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Microbiological quality of ice in hospital and community

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Summary: A survey was undertaken in response to a report of a clinical infection which had been related to an ice-making machine on a hospital ward. A detailed study of the ice microflora of 27 ice-making machines was performed. In a subsequent survey, ice samples ($N=194$) from establishments such as bars and hotels were examined for bacterial indicators of hygiene. Samples from hospital ice-making machines yielded low numbers of a wide range of potentially opportunistic micro-organisms, many of environmental rather than clinical origin. For ice sampled in the community, the total aerobic plate count (TAPC) at 37°C for 95% of the samples was <500 cfu/mL, and at 22°C 75% had <500 cfu/mL. Examination for coliforms showed that 69% of samples contained no coliforms, but 20% contained >100 coliforms/100 mL. *Escherichia coli* was detected in three samples but in very low numbers. This report investigates the relevance of ice machines to the control of hospital infection, the hygiene of ice in the community, discusses the microbiological quality of ice and proposes possible guidelines.

Keywords: Ice; ice-making machines; bacteriology; guidelines; infection control.

Introduction

The infection hazards posed by the consumption of ice have long been recognized, both in hospitals[1] and in the community.[2] Infection from ice may occur because of the use of contaminated water, staff or customer handling and environmental contamination within ice-making machines or during storage of ice. In hospitals uses of ice include ice packs, patient refreshment in drinks and by sucking, and placing ice packs near fans to enhance their cooling efficiency.[3] Where ice-making machines are installed in hospital kitchens or operating theatres, the catering and clinical uses may be separated, but frequently the machines are located on wards and

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used for both purposes. In the community the main use of ice is to cool drinks but it may have other uses such as the chilled packing and display of fresh foods, especially seafoods, which normally are not ready to eat without further cooking.

A recent community outbreak has shown an epidemiological association of tap water and ice consumption with shigellosis.[4] In addition to the transmission of enteropathogens such as *Salmonella* and *Shigella*, a number of earlier publications have described the presence in ice of water-borne pathogens such as *Legionella pneumophila*,[5] *Mycobacterium gordonae*[6] and *Mycobacterium fortuitum*.[7] The microbiological quality of ice is often taken for granted despite advice to travellers to avoid its consumption. Also, hospital outbreaks and recurring infections have sometimes been traced to inadequately maintained ice-making machines.

In the United States, the Packaged Ice Association produced guidelines[8] aimed at assuring the microbiological quality of packaged ice. These guidelines require that ice be manufactured indoors and separated from non-manufacturing areas, that product ice must contain total and faecal coliforms <2·2 coliforms/100 mL by most probable number (MPN) estimation, or <1 (membrane filtration) and heterotrophic aerobic plate count <500 colony forming units (cfu)/mL (temperature not specified), and that packaging must show the name, location and production code to ensure traceability.

Design and installation shortcomings in drink and slush vending machines have been noted previously.[9] These include poor quality supply water, especially if the machine has been inadequately sited and plumbed, contaminated header tanks and tubing which allowed the pooling of drinks but not drainage. Ice-making machines are rather different, but many of the same principles apply. Poor design and maintenance have been discussed in relation to machines involved in hospital outbreaks.[1,3,5] Discussions with Environmental Health Officers (EHOs) indicate that staff often are not adequately trained or motivated in the cleaning and maintenance of ice-making machines, and that manufacturers often have not given adequate consideration to hygienic design to minimize contamination and facilitate effective cleaning and maintenance.

Our study was prompted by a Regional Management Executive letter (Estate Services Directorate, Northern Ireland) requiring immediate action following reports of leukaemia patients who developed septicaemia as a result of *Xanthomonas maltophilia* infection. No subsequent information was made available regarding this outbreak and its investigation which occurred in a different region. *X. maltophilia* (renamed *Stenotrophomonas maltophilia*) had been detected (>10^6 cfu/mL) in the storage cabinet of an ice-making machine sited in a neutropenic ward. Such neutropenic patients are at particular risk if they are allowed to suck ice cubes which have sharp edges as they may lacerate the oral mucosa which has been compromised

by therapeutic regimens. This study investigates the relevance of ice-making machines in the control of hospital infection, the hygiene of ice in the community and discusses the microbiological quality of ice.

Materials and methods

Sampling

Ice samples were collected aseptically from 27 ice-making machines on hospital wards. In a separate survey, ice cubes were collected aseptically from 194 premises serving ice (mainly hotels, public bars and restaurants) by Environmental Health Officers (EHOs). Most of these were taken from ice buckets, but in some cases samples were taken directly from ice-making machines. At both locations, samples taken were solid ice with as little melt water as possible. These were sealed in sterile polythene bags and transported to the laboratory in cool boxes at <5°C. On receipt, samples generally contained solid ice and little melt water. Ice was melted in the laboratory at room temperature and promptly examined, usually within 1 h.

Microbiological examination

Hospital ice samples (100 mL volumes) were filtered through sterile 0·45 μm cellulose nitrate filters (Whatman 7141 204) using an enclosed water filtering system (Nalgene Company, UK) to minimize aerial contamination of the ice. Filters were placed onto the surface of each of one Columbia blood agar base (CBAB; Difco 0790-17-5), one Columbia blood agar base containing 5% horse blood (CBA), one MacConkey agar (MCA; Mast DM 140) and one pseudomonas isolation agar (PIA; Difco 00127–17-1). Plates were incubated at 22°C (to help prevent overgrowth by *Bacillus* spp.) and 37°C and examined daily for up to 72 h. Total aerobic plate counts (TAPCs) were determined after this period. The colour, size and morphology of colonies were noted and three colonies of each type were subcultured to MCA, CBAB and CBA agar plates. Colonies of each type were identified by Gram stain, catalase, coagulase, oxidase and lactose fermentaion. API 20E and API 20NE (bio-Mérieux) were used for further identification.

Microbiological examination of samples collected by EHOs was carried out according to UK legislative requirements for chlorinated waters.[10] Samples were prepared by membrane filtration (Millipore, UK) and tested for total coliforms and *Escherichia coli*. After the filtration of melt water, two filter membranes from each sample were placed in two separate petri dishes on pads soaked in membrane lauryl sulphate broth. The dishes were incubated for 4 h at 30°C. One membrane was then transferred to 37°C for total coliform counts and the other transferred to 44°C for *E. coli* counts after an additional 14 h incubation. Presumptive *E. coli* were confirmed by tests for acid, gas, oxidase and indole production. Nutrient agar pour plates

Table I. *Organisms isolated from hospital ice-making machines*

Organism	Number* (%) of ice machines containing organism
Acinetobacter spp.	9 (33)
Aeromonas spp.	2 (7)
Agrobacter/Radiobacter spp.	3 (11)
Bacillus spp.	25 (93)
Burkholderia cepacia	2 (7)
Chyseomomas luteola	4 (15)
Coagulase-negative staphylococci	23 (85)
Flavobacter spp.	2 (7)
Flavomonas indologenes	1 (4)
Klebsiella oxytoca	1 (4)
Micrococcus spp.	8 (30)
Ochrobacter anthropi	1 (4)
Oligella urethralis	3 (11)
Pseudomonas spp.	21 (78)
Sphingomonas paucimobilis	1 (4)
Stenotrophomonas maltophilia	1 (4)
Yeast forms	6 (22)

* No. of ice-making machines, 27.

were inoculated with 1:10 dilutions of samples and incubated at 22° and 37°C for 48 h to determine TAPCs.

Results

No hospital infections attributed to the use of ice were identified during this study. Information on the cleaning frequency and date of last cleaning of the ice-making machines was not available. A wide range of micro-organisms was found and these are shown in Table I. All of the organisms were present in low numbers (<10 cfu/mL) but may be considered to be potential opportunistic pathogens if present in larger numbers. The most common genera were coagulase-negative staphylococci, *Bacillus* spp., *Micrococcus* spp., *Acinetobacter* spp. and pseudomonads. Non lactose-fermenting colonies were usually identified to the genus level only by API 20NE and were assumed to be of environmental rather than of clinical origin. With the *Pseudomonas* genera which could be speciated, *Pseudomonas aeruginosa* was found to predominate. *Aeromonas hydrophilia/caviae* and *Burkholderia cepacia* were both isolated from two samples only. *Stenotrophomonas maltophilia* was isolated from one sample only.

Community ice samples were generally of good quality as shown by the indicator organisms. The opportunistic pathogens found in the hospital setting were not looked for in the ice samples from the community as these organisms presented little risk to the general public. However, we have previously identified a number of potentially pathogenic pseudomonad species in ice sampled from retail and catering premises. The indicator

Table II. *Coliform and* Escherichia coli *aerobic plate counts from ice samples (N=194)*

	Plate count [cfu/100 mL (%)]				
	0	1	≤10	≤100	>100
Coliforms	134 (69)	4 (2)	16 (8)	9 (5)	31 (16)
E. coli	191 (98)	2 (1)	1 (1)	0 (0)	0 (0)

Table III. *Total aerobic plate counts (TAPC) from ice samples (N=194)*

	Plate counts [cfu/mL (%)]					
TAPC at	<10	≤100	≤500	$\leq 1 \times 10^3$	$\leq 3 \times 10^3$	$>3 \times 10^3$
22°C	43 (22)	57 (29)	46 (24)	11 (6)	19 (10)	18 (9)
37°C	120 (62)	55 (28)	9 (5)	3 (2)	2 (1)	5 (3)

organism and TAPCs results are shown in Tables II and III. *E. coli* was found in only three samples (1%) by membrane filtration and the numbers were very low (Table II). One sample contained 2 cfu/100mL and two samples contained 1 cfu/100 mL.

While 69% of samples contained no coliforms, over 20% contained ≥100 coliforms/mL. According to the US packaged ice industry guidelines, 31% of samples failed on the coliform test.

TAPCs obtained at 22°C, which suggests environmental contamination, revealed that 75% of samples contained ≤500 cfu/mL, (25% of samples contained ≥1000 cfu/mL), the guideline limit set by the Packaged Ice Association. At 37°C, 95% of samples did not exceed these limits (Table III).

The percentage of samples found to be unsatisfactory, according to the packaged ice guidelines, varied markedly from month to month; from 20% in April to 79% in May (annual mean, 42%). Sample numbers varied considerably between months and were insufficent to show whether this was related to ambient temperature. Nevertheless, some of the highest TAPCs were found between May and August.

Discussion

Clinical aspects

Although previously implicated in ice-borne infection or pseudo-infection,[6] we did not consider *L. pneumophila*[5] and *M. gordonae*[6] to be of sufficient local incidence to justify the laborious methods required for their isolation

and identification, in this case. As the regional public health laboratory we isolate these organisms rarely from both clinical and environmental samples. In the region (population 1·6 million) *M. gordonae* and *L. pneumophila* are each isolated from clinical specimens around three times per year. *M. gordonae* is an environmental contaminant of water and not generally of clinical significance. *L. pneumophila* isolation is associated with foreign travel in around half of local cases. The 1 L volumes of ice required for examination could not reliably be obtained from ice machines on wards which frequently are small bench top models of low capacity.

Although no legislative standards exist in the UK, industry guidelines for packaged ice have been published[1,11] following those of the Packaged Ice Association. Guidelines have also been proposed for the maintenance and improved hygiene of ice-making machines in hospitals.[12] These include the choice of ice-dispensing rather than ice-storage machines, education on handwashing and scoop hygiene, restricted access and weekly to monthly cleaning supplemented by monthly to quarterly disassembly, inspection and disinfection. These recommendations are presented in place of microbiological investigations, the author considering microbiological sampling unnecessary when appropriate microbiological guidelines do not exist. Such an approach acknowledges the Hazard Analysis Critical Control Point concept[13] and is appropriate advice for hospitals.

For the majority of organisms isolated from hospital ice no special hazard could be associated, but their presence is an indication of the need for continued appropriate maintenance and domestic cleaning of the machines. However the isolation of *A. hydrophilia/caviae*, *B. cepacia* and *S. maltophilia* should prompt an appropriate response. *A. hydrophilia/caviae* has been documented as causing severe diarrhoea in elderly patients,[14] although in this instance the toxigenicity of the isolate was not established. *S. maltophilia* has been associated with septicaemia in leukaemia patients[15] and *B. cepacia* may present an infection control problem in cystic fibrosis patients.[15] While there is no special hazard associated with ice for immunocompetent patients, a clinical decision needs to be taken regarding the giving of ice containing potential pathogens to immunosuppressed patients.

Community aspects

Effective monitoring and enforcement activity in the community requires verification that cleaning has actually taken place and some microbiological indication of the efficacy of the cleaning procedures. The desirability of guidelines is increased outside the hospital setting where management may be insufficiently trained and the risks of inadequate hygiene less clearly understood. Consequently, other workers have argued that ice should be of similar microbiological quality to chlorinated water[16] and have discussed the details of ice-making techniques and the problems of machine management and maintenance. Indeed, there can be little excuse for freshly-made ice being of a lower quality than is expected of water. The ice-holding

section of some ice machines is recommended to be run at 2–4°C to prevent ice cubes sticking to each other, and may sometimes exceed this range. These authors review work showing that some organisms such as coliforms can survive and slowly multiply at ice-holding temperatures. It has been shown previously[17] that a greater increase in bacterial counts occurs when ice is transferred from the machine to the ice bucket than between the mains water and the manufactured ice in the machine. Self-service ice is particularly vulnerable even if a scoop or tongs are provided, and viral contamination from aerosol droplets is also a possibility. Ice that sits in a bucket exposed to airborne (including coughs and sneezes) and hand contamination should be expected to be of a lower microbiological quality than when freshly made, but still should be free of pathogens and faecal indicator organisms if it is to be considered suitable for consumption.

Ice-making machines are usually sited in neglected areas of premises, away from the food preparation and customer service areas which generally received more regular cleaning. Sampling officers (EHOs) report that bacterial slime and algal growth are found routinely in the ice formation mechanisms which are never cleaned. Although highly unlikely, it can be speculated that incidents of cyanobacterial poisoning might potentially arise from this situation under appropriate conditions of nutrient supply and temperature exceeding 10°C.[18] Some machines have a button marked 'cleaning' but its function is not understood by staff and consequently it is never used. One large manufacturer contacted by the authors showed a clearly-written weekly sanitization schedule, a proprietary chlorine-based 'anti-bacterial cleaner' and prudent design features including a range of replaceable 0·5 μm cartridge filters for the mains water inlet and pressure gauges and alarms to notify the need for replacement. The weekly sanitization schedule involves discarding ice, removal of the water curtain, cleaning with a non-abrasive cleaner, rinsing, cleaning with anti-bacterial cleaner without rinsing or dying. Anti-bacterial cleaner is then to be poured down the ice-bin drain and the plastic water curtain, scoops and utensils soaked in the solution for 90 min before re-insertion into the machine. Manufacturers and installers should work more closely with the management of food service establishments to ensure machines can be easily cleaned and that the necessity and methods of doing so are properly understood by staff.

The results presented here suggest that, in the temperate climate of the UK and with a generally high quality water supply, the likelihood of enteric infection from ice is low.

TAPCs in chlorinated mains water are not routinely monitored by us but generally appear to be low (<100 cfu/mL). In the hospital environment the greater proportion and range of susceptible individuals represents a higher risk and this is borne out by a number of incidents of non-enteric infection traced to hospital ice. That *E. coli* was isolated in only around 1% of samples and in very low numbers suggests that the chance of

contracting an enteropathogen infection such as salmonellosis from ice is not high. It is probable that on all three occasions *E. coli* was detected its presence was due to contamination from handling of the ice by staff or customers. *E. coli* should never be present in chlorinated mains water and seldom is. The low numbers of this indicator organism and its infrequent occurrence indicate that the likelihood of infection from contaminated supply water or an enteropathogen carrier via ice is low. Unusual exceptions may occur and Gardner[19] has commented on the death of eight acquired immunodeficiency syndrome (AIDS) patients from cryptosporidiosis following contamination of hospital ice through handling by an incontinent, psychotic patient. For this reason access to ice-making machines should be restricted to staff. Self-pasteurization cycles are used in ice-cream machines but are unlikely to provide a cost-effective improvement in ice hygiene because chlorinated water supplies generally are of a much higher microbiological quality than ice-cream mixes. A non-contact ice-cube dispenser operating by photocell is available from the company contacted by the present author and is likely to reduce the risk of infective hazards if properly maintained. Dispensers of this type would be a wise choice for hospitals and areas where management cannot control access to the ice-making machines.

Compliance and guidelines

On average, over 40% of ice was found to be unsatisfactory in any given month if the US packaged ice guidelines are applied to unpackaged ice. Given the generally high microbiological standard of water, the tendency for ice in hotels and bars to have higher counts than that stored under better conditions, and the low incidence of disease, it is proposed that these guidelines be relaxed for unpackaged ice. In particular, the TAPC at 22°C, which represents environmental organisms rather than those of human or animal origin, could perhaps be considered acceptable up to 1000 cfu/mL for ice served in the community. An argument against this relaxation is that pseudomonads isolated from human infections often are of such environmental origin. *P. aeruginosa* has been reported to cause potentially fatal necrotizing colitis in neutropenic patients and typhoid-like enteritis (Shanghai fever).[20] The presence of *Pseudomonas* spp. is now considered unacceptable in hydrotherapy and spa pools although the threshold level above which a definite health risk occurs is uncertain.[21] Given the frequent isolation of *Pseudomonas* spp. from the ice we examined, a zero-tolerance limit is unrealistic. Such a limit may, however, be appropriate for defined groups of patients at increased risk of infection.

We propose that suitable guidelines might be: total and faecal coliforms <10 cfu/100 mL, *E. coli* absent in 100 mL, and TAPCs at 22°C <1000 cfu/mL and TAPCs at 37°C <500 cfu/mL. These guidelines are arbitrary and attempt to balance counts which generally can be achieved against those which indicate unacceptable risk. More stringent guidelines may need to

be applied if, for example, a hazard from *E. coli* O157 is suspected, since this organism probably would be detected only as a coliform in many laboratories. The contrary argument that ice should be of the same microbiological quality as tap water is apparently reasonable but rather idealistic. The application of such a standard will result in an unnecessarily high failure rate and the consequent wastage of much enforcement officer time. It may be necessary to apply more stringent standards if it is known that there is increased likelihood of contamination, for example when the purity of a water supply is compromised. These suggestions may be of use to public health microbiologists who are asked to advise on industry standards. For ice in hospitals the packaged ice guidelines are probably more appropriate given the increased number of at risk patients and the findings of infections caused by bacteria from the environment.

Crushed, flake and scale ice used for the working of some food products and the transport and display of seafood has not been considered in this study. The microbiological quality of this ice will be reduced considerably by sitting at temperatures above 0°C for protracted periods but risk is low because the products in contact with it are raw and will be cooked before consumption.

Guidance has been issued on the microbiological safety of tissues and organs used in transplants.[22] With cadaveric donors these may be contaminated by endogenous bacteria *post mortem*. We recommend that possible further infection from ice be kept in mind when working with tissues and organs intended for transplant to immunosuppressed patients. Ice should not come into direct contact with these tissues and organs at any time.

Conclusion

Although hygienically-produced ice generally is a safe food, healthcare professionals and food service managers should remember the possibility of ice being a potential vehicle for the transmission of serious infectious disease and take appropriate infection control measures.[3] Manufacturers should participate in the adequate training of food service managers so that the importance of regular cleaning and maintenance of these machines is fully understood and practised. Perhaps in association with Environmental Health Departments, manufacturers may be in a position to lead the improvement in ice hygiene by developing industry guidelines for cleaning regimens and microbiological standards.

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References

1. Newsom SWB. Hospital infection from contaminated ice. *Lancet* 1968; **2**: 620–623.
2. Dickens DL, DuPont HL, Johnson PC. Survival of bacterial enteropathogens in the ice of popular drinks. *J Am Med Assoc* 1985; **253**: 3141–3143.

3. Burnett IA, Weeks GR, Harris DM. A hospital study of ice-making machines, their bacteriology, design, usage and upkeep. *J Hosp Infect* 1994; **28**: 305–313.
4. Anonymous. *Shigella sonnei* outbreak associated with contaminated drinking water—Island Park, Idaho, August 1995. *J Am Med Assoc* 1996; **275**: 1071.
5. Stout JE, Yu VL, Muraca P. Isolation of *Legionella pneumophila* from the cold water of hospital ice machines: implications for origin and transmission of the organism. *Infect Control* 1985; **6**: 141–146.
6. Panwalker AP, Fuhse E. Nosocomial *Mycobacterium gordonae* pseudoinfection from contaminated ice machines. *Infect Control* 1986; **7**: 67–70.
7. Laussucq S, Baltch AL, Smith RP *et al.* Nosocomial *Mycobacterium fortuitum* colonization from contaminated ice machine. *Am Res Resp Dis* 1988; **138**: 891–894.
8. Moyer NP, Breuer GM, Hall NH *et al.* Quality of packaged ice purchased at retail establishments in Iowa. *J Food Protect* 1993; **56**: 426–431.
9. Hunter PR. The microbiology of drinks' vending machines. *Microbiol Europe* 1994; **2**: 8–10.
10. Anonymous. The microbiology of water 1994. Part 1—drinking water. Report on public health and medical subjects No. 71. In: *Methods for the Examination of Waters and Associated Materials*. London: HMSO, 65–86.
11. Felix CW. Ice—the forgotten food. *J Assoc Food Drug Officials* 1989; **53**: 19–34.
12. Peterson NJ. Don't culture ice machines. *Hosp Infect Control* 1982; **9**: 8–9.
13. Majewski MC. Food safety: the HACCP approach to hazard control. *Comm Dis Rep Rev* 1992; **2**: R105–R108.
14. Jones BL and Wilcox MH. Aeromonas infections and their treatment. *J Antimicrob Chemother* 1995; **35**: 453–461.
15. Spencer RC. The emergence of epidemic, multiple-antiobotic-resistant *Stenotrophomonas (Xanthomonas) maltophilia* and *Burkholderia (Pseudomonas) cepacia*. *J Hosp Infect* 1995; **30** (Suppl): 453–464.
16. Murphy FJ, Mepham P. Dangers in the ice bucket. *Environ Health* 1988; **96**: 25–28.
17. Murphy FJ, Mepham P. Microbiological quality of ice cubes: a survey. *Br Food J* 1988; **90**: 120–122.
18. Hunter PR. An introduction to the biology, ecology and potential public health significance of the blue–green algae. *PHLS Microbiol Digest* 1991; **8** (1): 13–15.
19. Gardner CA. Ice-making machines. *J Hosp Infect* 1995; **29**: 312.
20. Porco FV, Visconte EB. *Pseudomonas aeruginosa* as a cause of infectious diarrhea successfully treated with oral ciprofloxacin. *Ann Pharmacother* 1995; **29**: 1122–1123.
21. Dadswell JV. Managing swimming, spa and other pools to prevent infection. *Comm Dis Rep Rev* 1996; **6**: R37–R40.
22. Committee on Microbiological Safety of Blood and Tissues for Transplantation. Guidance on the microbiological safety of human tissues and organs used in transplantation. London: NHS Executive; 1996.