Note to the editor

Infection control strategy by killing drug-resistant bacteria

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Persistent outbreaks of bacterial infections have puzzled the scientific community and have generated significant public interest. For example, if you type 'outbreaks of bacterial infections', in Google UK, more than 8 610 000 hits/websites appear, while pubmed search results in 143 879 articles. Despite the use of resources (human/financial) to eradicate this menace, we are witnessing a worsening trend and the emergence of superbugs is leading us to a pre-antibiotic era. For example, methicillin-resistant *Staphylococcus aureus* (MRSA) infection rates in New South Wales hospitals in early 2000s led to a high-profile 'hand-washing' hygiene campaign that seemed to achieve results. However, the latest hospital infection rates appear higher than they were after the campaign, despite the claims by health officials that the hand-washing targets were met. Recent data shows hospital staff treated 730 cases of MRSA infection in the first four months of 2012, up from 597 in 2011.[1]

Superbug infections were thought to be contracted mainly during hospital stays. Bacterial infection outbreaks, alarmingly, are however, appearing in the community, in people who have not been hospitalized or had a medical procedure performed recently, and who do not have immune deficiency. Because of the rising trends of infections in the community, schools and public places are being shut down on a regular basis followed by rigorous disinfection.[2–4] Centers for Disease Control and Prevention estimates that 12% of MRSA infections are now community-associated, which are on the rise compared to healthcare-associated MRSA infections. An example of community-associated infection was seen in June 2012, when an outbreak of Legionnaires' disease was reported in Edinburgh, UK, leading to a distillery shutting down its cooling towers. The number of cases in this deadly outbreak stands at 95 people; two people have died so far.[5]

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Although measures such as hand washing/use of disinfectants to combat infections are being implemented, they are still on the rise. Perhaps, a major factor that is deterring our success in preventing the spread of these fatal infections in hospitals, nursing homes, and the community is our inability to correctly identify the source/host of infectious agents.

Being a free-living amoeba, *Acanthamoeba* is the most ubiquitous protist that can harbour viruses, bacteria, yeast, protist, and is termed as the Trojan horse of the microbial world.[6] This symbiotic nature is unclear but may enable pathogens to survive in hostile conditions such as use of disinfectants, which may lead to their transmission to individuals to establish infection. Ability of pathogenic bacteria such as MRSA or *Legionella* to survive and multiply inside *Acanthamoeba*[7] suggests that amoeba acts not only as a vector but also as a reservoir. For the development of preventative/therapeutic measures in such cases, we can no longer focus on a single aetiological agent, where the link between exposure and infection is clearly defined. On the contrary, disease should be considered as having multiple and confounding factors, with different aetiologies specific to different subpopulations to enable us to understand dynamics of disease outbreaks. Based on these observations, it is tempting to speculate that targeting the host that harbours 'superbugs' may be an effective strategy in our fight against infectious diseases, but this requires further research.

Similarly, water-borne diseases have been recognized as a major threat to sustainable human development. For example, over 30 million cases globally each year are associated with poor water hygiene.[8] Improving water sanitation and supply has produced tremendous benefits to public health in the developed world nonetheless the situation in developing countries has remained dire. In the majority of developing countries, chlorination is the only measure undertaken to protect drinking water supplies against contamination, albeit intermittent. Additionally consumers may boil water as an added precaution. Moreover, despite chlorination and boiling of water

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by the consumer, drinking water and exposure to recreational water has remained a significant threat to public health resulting in serious infections, including gastroenteritis, paralysis, meningitis, hepatitis, respiratory illness, and diarrhoea, especially in the developing countries. For instance, diarrhoea is regarded as the leading cause of morbidity and mortality in children in Africa and South Asia.[9,10] In the city of Karachi alone, more than 20 000 children die annually, the majority of these deaths are thought to be associated with waterborne pathogens. Among others, major waterborne diseases include cholera, enterohaemorrhagic *Escherichia coli*, viral hepatitis, bacillary dysentery, typhoid, campylobacteriosis, cryptosporidiosis, giardiasis, and legionellosis. The fragility and fastidious nature of several viral and bacterial pathogens to survive harsh environmental conditions is unclear, let alone withstand disinfection strategies such as chlorination and boiling of water. To this end, several lines of evidence suggest that *Acanthamoeba* cysts are highly resistant to chlorine and remain viable even after boiling (reviewed in[6]) making such disinfection strategies ineffective. It is plausible that *Acanthamoeba* cysts provide shelter to microbial pathogens during disinfection and allow the spread of microbial pathogens to the susceptible population. Thus it is imperative that alternative anti-amoebic tactics, in addition to bacterial disinfection, should be employed to target the host that harbours 'terror cells' which may prove to be an effective preventative measure. Storage, sedimentation, coagulation, flocculation, and filtration of water, prior to disinfection, will also prove highly effective in reducing the content of microbial flora including germs-infested amoebae, in drinking water supplies. Ground water extracted from deep wells is usually free of microbes, while surface water and water obtained from shallow wells need to be disinfected. None of these methods, however, can guarantee the complete removal of germ-ridden amoebae. Routine monitoring of microbial changes including presence of amoebae, during and after application of various disinfection treatments, is essential to safeguard domestic water systems against infectious diseases that account for more than 50% of global child mortality.[9,10] Future research is needed to determine the efficacy of the proposition to add an anti-amoebic line of defence to combat bacterial infections in hospitals, nursing homes, schools, and water systems.

Author Contributions

NAK has a lifelong interest in the field of *Acanthamoeba*. RS is a microbiology researcher. All authors contributed equally to the manuscript and will act as guarantors.

Conflict of Interest

The authors declare (1) no conflicts of interests for the submitted work; (2) no financial relationships with commercial entities that might have an interest in the submitted work; (3) no spouses, partners, or children with relationships with commercial entities that might have an interest in the submitted work; and (4) no non-financial interests that may be relevant to the submitted work.

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