admission however, were associated (Table). Of five infants aged 2–6 months who were breast fed and receiving no extra water, none were re-admitted. Of 30 infants having boiled water only, five (22%) of 23 infants who were bottle fed were re-admitted. No re-admissions were reported among breast fed infants or infants on mixed feeding. For the 97 infants on filtered water, re-admission was similar for the different types of feeding (breast fed 13%, bottle fed 15%, and mixed feeding 8%). For the 51 infants on unfiltered water, the chance of re-admission was three times higher in bottle fed infants than in breast fed infants or infants on mixed feeding (breast fed 18%, bottle fed 46%, and mixed feeding 17%). Of 21 infants on mineral water, re-admission was twice as common in breast fed as in bottle fed infants.

There was a positive association between the number of bottles used and the frequency of admission ($p<0.001$). Out of 88 infants who had between one and three bottles, nine (10%) were re-admitted, and out of 57 infants having more than four bottles, 18 (32%) were re-admitted.

There was no association between re-admission and the type of micro-organisms detected in the stools.

Microbiological analysis of stool. Stool specimens were positive for micro-organisms in only 26 infants. Nine grew pathogenic *Escherichia coli*, nine *Salmonella* species, two *Shigella* species, and six *Giardia lamblia*. There was no association between positive stool culture and water use, type of feeding, or maternal education, though a relative association

with social class was apparent. Infectious diarrhoea was higher among the lower social classes ($p=0.06$).

Discussion

In this study of 204 infants existing feeding practices in the two hospitals (breast 29%, bottle 56%, and mixed 15%) were no different from those described in a community study of 966 infants in the same age group of less than 1 year (breast 32%, bottle 58%, and mixed 10%).² There seemed to be some association between admission and feeding practice, but this was not significant.

The results of this study suggest that many factors other than breast feeding are associated with frequency of infant admission for acute diarrhoea. Breast feeding did not seem to be protective against either single or multiple admissions if water was given as a supplement. The highest rate of re-admission was among infants on bottle feeding who received unfiltered water and infants on breast feeding who received mineral water; the lowest rate of readmission was among infants on breast feeding who received boiled water.

A recent study by Taylor *et al* showed that admissions to hospital for gastroenteritis in the first year of life were marginally less likely in breast fed infants.³ In a similar survey in New Zealand, which investigated a wide range of gastrointestinal illnesses, there seemed to be some protective effect from breast feeding.^{4 5} This effect was restricted, however, to the first four months of life. Other studies in the UK and United States assessing the role of breast feeding in rates of hospital admission for gastroenteritis have shown conflicting results, some showing a benefit (usually without sufficient consideration of possible confounding associations)^{6–9} and others showing no protection.^{10 11} In the present study more than half of the mothers classed as illiterate were exclusively breast feeding their babies and giving unboiled (unfiltered) water for drinking. Yet the overall frequency of re-admission was not significantly higher from this group than from the other groups. On the other hand, the infants of

educated mothers were mostly fed artificially using predominantly boiled or filtered water. The overall frequency of re-admission in these infants was lower, unless mineral water was used, which doubled the frequency of admission. Frequency of admission was significantly associated with the number of bottles used (more than three bottles). It may have been that the more bottles used the less carefully they were sterilised.

Mothers who breast fed infants used significantly less drinking water on ordinary days and during episodes of fever, diarrhoea, or vomiting, probably because of low demand or unavailability of feeding bottles: mothers giving artificial feeding alone or as a supplement used water more often. This could be another reason that fewer breast fed infants were admitted, as fewer were exposed to contaminated water and utensils. In a recent case control study of cholera in infants from Bahrain Gunn *et al*¹² did not determine whether breast milk had a physiological preventive effect or whether its use simply minimised exposure to contaminated liquids and food.

Although in almost all studies different types of feeding were treated as separate variables, this does not necessarily mean that the infant received nothing else. As is shown in the present study, 98% of mothers gave water to their infants because of the hot climate, even though they were breast fed. Both the factors of exposure to the contaminated bottles and the use of unsuitable unboiled (unfiltered or mineral) water for infants were unavoidable.

There is no evidence that mineral water does not contain micro-organisms, as not every bottle can be analysed microbiologically. The chance of survival of micro-organisms in mineral water depends largely on its pH and whether it is aerated. In general, survival of enteric bacteria decreases at pH values below 5.0, but the pH of most mineral water ranges from 7.2–7.8.

Most of the published studies have related diarrhoea simply to breast or bottle feeding without considering mixed feeding. This study showed that fewer infants on mixed feeding were re-admitted, though the differences did not reach significance. Cullinan found that the incidences of symptoms of 'running nose', 'colic', and 'thrush' were lowest among babies on mixed feeding.¹³

It has been said that breast milk is the best infant food where water supplies are bad and hygiene is difficult. This study, however, showed that breast feeding is not sufficient protection, as no infant is exclusively breast fed after the neonatal period. Water hygiene is probably the key factor in decreasing the incidence of diarrhoeal disease.

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