ENWARE

The Coming Shift to Lead Free Plumbing Materials - Understanding the Risks that Lurk in the Choice of Replacement Materials for the Healthcare Sector

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Published: August 2022

Introduction

Over the next 3 years the Australian plumbing industry will see a significant change in the types of materials used in potable water systems. These changes are the product of the Australian Building Codes Board (ABCB) consultation regulation impact statement (CRIS) released in 2020 titled "Lead in plumbing products in contact with water" which was designed to engage discussion with industry stakeholders on options to reduce the risks of lead contamination of potable water systems via lead leaching from brass plumbing products. This consultation resulted in the adoption of a prescribed maximum wetted surface area lead content of 0.25% for plumbing products in contact with potable water (current brass components may have a lead content of 4-6%).

The changes have been broadly welcomed by the plumbing industry as they will ultimately improve the quality and safety of potable water delivered to their customers. However, some stakeholders are concerned at the speed at which the regulations have been introduced, and the failure to consider the potential unintended consequences that the changes will have on other public health risks associated with potable water. Specifically, concerns have been raised over the impact that changes may have on the prevalence of opportunistic premise plumbing pathogens (OPPPs). Within the healthcare industry, OPPPs are an increasingly significant threat to public health, and are responsible for an increasing number of healthcare associated infections (HAIs).

Changes in Regulation

The potential change in regulation is motivated by the attention lead contamination of drinking water has received over the past two decades, in part due to the large-scale lead leaching events in Flint, Michigan, and Washington DC, in the USA. In these cases, the corrosion of lead piping due to a change in water chemistry and/or water source was deemed to be the cause. A similar event in Australia is highly unlikely due to Australia replacing lead piping with copper from the 1930s onwards.

In Australia, concerns have been heightened due to detections of elevated lead levels in the recently completed Perth Children's Hospital, Western Australia, and public drinking fountains in Geelong, Victoria. In both instances lead leaching from brass plumbing components was determined to be the likely cause; however, both were deemed largely isolated cases where several factors conspired to contribute to the elevated lead water concentrations. This included the use of non-compliant materials, unsatisfactory water system management, and significant periods of stagnation.

During this period (2018), Australia's then Chief Medical Officer, Prof Brendan Murphy, assured the public in a press release that

> "There is no evidence of adverse effects on human health from the consumption of lead in drinking water in Australia",

> "The concentration of lead set in the drinking water guidelines is very conservative so that it can be sure to protect the most vulnerable people, such as very young children and pregnant women".

The scientific literature also identifies lead in water as contributing a relatively small proportion of the overall lead body burden for individuals over 1 year old, with the major contributions coming from food and soil/dust. For example, data from Victoria between 2011 – 2014 showed there were 671 notifiable cases of elevated lead level (> 10 µg/dL). Of these, 81% of cases were determined to have an occupational risk factor, while only 3 cases total were linked to potable water as a risk factor. Whilst strategies to reduce the consumption of lead should be explored, it is essential that when mandating regulatory changes an evidence-based approach that considers all aspects of the problem is applied. This ensures that the potential benefits of a regulatory intervention are considered in the context of any other potential identified consequences.

Missed Opportunities

It is in this respect that the introduced regulatory changes fall short. This represents a missed opportunity for a more thorough and impactful consideration of the regulatory environment around plumbing materials and health risks, particularly those associated with healthcare facilities where the most vulnerable users are exposed. In the ABCBs final CRIS document it notes in several sections that there is a lack of available data in support of critical conclusions around the magnitude and extent of the problem of lead in water in Australia , with perhaps the starkest acknowledgement being that the ABCB remains unclear whether any tangible and measurable health benefits will flow from the regulatory changes.

Given the uncertainty as to the actual benefits that will come from the regulatory changes, the potential for the worsening of the problem of microbial contamination of building water systems in healthcare facilities becomes even more concerning, with such concerns now being justified given how some in the industry have responded to the changes.

The tangible outcomes from the announced changes have been two-fold. The first is the reduction in lead content in plumbing materials. This will effectively outlaw standard brass materials (lead content of 4-6%), with its direct replacement being lead free brass (with a maximum lead content of 0.25%). Lead free brass is more expensive to produce than standard brass, increasing its cost and having plumbing manufacturers, suppliers, architects, and facility managers considering alternatives. Furthermore, brass, including the 'lead free brass', has been stigmatised (unfairly in our view) as an unsafe material, leading to the increased adoption of alternatives.

The second effect is the resultant wave of marketing and advertising of products by many plumbing device suppliers with an aim to gain market share and replace the now out of favour brass materials with other so called 'safe' alternatives, in particular stainless steel. Many of these materials are also being advertised as 'antibacterial' without any clear supporting evidence.

It is here where we find our problem. Brass materials, including lead free brass, are copper alloys. Copper is well known to exhibit a bactericidal property, and therefore copper and brass materials in plumbing systems will present a level of protection against OPPP contamination of their surfaces and thus plumbing components. The same cannot be said for most, if not all, of the replacement materials being pushed by some in the industry, and it is here where it is critical that we have an evidence-based discussion around the potential risks associated with the different possible replacement materials. Do any of the replacement materials present antibacterial properties? Which materials are best to reduce the risks of microbial contamination in healthcare settings? Do any of the materials interact with free chlorine in the water, reducing its disinfection power? .

Can the regulations be improved by introducing standards on the types of materials recommended for specific settings where vulnerable individuals will access the potable water, based on studies and evidence? These are just some of the questions that we believe would have served well in a broader scope of discussion with regards to the recent lead in water CRIS.

This has been a missed opportunity that may result in the aggravating of the existing, and far more acute and insidious known risk of microbial contamination of building potable water systems in the healthcare industry.

Risks

So how serious is this threat of microbial contamination of building water systems by OPPPs? Hospital acquired infections (HAIs) from OPPPs have already been described as a public health crisis in the healthcare industry, with hospital tap water described "as the most overlooked, important, and controllable source of hospital acquired infections". It is estimated that hospital acquired pneumonia infections caused by waterborne Pseudomonas aeruginosa alone are responsible for 1,400 deaths per year in the U.S. healthcare system. Legionella spp. has also been identified as a leading cause of drinking water outbreaks in the U.S., with annual economic costs of infections requiring hospitalisation estimated at $430 million USD, with costs for NTM estimated to be $425 million USD. Many studies have linked the bacterial contamination of a water outlet directly with an infection of the tap end user.

When considering the public health risks associated with potential lead contamination versus OPPP contamination, it is essential that dose response is taken into consideration. Studies have shown that the highest concentration of both lead and OPPPs is association with stagnation events, with concentrations of both hazards reduced through flushing. However, whilst a one-off exposure event to a lead concentration above drinking water guidelines is not ideal, the associated clinical consequence is relatively low compared with a one-off exposure to an infectious dose of an OPPP. This is particularly important for vulnerable populations, such as the young, the old, and the immunocompromised, as it only takes one exposure event to an OPPP above an infectious dose to result in a potentially fatal infection.

Water system contamination may occur both the distal and proximal to the mains water supply entering the building. However, contamination of end of the line devices and components such as taps, valves, aerators and showerheads have been shown to be far more prevalent, placing the contaminated plumbing components directly at the interface with the end user. End-of-line fixtures and devices are more likely to present niche microenvironments for organisms to adhere-to and colonise, are frequently subjected to heating/cooling of water to levels known to be beneficial to microbial growth, suffer from stagnation, and present lower concentrations of free chlorine relative to regions of the plumbing system more proximal to the building/municipal source supply.

Actions by Industry Groups

Some industry groups are already going far beyond the ABCB regulatory changes. For example, the Victorian School Building Authority has mandated that stainless steel be used for certain plumbing outlets and devices within schools. It is unclear why this decision has been made, and from what advice or evidence it has been formed. Even though stainless steel has been touted by some as an 'antibacterial' material in the industry for plumbing applications, there is in fact little, if any, evidence to support these claims. There is no obvious reason or mechanism through which stainless steel would inhibit bacterial adhesion or growth, in fact in the literature data supporting the opposite is often presented.

Studies and Results

We have undertaken short (20 hr) and longer term (30 & 70 day) studies looking at the adhesion and growth of several different OPPPs on polymers, metals and metal alloys used in the plumbing industry. A study investigating the adhesion and growth of Pseudomonas aeruginosa on stainless steel (304 and 316), lead Free and Standard WaterMark approved Brass, and Acetal, over a 20-hr period showed both stainless steel samples to present the greatest degree of bacterial fouling, followed by acetal (Figure 1). Both the lead free and standard brass materials demonstrated the least bacterial fouling, likely owing to their high copper content. Preliminary data from longer term studies measures the ability for the OPPP organisms Acinetobacter baumannii and Pseudomonas aeruginosa to grow under stagnant conditions in standard brass and stainless-steel piping. Our results showed that at both 30 and 70 days, A. baumannii and P. aeruginosa were present in significantly greater numbers in the water in the stainless steel piping, relative to the brass piping, mirroring our previous work.

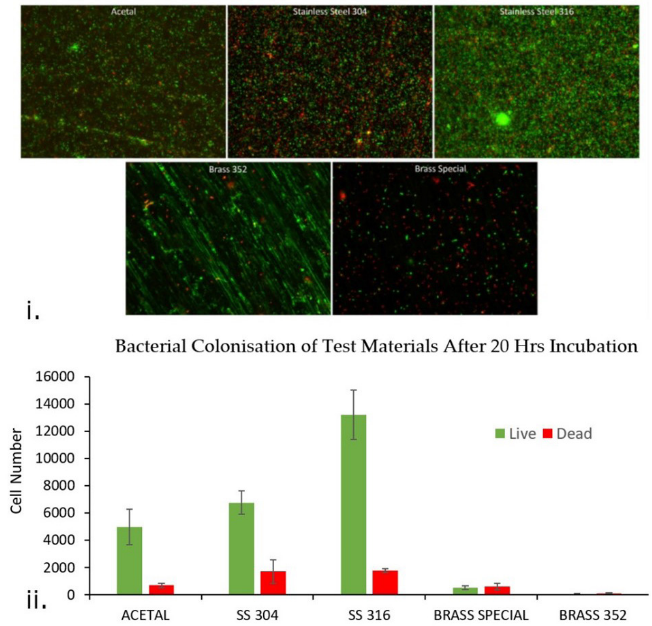

Figure 1

Figure 1. i. Representative fluorescence microscopy images of live (green) and dead (red) Pseudomonas aeruginosa cells on acetal, stainless steel (304 and 316), standard brass (Brass 352) and low lead brass (Brass Special). ii. Live (green) and dead (red) cell counts from adhered Pseudomonas aeruginosa cells on test polymeric and metallic materials (Acetal, Stainless Steel 304 (SS 304), Stainless Steel 316 (SS 316), Brass Special, and Brass 352). All data points represent data from triplicate samples, and error bars represent 95% confidence intervals around the mean.

Some data in the literature in this space are however contradictory, and therefore further investigations must be undertaken to understand the implications and consequences of using different plumbing materials in building water systems, especially where vulnerable individuals may be exposed. The industries' goal must be to determine what materials provide the least risk in terms of microbial contamination by waterborne OPPPs and ensure corresponding advice and regulatory efforts all work towards ensuring we can deliver the highest quality and safest possible water to our most vulnerable citizens.

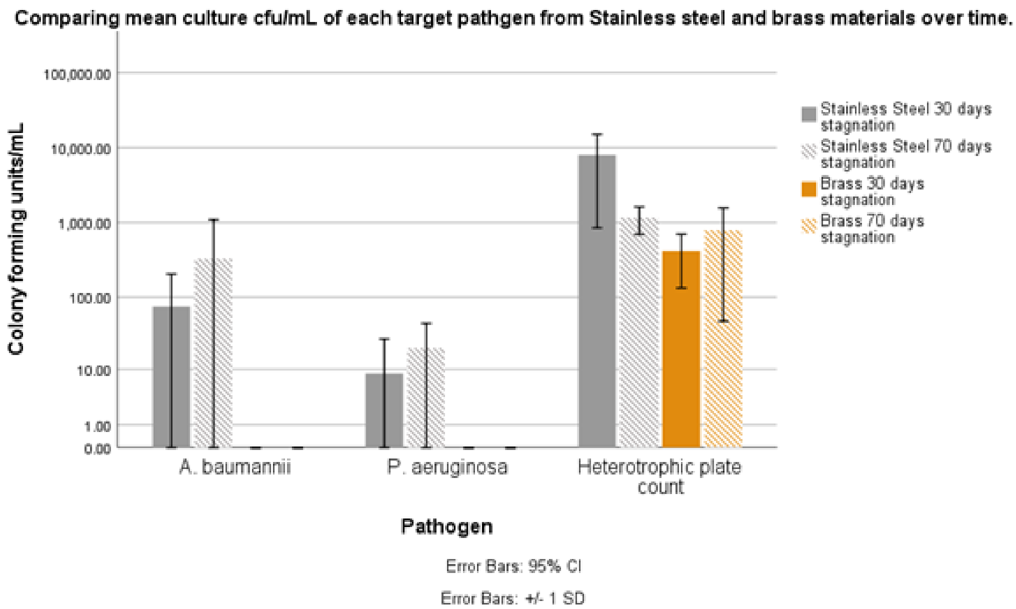

Figure 2

Figure 2. Comparison of mean bacterial culture colony forming units (cfu/mL +/- SD) from water seeded with A. baumannii or P. aeruginosa after 30 (solid) or 70 days (dashed) stagnation in piping made from either stainless steel or brass. Heterotrophic plate count also enumerated.

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