Consumption of Tank Rainwater and Influence of Recent Rainfall on the Risk of Gastroenteritis among Young Children in Rural South Australia

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ABSTRACT

Background: The proportion of households that use tank rainwater as their main source of drinking water is similar to the proportion using reticulated public mains supplies in South Australia. However, little is known about risk to health from consuming rainwater.

Aims: (1) To determine whether the risk of gastroenteritis among children who drank tank rainwater differed from that of children who drank treated public mains water. (2) To investigate whether recent rainfall affected this risk.

Methods: A cohort study of 1,016 four- to six-year-old children who drank rainwater or treated mains water in rural South Australia was undertaken in 1999. Parents kept a daily diary of their child's gastrointestinal symptoms and water consumption for a period of six weeks. Data on respiratory illness and other risk factors for gastroenteritis were also collected.

Results: No increase in risk of gastroenteritis was observed among children who drank rainwater consumption compared with treated mains water. The adjusted odds ratio for gastroenteritis associated with rainwater consumption compared with mains consumption was 0.84 (95% confidence interval: 0.63- 1.13).

Conclusions: Young children who were regular consumers of tank rainwater, were at no greater risk of gastroenteritis than those who drank treated public mains water.

INTRODUCTION

Tank rainwater is a common source of water in Australia (Australian Bureau of Statistics, 2001, Heyworth et al., 1998). A study of 3,014 households in South Australia found that the proportion of households using tank rainwater as their main source of drinking water was similar to the proportion using public mains supply water; 42% and 40% respectively (Heyworth et al., 1998). Recognising the community preference for tank rainwater consumption and the need to conserve water, the South Australian Department of Health was willing to promote the use of tank rainwater as a sustainable source of water for consumption. First they required further evidence that it did not present a significant risk to health.

Because rainwater is an untreated source of water, which is may be contaminated by bird and animal faeces, it is considered a potential risk to health. Recent rainfall may increase the contamination of the tank rainwater in two ways. First, an influx of large volumes of fresh rainwater into tanks can influence the water quality by delivering a fresh load of contaminants from the catchment surface (Plazinska). Second, rainfall compromises water quality by resuspending the bottom sludge in the rainwater tank (Plazinska, , Lye, 1992)

Evidence on health risk arises mainly from descriptive studies, which have enumerated indicator organisms in tank rainwater at levels potentially hazardous to health.(Thomas and Greene, 1993, Fuller et al., 1981) In addition, worldwide there have been reported outbreaks of illness associated with rainwater (Brodribb et al., 1995, Merritt et al., 1999, Koplan et al., 1978, Schlech et al., 1985, Simmons and Smith, 1997). While these data suggest rainwater, along with other water sources, may be a risk factor for disease outbreaks, data on the role of tank rainwater to community-based cases of gastroenteritis is limited.

The specific objectives of this study were two-fold. The first was to determine whether the risk of gastroenteritis among four- to six-year-old children who drank tank rainwater compared with those children who drank treated public mains water in rural South Australia and the Adelaide Hills. The second was to assess the impact of rainfall on the risk of gastroenteritis.

METHODS

Study Population:

The sample was selected from 3,413 rural children who had taken part in an earlier state-wide survey on gastroenteritis and water consumption (Heyworth et al., 2003). Parents were asked if they were willing to participate in a second study and 1,960 parents (57%) agreed. To be eligible for the current study children had to: (1) reside in rural South Australia or the Adelaide Hills; and (2) drink public mains water that was filtered and disinfected, as their main source of drinking water; or drink rainwater from an above-ground tank as their main source of drinking water; and (3) not have an ongoing illness or treatment that led to gastrointestinal symptoms. Of the1,960 children, 869 were ineligible and 49 children were no longer contactable, leaving 1,042 children available for study. The study was conducted over a three-month period from January 1999 to March 1999.

Survey Instruments

Participants completed four survey instruments: a baseline questionnaire; a daily diary (42 days); three and six week telephone questionnaires. Data on daily gastrointestinal and respiratory symptoms, water consumption, cordial and soft drink consumption and antibiotic use were collected using a daily diary. The baseline questionnaire and telephone questionnaires at 3 and 6 weeks obtained data on: rainwater tank construction and maintenance; number of children in household; pets in home; contact with farm animals; attendance at preschool or school; swimming; contact with a sick pet; and time spent away overnight from home by child.

Daily rainfall data were obtained for 33 regional sites throughout South Australia for the period January to June 1999 from the Australian Bureau of Meteorology. The rainfall data were allocated to each child on the basis of the nearest weather station which corresponded to the rainfall band in which their place of residence fell. Rainfall was categorised as follows:

Table 1: Rainfall categories used in the statistical modelling

Rain group 1	No rainfall	<2mm for the day
Rain group 2	Low rainfall	≥2mm and <10mm for the day
Rain group 3	High rainfall	≥10mm and <60 mm for the day

Definition of gastroenteritis

The definition of gastroenteritis was based upon highly credible gastrointestinal symptoms (HCGI) (Payment et al., 1991), that is the presence of vomiting or liquid bowel movements, or nausea or soft bowel movement/s combined with abdominal cramps in a 24-hour period, unless a chronic cause for these symptoms was known to exist. A new episode of gastroenteritis was defined when there were seven symptom-free days preceding the onset of gastrointestinal symptoms.

Statistical analysis
Logistic regression was used to model the dependence of the binary response, HCGI, on water consumption and the other potential risk factors and confounders. Random effects models were used to allow for correlations between the responses from the same subject on different occasions (Diggle et al., 1996). To examine the influence of rainfall among rainwater users, the analyses were stratified by water source. These analyses were computed using STATA V8 software (Stata Corp, 2003).

RESULTS

Response

Of the 1,042 parents who were approached to participate, 965 children (93%) completed all components.

Incidence rate:

Over the six-week diary period there were 524 episodes of HCGI among 965 children. The incidence rate for HCGI was 5.5 episodes/child-year (95% CI: 4.9- 5.8 episodes/child-year).

Water Consumption

Children on average drank 4.3 cups per day of rainwater or 4.4 cups public mains per day. Each cup was between 160mL and 200mL and hence children drank between 672mL to 840mL each day.

For the 710 children who drank tank rainwater, parents were asked the length of time their child had been drinking tank rainwater; 94% had drunk tank rainwater for more than two years and 98% for more than 1 year.

Table 2 Length of time child has been drinking tank rainwater (n=710)

Duration	Frequency	Per cent
For 6 months or less	4	0.5
For 7 to 12 months	14	2.0
For 13 months to 2 years	24	3.4
For more than 2 years	666	94.1
Total	708[#]	100.0

Two missing data

Rainwater tank environment

Most rainwater tanks were constructed of galvanized iron (59%) and 43% of tanks were at least 10 years old. For those tanks that were more than two years old, the sludge had never been removed in 42% of tanks. A proportion of respondents, 26%, were not aware of whether the sludge had ever been removed. Only 8% had first flush diversion devices and 40% a screened

inlet, but 82% had sealed roofs. Of the roof catchments; 77% were reported to be free of overhanging trees and 65% of gutters had been cleaned in the last year.

Tank rainwater and gastroenteritis

The single variable analysis of the association between tank rainwater and gastroenteritis indicated that relative to public mains water consumption, there was a significantly decreased risk of gastroenteritis among children (Table 3). Length of time a child had been drinking tank rainwater was also significantly associated with HCGI (Table 3).

Table 3 Associations between HCGI episode and drinking water variables - single variable logistic regression analyses

		HCGI	
Risk Factor	**Days-at-risk**	**Odds Ratio**	**95% CI**
Model 1: Main Drinking water source	35,545		
Public mains only	5,034	1 (ref)	
Rainwater only	15,661	0.6	0.5 – 0.8
Rainwater & public mains water	11,600	0.7	0.6 – 1.0
Public mains & spring/bottled water	1,099	0. 6	0.3 – 1.1
All three	2,151	0.5	0.3 – 0.8
Model 2: Length of time child has drunk tank rainwater	32,370		
Never drunk tank rainwater	6,133	1 (ref)	
12 months or less	613	0.8	0.4 – 1.8
13-24 months	905	0.5	0.2 – 1.0
More than 24 months	24,719	0.7	0.6 – 0.9

Multivariable analysis

A range of potential confounding variables were added to model 1 shown in Table 3. When adjusted for confounders, the odds ratio for childhood gastroenteritis associated with tank rainwater consumption was 0.84 Table 4. This was not significantly different to that for the reference category, treated public mains (95% CI 0.63-1.13).

Table 4: HCGI and drinking water source - multivariable random effects logistic regression (34,722 days-at-risk)

	HCGI	
Variable	**Odds Ratio**	**95% CI**
Drinking Water Source		
Public mains	1 (ref)	
Rainwater only	0.8	0.6 – 1.1
Rainwater & public mains	0.9	0.7 – 1.3
Public mains & bottled/spring water	0.6	0.3 – 1.1
All three	0.6	0.4 – 1.0
Sore throat, cold or influenza		
No	1 (ref)	
First day of episode	3.4	2.3 – 5.0
Subsequent day of episode	2.3	1.8 – 2.9
First day of earache or infection		
No	1 (ref)	
Yes	2.8	1.3 – 6.2
First day of antibiotic use		
No	1 (ref)	
Yes	4.8	2.3 – 10.0
Contact inside the home with a person who had gastroenteritis on the same day		
No	1 (ref)	
Yes	2.1	1.2 – 3.7
Contact inside the home with a person who had gastroenteritis on the same day or previous 3 days		
No	1 (ref)	
Yes	1.8	1.0– 2.9
Contact outside the home with someone who had gastroenteritis on same day		
No	1 (ref)	
Yes	3.5	2.4 – 5.0
Do not know	1.2	1.0 – 1.5
Pet dog in the household		
No	1 (ref)	
Yes	0.9	0.7 – 1.0
Swam during diary period		
No	1 (ref)	
Yes, in a private pool	1.8	1.2 – 2.6
Yes, swam elsewhere	1.1	0.9 – 1.3
Average frequency of consumption of takeaway foods		
Less than once per week	1 (ref)	
1 or more times per week	1.3	1.1 – 1.6
Respondent rating of risk to health from tank rainwater		
Low/medium risk	1 (ref)	-
High risk	1.7	1.2 – 2.4
Not sure	1.7	1.2 - 2.5

Rainfall

Results of the single variable random effects logistic regression models stratified by water source are shown in Table 5. The results suggest an association between HCGI and increased rainfall among children who drink rainwater. However, the results were not statistically significant and when a rainfall-water group interaction term was added to the model shown in Table 4, no statistically significant effect was seen (p-value=0.21).

Table 5 HCGI and rainfall stratified by drinking water source -single variable random effects logistic regression models

			HCGI		
Model	**Variable**	**n**	**Odds Ratio**	**95% CI**	**p-value**
1	*Public mains only*	144			
	No rainfall		1 (ref)		
	Low rainfall		1.05	0.52-2.11	0.90
	High rainfall*		-	-	-
2	*Any rainwater consumption*	790			
	No rainfall		1 (ref)		
	Low rainfall		1.28	0.96-1.72	0.10
	High rainfall		1.49	0.96-2.31	0.08

* inadequate children in the high rainfall group

DISCUSSION

Association between tank rainwater and gastroenteritis

While it was observed that the maintenance of rainwater tanks was not of a high standard among this study population, the risk of gastroenteritis associated with regular consumption of tank rainwater was no greater than that associated with drinking treated public mains water.

The results of this study showed a suggestion of an increased risk of gastroenteritis with an increased level of rainfall among rainwater users. However, overall a significant association was not found between rainfall and gastroenteritis.

A possible explanation for the lack of association between rainfall events and increased gastroenteritis amongst rainwater consumers, even in the light of having poor rainwater tank and only moderate roof-catchment maintenance, is that the majority of exposed children in this study had developed immunity to the potential contaminants of tank rainwater. A majority (98%) of the children in the cohort study who consumed rainwater had done so for at least one year. It could be argued that drinking rainwater lead to a low level of exposure to the contaminants, and subsequently the children had developed immunity to the rainwater contaminants over time. Payment and Hunter (2001) have suggested the rates of water-borne illness within the community are lower than would be expected because there is a level of pre-existing immunity in the community resulting from previous exposure to micro-organisms.

These results may be generalized to people who are regular consumers of tank rainwater. New consumers on the other hand, maybe at increased risk. Children under the age of four years or the elderly may also be at a different risk of gastroenteritis form exposure to water-borne contaminants.

CONCLUSION

Consumption of tank rainwater did not increase the risk of gastroenteritis relative to public mains water consumption among four to six-year-old children in South Australia. In addition, recent rainfall events did not increase the risk of gastroenteritis significantly. Possibly this reflects a level of acquired immunity among regular users of tank rainwater and may not reflect the risk in new users of this water supply. Further studies are needed to clarify the role of immunity in the risk of tank rainwater consumption and whether new consumers are at a greater risk of gastroenteritis than are regular consumers.

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