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EVIDENCE BASED PUBLIC HEALTH POLICY AND PRACTICE

Social deprivation and the public health risks of community drinking water supplies in New Zealand

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Study objective: Quantitative evidence linking environmental exposures and social status at sub-national scales is surprisingly limited. This study investigated the public health risks associated with community water supplies in relation to social status in New Zealand.

Design: An ecological study using a Geographic Information System (GIS) to compare the grade of community water supplies with an index of social deprivation for small areas.

Setting: New Zealand.

Participants: The New Zealand population usually resident in meshblocks (census areas) with a community water supply (70% of the 1996 population of 3.6 million people).

Main results: People living in deprived areas are exposed to greater public health risks from community water supplies. In urban areas, the odds of water supplies being high risk were 3.76 times greater for the most deprived decile compared with the least deprived decile (95% CI: 2.95 to 4.78).

Conclusions: It is probable that deprived communities in New Zealand are experiencing a disproportionate burden of adverse health effects as a result of poor water quality.

Socially deprived people tend to live in unhealthy environments.^{1–3} There is evidence, for example, of greater exposure to air pollution and heavy metals—especially lead—in poor communities⁴; hazardous waste sites and polluting industries have been shown to be concentrated in poor areas both in the USA⁵ and in New Zealand.⁶ Yet evidence linking environmental exposures and social status at sub-national scales is surprisingly limited. We are not aware of previous studies investigating the public health risk of water supplies according to socioeconomic status.

We used a Geographic Information System (GIS) to combine two datasets: one estimating the public health risks of community drinking water supplies and the other estimating levels of socioeconomic deprivation among small areas in New Zealand.

METHOD

Socioeconomic deprivation for small areas

Deprivation refers to relative disadvantage and consists of material deprivation, such as housing and living conditions, and social deprivation, such as social support and education factors. The 1996 New Zealand census contained many questions that measured aspects related to deprivation. Nine deprivation indicators derived from this information were: having no access to a telephone; aged 18–59 receiving a means tested benefit; aged

18–59 unemployed; living in households with equalised income (that is, adjusted to control for household composition) below an income threshold; having no access to a car; aged <60 living in a single parent family; aged 18–59 without any qualifications; not living in family owned home; living in households above an equalised bedroom occupancy threshold.

These nine source variables were used in the construction of the area based measure of deprivation, NZDep96, where the derived variables were age/gender standardised proportions of people in a small area with the deprivation characteristic.^{7,8} NZDep96 is an index of these nine variables, obtained as the first principal component in a principal component analysis (that is, the weighted sum of these nine variables that has the largest variance of any such sum) thus maximally ordering the areas along a deprivation continuum. The continuous distribution of NZDep96 scores was also split into deciles, to form a simple ordinal scale with each decile representing exactly one tenth of the small areas in New Zealand. This meant that each decile included close to one tenth of the population. The small areas used to define populations in this study are termed “meshblocks”, which are the smallest administrative area used by Statistics New Zealand for the purpose of New Zealand's five yearly census (there are about 38 000 meshblocks). Information from neighbouring meshblocks was pooled, if necessary, so that, as far as possible, the small areas used in NZDep96 contained at least 100 people (92% contained 100–200 people). In these cases, each meshblock was assigned the small area NZDep96 value.

Community drinking water supplies

Surface water from lakes and rivers provides about 60% of the drinking water consumed by New Zealanders. A further 15% of the population draw their water directly from rainfall by collecting it off roofs in storage tanks, resulting in drinking water of highly variable microbial quality (V Hope, personal communication, 2002). The Register of Community Drinking Water Supplies presents the results of a risk assessment of community drinking water supplies for the whole of New Zealand. A “community drinking water supply” is defined as:

“A publicly or privately owned drinking-water supply (consisting of one or more distribution zones and their contributing treatment plants and sources) which serves 25 or more people for at least 60 days per year”⁹

Key points

- People living in deprived areas are exposed to greater public health risks from drinking water supplies.
- It is probable that deprived communities in New Zealand are experiencing a disproportionate burden of adverse health effects as a result of poor water quality.

Policy implications

- Studies of the relation between water quality and gastrointestinal disease will be needed to quantify the impact of water supplies on the health of deprived communities.

Table 1 Population (percentage of total), by water supply grade and NZDep96 index of socioeconomic deprivation

NZDep96 decile (lower is less deprived)	Supplies serving less than 25 people	Grade (lower is better)					
		A 1	B 2	C 3	D 4	E 5	U 6
1	2.6	4.8	1.0	1.0	0.3	0.5	<0.1
2	3.2	4.2	0.9	0.6	0.5	0.7	<0.1
3	3.4	3.9	0.6	0.6	0.6	0.8	<0.1
4	3.4	3.6	0.8	0.6	0.6	0.9	<0.1
5	3.1	3.6	1.0	0.6	0.6	0.9	<0.1
6	2.8	3.6	1.0	0.6	0.7	1.1	<0.1
7	2.7	3.7	1.0	0.8	0.7	1.0	<0.1
8	2.6	3.7	1.2	0.6	0.7	1.1	<0.1
9	2.9	3.6	1.3	0.5	0.7	1.0	<0.1
10	2.6	4.5	1.3	0.5	0.7	0.5	<0.1
Unclassified	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Totals	29.4	39.3	10.1	6.5	6.1	8.4	0.2

A water distribution zone is part of a water supply network within which all consumers should receive drinking water of similar quality. Water within a distribution zone is supplied to all consumers from a similar origin or origins, with the same treatment, through a common reticulation system. A small community will usually have a single water distribution zone, while larger towns and cities may have multiple zones because of different sources or source combinations being used, different treatment plants, separate pipe networks, differing reticulation characteristics, or some other factor potentially resulting in different water quality being received by the consumer.⁹

Each distribution zone serving 500 or more people has a public health grading. The grading is an assessment of confidence in the risk to public health from the supply. Each grading consists of two letters: the first (upper case) letter refers to the source and plant grading and the second (lower case) letter refers to the water in the reticulation network (the distribution grading). Gradings range from Aa "completely satisfactory, negligible or low level of risk" to Ee "completely unsatisfactory, very high level of risk" or ungraded (Uu). The alphabetical water quality grades were recoded numerically as shown in tables 1 and 2. Unsatisfactory gradings may reflect poor water quality, but also inadequate monitoring of water supplies or a risk of sudden deterioration, such as might occur with an unprotected water catchment or with a poorly maintained reticulation system. To reflect this, ungraded supplies or distribution zones were attributed the highest level of risk. Inclusion of risk related criteria sets the New Zealand drinking water grading system apart from other standards, which specify measurable indicators only.

Analysis

Geographical boundaries of the water distribution zones (for the year 1999) and meshblocks with deprivation scores (for the year 1996) were integrated within a GIS. Meshblocks were assigned to urban or rural categories according to Statistics New Zealand definitions. The reason for this distinction is that socioeconomic deprivation often manifests itself differently according to the degree of remoteness or rurality. Water supplies are also likely to be very different for rural and urban populations, with rural populations generally not being served by large filtration/treatment plants listed in the Register of Community Drinking Water Supplies.

Meshblocks were assigned to water distribution zones where any part of a meshblock intersected a zone. Meshblock populations were assigned to a distribution zone if their boundaries were entirely within a particular zone. It was found that of the 36 806 meshblocks in the dataset, 2361, (6.4%), intersected two distribution zones and were assigned

to both; 9026 meshblocks did not fall within any community water zone. In the few cases where meshblocks included two distribution zones the average water quality grading was calculated and assigned to both. For subsequent analyses, these average gradings were rounded down to the nearest integer.

We calculated Spearman rank correlation coefficients (r_s) and Kruskal-Wallis tests of the hypothesis that there was no association between deprivation and water quality.

Regression analyses of water quality (dependent variable) in relation to urban-rural status and the continuous NZDep96 deprivation score (independent variables) were restricted to meshblocks with data for deprivation (98.7%) and either source grade (n=22 747) or distribution zone grade (n=21 516).

RESULTS

The estimated usually resident 1996 population in meshblocks intersecting water distribution zones are shown by decile of NZDep96 and source grade (table 1), or water distribution zone grade (table 2).

There was a weak but statistically significant correlation between NZDep96 and source grade ($r_s=0.06$, $p<0.001$) and between NZDep96 and water distribution zone grade ($r_s=0.08$, $p<0.001$). Using Kruskal-Wallis tests to compare the numbers served in the ordered water distribution zones across the 10 deciles of deprivation, the hypothesis that water quality was unrelated to deprivation was rejected (source grade: $\chi^2=261.1$ with 10 df; $p<0.001$; distribution zone grade: $\chi^2=107.6$ with 10 df; $p<0.001$).

We recoded source and distribution zone grades as binary variables: for water source grades A, B=0 and grades C, D, E=1 (and similarly for the water distribution grades). We then fitted logistic models, with the NZDep96 decile coded using dummy variables, and tested the effect of an urban-rural indicator variable and interaction terms between NZDep96 decile and urban-rural status. These models confirmed that deprivation score was a statistically significant predictor of the binary water distribution zone grade. Urban-rural interaction terms were statistically significant. We found that if we divided the data into urban and rural areas, there were still adequate numbers of meshblocks with water distribution zone gradings, by decile of NZDep96 (data not shown). To make interpretation of these results easier, we carried out separate analyses within urban or rural populations.

The regression results are shown in table 3. These results suggest that the level of risk tends to increase with increasing levels of deprivation, and that this effect is strongest in urban areas. The increasing standard errors with increasing deprivation reflect a greater variability of water quality in more deprived communities.

Table 2 Population (percentage of total), by water distribution zone grade and NZDep96 index of socioeconomic deprivation

NZDep96 decile (lower is less deprived)	Supplies serving less than 25 people	Grade (lower is better)					
		a 1	b 2	c 3	d 4	e 5	u 6
1	2.3	3.9	2.6	0.2	0.3	0.2	0.6
2	3.0	3.3	2.4	0.3	0.4	0.3	0.6
3	3.1	2.9	2.1	0.3	0.4	0.4	0.7
4	3.1	2.9	1.9	0.3	0.5	0.5	0.6
5	2.8	3.1	1.8	0.4	0.5	0.5	0.7
6	2.6	3.3	1.8	0.5	0.6	0.5	0.7
7	2.4	3.6	1.6	0.4	0.7	0.5	0.7
8	2.3	3.6	1.7	0.4	0.8	0.5	0.8
9	2.5	3.5	1.5	0.3	0.8	0.4	0.9
10	1.9	4.3	1.4	0.2	1.0	0.5	1.0
Unclassified	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Totals	26.1	34.6	18.7	3.2	6.0	4.1	7.3

Comparable results were obtained for water source grade, although the increasing trend in risk was not so apparent; we also tested the effect of recoding source and distribution zone grades as follows: A, B, C=0 and grades D, E, U=1. Similar results were obtained (not shown).

DISCUSSION

The results reported here suggest that socioeconomically deprived urban communities tend to be exposed to greater public health risks from drinking water supplies, compared with less socioeconomically deprived areas. A limitation of the study was that we had no information about the quality of water supplies serving less than 500 people.

Several causal mechanisms might explain the results. It is possible that less deprived people tend to move to areas with high quality water supplies, or that more deprived people tend to move to areas with poor quality supplies. Alternatively, there may be greater investment in water supplies in less deprived areas.

While most of the population receive drinking water of high quality, New Zealand has some of the highest incidence rates of campylobacteriosis and cryptosporidiosis in the industrialised world. It has been recently shown that notification rates of cryptosporidiosis are inversely correlated with the grade of the drinking water supply.¹⁰ In general, socioeconomically deprived people tend to be less healthy and may therefore be more susceptible to adverse effects for a given level of exposure.¹ Therefore, it is probable that deprived communities in New Zealand are experiencing a disproportionate burden of adverse health effects as a result of poor water quality. Because of geo-referencing uncertainties in New Zealand's notifiable disease data for gastrointestinal disease, it is not possible to directly compare notification rates with urban-rural status¹¹ or socioeconomic deprivation. Further studies will be needed to quantify the impact of water supplies on the health of deprived communities in New Zealand.

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Table 3 Results of logistic regression models of water distribution zone grade, and NZDep96 index of socioeconomic deprivation, by urban-rural status

Variable	OR*	SE	p Value	95% CI
Model 1: Urban				
1	1.00	—	—	—
2	1.14	0.17	0.39	0.85 1.53
3	1.90	0.26	<0.001	1.45 2.50
4	2.48	0.33	<0.001	1.91 3.23
5	2.60	0.34	<0.001	2.01 3.36
6	3.49	0.44	<0.001	2.72 4.47
7	3.16	0.40	<0.001	2.47 4.04
8	3.89	0.48	<0.001	3.06 4.95
9	4.01	0.49	<0.001	3.15 5.10
10	3.76	0.46	<0.001	2.95 4.78
Model 2: Rural				
1	1.00	—	—	—
2	1.67	0.21	<0.001	1.30 2.15
3	2.34	0.29	<0.001	1.83 2.99
4	2.53	0.32	<0.001	1.98 3.23
5	2.31	0.29	<0.001	1.80 2.96
6	2.33	0.31	<0.001	1.79 3.02
7	2.45	0.32	<0.001	1.90 3.17
8	2.65	0.35	<0.001	2.05 3.43
9	2.09	0.30	<0.001	1.59 2.76
10	1.72	0.24	<0.001	1.30 2.27

*Odds ratios (OR) are defined as the ratio of A:B where A is the odds of water supplies being high risk in a given decile of NZDep96 and B is the odds of water supplies being high risk in the least deprived decile.

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