A Call for a New Standard for Water Quality in Health Care Facilities

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Waterborne Disease

It is estimated that as much as 25-33% of the global burden of disease can be attributed to environmental risk factors such as contaminated water (Smith, Corvalan & Tord, 1999). Almost 10% of the global disease burden could be prevented by improving water supply, sanitation, hygiene and management of water resources (WHO, 2009). Waterborne disease statistics only begin to estimate the global burden of infectious diseases from contaminated drinking water (Ford, 1999). Waterborne disease is not restricted to developing countries. Morris and Levine (1995) attempted to estimate the annual waterborne disease burden in the United States of America (US) and indicated that 560,000 people may suffer from a moderate to severe waterborne infection, and that 7.1 million suffer from a mild to moderate waterborne infection each year.

To really understand the condition of water entering a US health care facility consider that there are approximately 158,000 public drinking water systems in the United States. Each of these systems regularly supplies drinking water to at least 25 people or 15 service connections. Beyond their common purpose these systems vary widely (US EPA, 2008). In addition, there are 7,569 hospitals in the US each with a unique water system (US Census, 2005). Patterns of infection change over time and public health authorities can be been faced with newly discovered or emerging pathogens that may be able to overcome the many barriers of the water treatment and distribution systems (CDR, 1998). Examples of these evasive enteric waterborne emerging pathogens include: caliciviruses, *E. coli* O157:H7, *Helicobacter* sp., *Mycobacterium avium* complex (MAC); and protozoan contaminates such as: *Cryptosporidium* sp., *Cyclospora* sp. and *Toxoplasma* sp. There are other menacing water borne threats such as Hepatitis A which is one of most frequently reported viruses in water, which can cause: fever, nausea, diarrhea, and hepatitis. In addition, there are other viruses imposing health threats including: poliovirus, Norwalk virus, adenovirus, and reovirus. In fact there are over 110 types of human enteric viruses currently identified that can cause human health problems (Michigan Public Health Institute, 2008).

This problem requires constant vigilance in terms of what may pose a 'new threat' and also constant development with regard to methodologies and techniques for the detection of such threats. As noted by LeChevallier et al. (1999a), "knowledge is the first line of defense toward providing safe drinking water." The number of outbreaks that has been reported throughout the world demonstrates that transmission of pathogens by drinking water remains a significant cause of illness. However, estimates of illness based solely on detected outbreaks are likely to underestimate the problem. *A significant proportion of waterborne illness is likely to go undetected* by the communicable disease surveillance and reporting systems (Stenström, 1994).

The World Health Organization points out that the identification and enumeration of microorganisms in a water supply is slow, and hence is not suitable for early warning or control purposes. Sampling and monitoring the microbial quality of the water supplied to the consumer can only verify that the water was safe after it was supplied and perhaps ingested. They recommend a holistic approach to quality assurance which includes

assessment and control of source waters to prevent or reduce pathogen contamination. In addition, the selection and operation of treatment processes to reduce pathogens to target levels. They encourage the prevention of contamination by pathogens from water to people in the supply and distribution system by using water treatment and filtration. (WHO, 2004).

New effort from the Center for Disease Control

In February 2008, the US Center for Disease Control (CDC) began an effort to expand and strengthen the process to identify unregulated contaminants that may require a US national drinking water regulation in the future.

The CDC recognizes a broad universe of potential drinking water contaminants (called the CCL 3 Universe). They initially considered approximately 7,500 potential chemical and microbial contaminants. Applying screening criteria to the universe they identified 560 of those contaminants that should be further evaluated (the preliminary CCL or PCCL) based on a contaminant's potential to occur in public water systems and the potential for public health concern. The CDC selected 104 contaminants from the PCCL to include on the CCL based on more detailed evaluation of occurrence and health effects and expert judgment applied in a transparent reproducible manner.

List of CCL 3 Candidates

Microbial Contaminant Candidates

Microbial Contaminant Name	Information
Caliciviruses	Virus (includes Norovirus) causing mild self-limiting gastrointestinal illness
Campylobacter jejuni	Bacterium causing mild self-limiting gastroentestinal illness
Entamoeba histolytica	Protozoan parasite which can cause short as well as long-lasting gastrointestinal illness
Escherichia coli (0157)	Toxin-producing bacterium causing gastrointestinal illness and kidney failure
Helicobacter pylori	Bacterium sometimes found in the environment capable of colonizing human gut that can cause ulcers and cancer
Hepatitis A virus	Virus that causes a liver disease and jaundice
Legionella pneumophila	Bacterium found in the environment including hot water systems causing lung diseases when inhaled
Naegleria fowleri	Protozoan parasite found in shallow, warm surface and ground water causing primary amebic meningoencephalitis
Salmonella enterica	Bacterium causing mild self-limiting gastrointestinal illness
Shigella sonnei	Bacterium causing mild self-limiting gastrointestinal illness and bloody diarrhea
Vibrio cholerae	Bacterium found in the environment causing gastrointestinal illness

Chemical Contaminant Candidates

Contaminant	CASRN	Information about the contaminant
alpha-Hexachlorocyclohexane	319-84-6	It is a component of benzene hexachloride (BHC) and was formerly used as an insecticide.

Contaminant	CASRN	Information about the contaminant
1,1,1,2-Tetrachloroethane	630-20-6	It is an industrial chemical used in the production of other substances.
1,1-Dichloroethane	75-34-3	It is an industrial chemical used as a solvent.
1,2,3-Trichloropropane	96-18-4	It is an industrial chemical used in paint manufacture.
1,3-Butadiene	106-99-0	It is an industrial chemical used in rubber production.
1,3-Dinitrobenzene	99-65-0	It is an industrial chemical and is used in the production of other substances.
1,4-Dioxane	123-91-1	It is used as a solvent or solvent stabilizer in the manufacture and processing of paper, cotton, textile products, automotive coolant, cosmetics and shampoos.
1-Butanol	71-36-3	It is used in the production of other substances, and as a paint solvent and food additive.
2-Methoxyethanol	109-86-4	It is used in consumer products, such as synthetic cosmetics, perfumes, fragrances, hair preparations, and skin lotions.
2-Propen-1-ol	107-18-6	It is used in the production of other substances, and in the manufacture of flavorings and perfumes.
3-Hydroxycarbofuran	16655-82-6	It is a carbamate, and is a pesticide degradate. The parent, carbofuran, is used as an insecticide.
4,4'-Methylenedianiline	101-77-9	It is used in the production of other substances, and as a corrosion inhibitor and curing agent for polyurethanes.
Acephate	30560-19-1	It is used as an insecticide.
Acetaldehyde	75-07-0	It is used in the production of other substances, and as a pesticide and food additive.
Acetamide	60-35-5	It is used as a solvent, solubilizer, plasticizer, and stabilizer.
Acetochlor	34256-82-1	It is used as an herbicide for weed control on agricultural crops.
Acetochlor ethanesulfonic acid (ESA)	187022-11-3	Acetochlor ESA is an acetanilide pesticide degradate. The parent, acetochlor, is used as an herbicide for weed control on agricultural crops.
Acetochlor oxanilic acid (OA)	184992-44-4	Acetochlor OA is an acetanilide pesticide degradate. The parent, acetochlor, is used as an herbicide for weed control on agricultural crops.
Acrolein	107-02-8	It is used as an aquatic herbicide, rodenticide, and industrial chemical.
Alachlor ethanesulfonic acid (ESA)	142363-53-9	Alachlor ESA is an acetanilide pesticide degradate. The parent, alachlor, is used as an herbicide for weed control on agricultural crops.
Alachlor oxanilic acid (OA)	171262-17-2	Alachlor OA is an acetanilide pesticide degradate. The parent, alachlor, is used as an herbicide for weed control on agricultural crops.
Aniline	62-53-3	It is used as an industrial chemical, as a solvent, in the synthesis of explosives, rubber products, and in isocyanates.
Bensulide	741-58-2	It is used as an herbicide.
Benzyl chloride	100-44-7	It is used in the production of other substances, such as plastics, dyes, lubricants, gasoline and pharmaceuticals.
Butylated hydroxyanisole	25013-16-5	It is used as a food additive (antioxidant).
Captan	133-06-2	It is used as a fungicide.
Chloromethane (Methyl chloride)	74-87-3	It is used as a foaming agent and in the production of other substances.
Clethodim	110429-62-4	It is used as an herbicide.
Cobalt	7440-48-4	It is a naturally-occurring element and was formerly used as cobaltus chloride in medicines and as a germicide.
Cumene hydroperoxide	80-15-9	It is used as an industrial chemical and is used in the production of other substances.
Cyanotoxins (3)*		Toxins naturally produced and released by cyanobacteria ("blue-green algae"). Various studies suggest three cyanotoxins for consideration: Anatoxin-a, Microcystin-LR, and Cylindrospermopsin.
Dicrotophos	141-66-2	It is used as an insecticide.
Dimethipin	55290-64-7	It is used as an herbicide and plant growth regulator.
Dimethoate	60-51-5	It is used as an insecticide on field crops, (such as cotton), orchard crops, vegetable crops, in forestry and for residential purposes.
Disulfoton	298-04-4	It is used as an insecticide.
Diuron	330-54-1	It is used as an herbicide.
Ethion	563-12-2	It is used as an insecticide.
Ethoprop	13194-48-4	It is used as an insecticide.
Ethylene glycol	107-21-1	It is used as an antifreeze, in textile manufacture and is a cancelled pesticide.
Ethylene oxide	75-21-8	It is used as a fungicidal and insecticidal fumigant.
Ethylene thiourea	96-45-7	It is used in the production of other substances, such as for vulcanizing polychloroprene (neoprene) and polyacrylate rubbers, and as a pesticide.
Fenamiphos	22224-92-6	It is used as an insecticide.
Formaldehyde	50-00-0	It has been used as a fungicide, may be a disinfection byproduct, and can occur naturally.
Germanium	7440-56-4	It is a naturally-occurring element and is commonly used as germanium dioxide in phosphors, transistors and diodes, and in electroplating.
HCFC-22	75-45-6	It is used as a refrigerant, as a low-temperature solvent, and in fluorocarbon resins, especially in tetrafluoroethylene polymers.
Hexane	110-54-3	It is used as a solvent and is a naturally-occurring alkane.
Hydrazine	302-01-2	It is used in the production of other substances, such as rocket propellants, and as an oxygen and chlorine scavenging compound.

Contaminant	CASRN	Information about the contaminant
Methamidophos	10265-92-6	It is used as an insecticide.
Methanol	67-56-1	It is used as an industrial solvent, a gasoline additive and also as anti-freeze.
Methyl bromide (Bromomethane)	74-83-9	It has been used as a fumigant as a fungicide.
Methyl tert-butyl ether	1634-04-4	It is used as an octane booster in gasoline, in the manufacture of isobutene and as an extraction solvent.
Metolachlor	51218-45-2	It is used as an herbicide for weed control on agricultural crops.
Metolachlor ethanesulfonic acid (ESA)	171118-09-5	Metolachlor ESA is an acetanilide pesticide degradate. The parent, metolachlor, is used as an herbicide for weed control on agricultural crops.
Metolachlor oxanilic acid (OA)	152019-73-3	Metolachlor OA is an acetanilide pesticide degradate. The parent, metolachlor, is used as an herbicide for weed control on agricultural crops.
Molinate	2212-67-1	It is used as an herbicide.
Molybdenum	7439-98-7	It is a naturally-occurring element and is commonly used as molybdenum trioxide as a chemical reagent.
Nitrobenzene	98-95-3	It is used in the production of aniline, and also as a solvent in the manufacture of paints, shoe polishes, floor polishes, metal polishes, explosives, dyes, pesticides and drugs (such as acetaminophen), and in its re-distilled form (oil of mirbane) as an inexpensive perfume for soaps.
Nitrofen	1836-75-5	It is used as an herbicide.
Nitroglycerin	55-63-0	It is used in pharmaceuticals, in the production of explosives, and in rocket propellants.
N-Methyl-2-pyrrolidone	872-50-4	It is a solvent in the chemical industry, and is used for pesticide application and in food packaging materials.
N-nitrosodiethylamine (NDEA)	55-18-5	It is a nitrosamine used as an additive in gasoline and in lubricants, as an antioxidant, as a stabilizer in plastics, and also may be a disinfection byproduct.
N-nitrosodimethylamine (NDMA)	62-75-9	It is a nitrosamine and has been formerly used in the production of rocket fuels, is used as an industrial solvent and an anti-oxidant, and also may be a disinfection byproduct.
N-nitroso-di-n-propylamine (NDPA)	621-64-7	It is a nitrosamine and may be a disinfection byproduct.
N-Nitrosodiphenylamine	86-30-6	It is a nitrosamine chemical reagent that is used as a rubber and polymer additive and may be a disinfection byproduct.
N-nitrosopyrrolidine (NPYR)	930-55-2	It is a nitrosamine used as a research chemical and may be a disinfection byproduct.
n-Propylbenzene	103-65-1	It is used in the manufacture of methylstyrene, in textile dyeing, and as a printing solvent, and is a constituent of asphalt and naptha.
o-Toluidine	95-53-4	It is used in the production of other substances, such as dyes, rubber, pharmaceuticals and pesticides.
Oxirane, methyl-	75-56-9	It is an industrial chemical used in the production of other substances.
Oxydemeton-methyl	301-12-2	It is used as an insecticide.
Oxyfluorfen	42874-03-3	It is used as an herbicide.
Perchlorate	14797-73-0	It is both a naturally occurring and man-made chemical. Most of the perchlorate manufactured in the United States is used as the primary ingredient of solid rocket propellant.
Permethrin	52645-53-1	It is used as an insecticide.
PFOA (perfluorooctanoic acid)	335-67-1	It is used for its emulsifier and surfactant properties in or as fluoropolymers (such as Teflon), fire-fighting foams, cleaners, cosmetics, greases and lubricants, paints, polishes and adhesives and photographic films.
Profenofos	41198-08-7	It is used as an insecticide and an acaricide.
Quinoline	91-22-5	It is used in the production of other substances, and as a pharmaceutical (anti-malarial) and as a flavoring agent.
RDX (Hexahydro-1,3,5-trinitro-1,3,5-triazine)	121-82-4	It is used as an explosive.
sec-Butylbenzene	135-98-8	It is used as a solvent for coating compositions, in organic synthesis, as a plasticizer and in surfactants.
Strontium	7440-24-6	It is naturally-occurring element and is used as strontium carbonate in pyrotechnics, in steel production, as a catalyst and as a lead scavenger.
Tebuconazole	107534-96-3	It is used as a fungicide.
Tebufenozide	112410-23-8	It is used as an insecticide.
Tellurium	13494-80-9	It is a naturally-occurring element and is commonly used as sodium tellurite in bacteriology and medicine.
Terbufos	13071-79-9	It is used as an insecticide.
Terbufos sulfone	56070-16-7	Terbufos sulfone is a phosphorodithioate pesticide degradate. The parent, terbufos, is used as an insecticide.
Thiodicarb	59669-26-0	It is used as an insecticide.
Thiophanate-methyl	23564-05-	It is used as a fungicide.

Contaminant	CASRN	Information about the contaminant
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Toluene diisocyanate	26471-62-5	It is used in the manufacture of plastics.
Tribufos	78-48-8	It is used as an insecticide and as a cotton defoliant.
Triethylamine	121-44-8	It is used in the production of other substances, and as a stabilizer in herbicides and pesticides, in consumer products, in food additives, in photographic chemicals and in carpet cleaners.
Triphenyltin hydroxide (TPTH)	76-87-9	It is used as a pesticide.
Urethane	51-79-6	It is used as a paint ingredient.
Vanadium	7440-62-2	It is a naturally-occurring element and is commonly used as vanadium pentoxide in the production of other substances and as a catalyst.
Vinclozolin	50471-44-8	It is used as a fungicide.
Ziram	137-30-4	It is used as a fungicide.

Hospital Acquired Infections (HAIs)

It is estimated that in American hospitals, HAIs accounted for an estimated 1.7 million infections and 99,000 associated deaths. Of these, HAIs: 32 percent were urinary tract infections, 22 percent were surgical site infections, 15 percent were pneumonia (lung infections) and 14 percent were bloodstream infections (CDC, 2008). HAIs in hospitals are a significant cause of morbidity and mortality in the United States (Klevens et al., 2003). Determining what percentage of US hospitals are testing the water used in their facility could provide an opportunity for intervention leading to a reduction in HAIs. *The most overlooked, important, and controllable source of HAIs is hospital water* **(**Ortolano et al., 2005).

Water-based pathogens occur naturally in water and are usually not transmitted from person to person (i.e. *Legionella* spp.). There are more than 140 known microorganisms recognized as waterborne or water-based pathogens. The waterborne and water-based pathogens have emerged as important to health care because of the increase in the size of sensitive populations in the US, which now comprise 25% of the population. Other drivers of this growing concern include:

- the improved methods for identification of outbreaks and their sources
- the increase in importation of foods from developing countries
- natural evolution of microbes with increased virulence
- additional health effects including chronic sequelae brought on by these pathogens
- the human cost in morbidity and mortality
- economic loss brought on by these preventable illnesses.

The chronic sequelae are diseases that develop in the days, weeks, or years after initial infection include diabetes, autoimmune disease, and cancer (Reynolds, Mena & Gerba, 2008). US hospitals are urged but not required to use data provided by the National Nosocomial Infection Surveillance System (NNIS) and the suggested method for calculating HIAs at their facility. The NNIS was established in 1970 when selected hospitals in the United States routinely began reporting their nosocomial infection surveillance data for aggregation into a national database. There are over 300 hospitals that currently participate in the NNIS system. There are approximately 7500 hospitals in the US hospital system.

The monitoring of water quality in the US hospital system is not uniform despite government oversight by agencies such as the NNIS, and there appears to be limited public information about individual facility quality. There is no rating system to categorize hospital water. The prevailing wisdom in the US may be that if the water has met the municipal water standard it is good to use in a health care facility. Hospitals may be using municipal water with limited information about the distribution system, groundwater, individual water

system and secondary transmission risks (Craun & Calderon, 2006). The use of municipal water may cause problems for sensitive subpopulations in given hospitals. These subpopulations include: the elderly, the very young, the chronically ill, recipients of immunosuppressive therapies, and pregnant woman (Smith, Corvalan & Tord, 1999). If hospitals do not test the water for all pathogens they cannot be certain it is safe to use with these sensitive populations.

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