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INVESTIGATION OF SUSPECTED COPPER INTOXICATION IN CHILDREN FROM DRINKING WATER

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BACKGROUND

In September 1993 the supervisor of a tennis club in South Western Sydney reported to the Public Health Unit (PHU) that 15 children became ill at a school holiday tennis clinic after consuming water drawn from a distribution system that supplies potable water to a semi-rural township. In response to a suspected outbreak of a waterborne illness, Environmental Health Officers of the PHU and the local authority investigated the water supply at the tennis clinic and surrounding recreation reserve.

The findings of the investigation suggest that elevated levels of copper in the reticulated town water supply induced symptoms of copper intoxication in children who consumed the water. The consumption of water containing elevated levels of copper drawn from the water distribution system or suicide attempts involving copper sulfate have previously been causally associated with copper toxicity[1].

This report presents the results of an investigation of suspected copper intoxication in children following consumption of drinking water.

INVESTIGATION

Fifteen children became ill at the two-day tennis clinic in September 1993. Three children reported vomiting after consuming water directly from an external tap connected to the reticulated town water supply on the first day of the tennis clinic and 12 children reported vomiting after consuming cordial from a receptacle containing water drawn from the external tap the next day.

The vomiting occurred 15-20 minutes after the children consumed the water. No children visited a general practitioner or required admission to hospital and after the initial episode of vomiting they experienced no further ill health.

Food was ruled out as a possible source of infection as no common foods were consumed by children who reported illness on the first day and on the subsequent day children who reported illness after drinking the cordial mixture had not eaten.

Water samples were collected from the external tap and the receptacle containing cordial mixture for microbiological and chemical analysis by the NSW Health Department Division of Analytical Laboratories. Additional water samples were collected over two months for further microbial and chemical analysis from the implicated tap and other outlets in the surrounding recreation reserve to ascertain copper concentrations in the water supply over a wider area.

RESULTS

The microbiological analysis found water samples were in compliance with the National Health and Medical Research Council and Australian Water Resources Council (NHMRC/AWRC) Guidelines for Drinking Water Quality in Australia (1987).

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Suspected copper intoxication

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Chemical analysis of water samples collected from the external tap and cordial mixture disclosed the presence of elevated levels of copper. All other chemical properties of the water analysed, with the exception of iron, were in compliance with the NHMRC/AWRC Guidelines for Drinking Water Quality in Australia (1987). The iron concentration was found to be 0.66mg/L in the cordial mixture, which is slightly above the NHMRC/AWRC guideline value of 0.3mg/L. However iron levels below 3mg/L have not been shown to produce adverse health effects in humans[2].

TABLE 1

DRINKING WATER QUALITY
TENNIS CLUB EXTERNAL TAP AND CORDIAL MIXTURE

Characteristic	Tennis club external tap	Cordial mixture	NHMRC guideline value
Copper (Cu) mg/L	3.1	17	1
pH	7.1	3.5	6.5-8.5
Hardness ($CaCo_3$) mg/L	17	50	500

TABLE 2

DRINKING WATER QUALITY
TENNIS CLUB – EXTERNAL FAUCET

Days post index day	Copper (Cu) mg/L	pH	Total hardness ($CaCo_3$) mg/L
2 days	2.5	7.6	18
22 days	2.6	6.2	16
28 days	3.3	6.5	13

TABLE 3

DRINKING WATER QUALITY
OTHER LOCATIONS WITHIN RECREATION RESERVE

Source of water	Copper (Cu) mg/L	pH
Tennis club – kitchen tap	2.4	6.4
Tennis club – male WC tap	2.4	6.2
Soccer club – bar sink tap	3.0	6.3
Soccer club – external tap	0.9	6.3
Recreation oval – bubbler	1.8	6.3

Table 1 shows that copper levels in water from the external tap (3mg/L) and the cordial mixture (17mg/L) exceeded the value for copper as stated in the NHMRC/AWRC guidelines. The guideline value for copper in drinking water is 1mg/L[3]. This guideline is based on health and aesthetic considerations. In major Australian reticulated water supplies, total copper concentrations range up to 0.8mg/L, with typical concentrations of about 0.05mg/L reported[2]. The low pH of the cordial mixture was due to the acidic properties of cordial.

Total water hardness was significantly lower than the NHMRC/AWRC guideline value of 500 mg/L. Subsequent water sample results for total hardness and pH (Table 2) show that water collected from the external tap was soft and had a tendency to be acidic. Although pH and hardness are not health-related criteria for drinking water supplies in Australia[3], studies in the United States have demonstrated that soft and acidic waters enhance leaching of copper from the distribution system, resulting in elevated levels of copper in reticulated water supplies[4].

Table 2 shows that copper levels in water samples subsequently collected from the external tap were consistently above the NHMRC/AWRC guideline value for copper of 1mg/L.

Water samples collected from other locations in the reserve (Table 3), demonstrate that acidic pH values and elevated copper levels are prevalent in the reticulated town water supplying the reserve.

Discussion

We suspect the vomiting by the children was the result of acute copper intoxication induced by the consumption of drinking water from the reticulated town water supply containing elevated levels of copper. Previous reports suggest the primary toxicological effect of consuming water containing elevated levels of copper in humans is gastrointestinal irritation, manifested by vomiting[1,3,5], often immediately after consumption[5].

The results of water samples collected on the second day of the tennis clinic disclosed copper levels of 17mg/L in the cordial mixture and 3.1mg/L in water drawn from the external tap. Concentrations of copper above 2mg/L are known to cause ill effects in some people[3] and ingestion of water containing copper levels ranging from 2.8-7.8mg/L has been associated with vomiting among school-age children[5].

Unfortunately we did not interview three children who reported vomiting after consuming water. But it is postulated that fewer children experienced symptoms consistent with copper intoxication on the first day of the tennis clinic due to copper being readily detected in the water on the basis of taste and discolouration, leading to its rejection. It is likely that more children became ill after drinking the cordial mixture because the cordial flavour

masked the bitter taste and discolouration produced by copper. Copper in concentrations above 3mg/L is known to impart a bitter taste to water[2].

The disparity between the level of copper recorded in the cordial mixture (17mg/L) and water drawn from the external tap (3mg/L) may be attributed to the cordial concentrate being mixed with the initial flush of water from the external tap.

Elevated levels of copper in the drinking water most likely resulted from a combination of factors:

- the presence of soft, acidic water enhancing leaching of copper into the water reticulation system; and
- the external tap not being flushed for some time before the tennis clinic.

It is well documented that concentrations of copper in reticulated water supplies can rise substantially when soft, acidic waters remain in stagnant contact with copper pipework[1,6,7].

Conclusion

The findings of this investigation suggest that the symptoms experienced by children at the tennis clinic were the result of acute copper intoxication induced by the consumption of drinking water containing elevated levels of copper. Based on the results of water sampling, it is plausible that elevated copper levels may be more widespread in the distribution system supplying water to the semi-rural township, in circumstances where the water is soft, acidic and in stagnant contact with copper pipework.

In recognition of the problem, the PHU discussed with the Water Board and the local authority appropriate corrective action to reduce copper levels in the town water supply under investigation. The Water Board advised that it was implementing a progressive works program which would enhance water quality throughout the entire reticulated town water supply.

The PHU recommended that the local authority monitor the quality of water connected to public amenities in the local government area to determine whether elevated copper levels were more widespread throughout the reticulated town water supply. A logical extension of this surveillance program would be development of an appropriate public risk communication strategy. Aspects of the strategy should include advising community groups which use public amenities to flush taps before use, and to report illness associated with the reticulated town water supply to a general practitioner, hospital or the PHU.

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School entry immunisation

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Important differences were found when school type was examined (see Table 1). Certificate return rate was significantly lower in Catholic schools than government schools or independent schools (P< 0.0001). Complete immunisation was slightly, but not significantly, lower in government schools compared to Catholic schools but significantly lower than in independent schools (P<0.0001). There was great variability in the percentage of children with complete immunisation within each school type.

Discussion

The census of school immunisation certificates described in this report represents a simple method of ascertaining verified immunisation status of kindergarten enrollees. It could be done annually as an indicator of childhood immunisation. As the census is carried out by mail, it provides an opportunity for the Public Health Unit to inform and educate primary schools about the Public Health (Amendment) Act 1992. Results of the survey could be fed back to the schools with an indication of their performance relative to other local schools, to provide an incentive for improved performance the following year.

The census, carried out in the first year of the legislation being in force, estimated that at best 89.9 per cent of the children enrolling in kindergarten had complete immunisation, with a worst case figure of 72.7 per cent. A Victorian survey based on mandatory immunisation certificates for children entering 19 primary schools found that 74 per cent of children (worst case figure) had complete certificates the second year after legislation was introduced and 89 per cent had complete certificates the following year[3].

The main limitation of our census was that it did not provide information on actual vaccine doses missed by children with incomplete certificates. This information could be ascertained by a telephone survey of a random sample of schools[4] or by adding a limited number of questions to the postal questionnaire used in the census.

The survey demonstrated significant differences in return rates and complete certificate rates between school types, with discrepant results for the two parameters. The differences are difficult to interpret because some schools responded later in the year than others, and these schools had higher return rates. This report does not analyse the potential confounding effects of this factor. In the light of previous research[1,2], it is suggested that discrepancies between return rate and complete immunisation rate may be partly explained by literacy and access to health care among families from non-English speaking backgrounds.

TABLE 1

RESULTS OF IMMUNISATION CERTIFICATES CENSUS BY SCHOOL TYPE

	School type			
	Govt	Cath	Indep	Total
Number of schools	36	19	14	69
Kindergarten enrolment	1,482	624	558	2,664
Certificates collected, %	81.6	71.0	90.0	80.9
Complete certificates, % *	87.4	89.4	96.4	89.9
Percentage range of complete certificates	61-100	22-100	68-100	22-100

* as percentage of certificates collected

The prevalence of non-English speaking families varies appreciably among the different school types in Eastern Sydney. Schools drawing children from communities with a high prevalence of non-English speaking families and less access to primary health care may have had a poor return rate but a better immunisation compliance among the self-selected population of children providing certificates. In contrast, schools in communities with high literacy rates but suboptimal access to primary health services had good return rates, but the certificates reflected suboptimal immunisation uptake. Schools used by families with both good literacy and good access to primary health care showed high return rates and high immunisation uptake.

The study has shown that annual immunisation surveillance of kindergarten enrollees through schools, using the provisions of the Public Health (Amendment) Act 1992, is a feasible method for obtaining indicator information on immunisation coverage. Because this method generates detailed small-area data, with each school representing its often unique local population, results of the surveillance can be used to target particular subgroups and improve immunisation coverage at the community level.

1. Ferson MJ, Christie D. Measles immunisation compliance: poor impact of bicentennial measles control campaigns on children under five. *Aust J Public Health* 1992; 16:31-34.
2. Ferson MJ, Fitzsimmons G, Christie D, Woollett H. School health nurse interventions to increase immunisation uptake in school entrants. *Public Health* 1995; 109:25-29.
3. Thompson SC, Cocotsi L, Goudey RE, Murphy A. An evaluation of school entry immunisation certificates in Victoria. *Aust J Public Health* 1994; 18:269-273.
4. Rixon G, Hort K, Liddle J. School entry certificate survey, Northern Sydney Area. *NSW Public Health Bulletin* 1994; 5:92.

Editorial note

In the last issue of the *NSW Public Health Bulletin,* Scholtz and Cavagnino[1] reported on the results of an investigation of an illness in 15 children. They suggested that the children's symptoms were the result of acute copper intoxication – induced by the consumption of drinking water containing elevated levels of copper. Following publication of the article, it was pointed out that the symptoms were likely to have been due to gastric irritation rather than systemic poisoning. Although soluble salts of copper are poisonous, systemic poisoning is likely to result only if larger quantities are ingested (e.g. gram quantities of copper sulphate). Gastrointestinal irritation can result from drinking carbonated water or citrus fruit juices which have been in contact with copper vessels or pipes[2]. The findings of Scholtz and Cavagnino accord with this.

1. Scholtz A and Cavagnino P. Investigation of suspected copper intoxication in children from drinking water. *NSW Public Health Bulletin* 1995; 6(1):1-3.
2. Parmeggiani L (ed). Encyclopaedia of Occupational Health and Safety, 3rd (revised) edition. Geneva: International Labour Office, 1993.