

# Infection control in the post-antibiotic era

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**Abstract.** There are enormous challenges facing infection control in the 21st century. Countries across the world are confronted by ageing populations, restricted healthcare resources, demands for modern medicine and increasing antimicrobial resistance. Problem pathogens in the community are set to invade hospitals, and those created in hospitals are seeding into the community. Continued consumption of antimicrobial agents is generating and consolidating resistance to nearly all classes of drugs. New resistance mechanisms arising in one locality rapidly spread across the 'global village' courtesy of migration, conflict and international travel. We are facing unprecedented threats to the management of infection both in healthcare and communities across the world. This review summarises the current challenges for infection control and proposes a range of solutions encompassing novel strategies and technologies aimed at protecting us against untreatable infection.

**Additional keywords:** antimicrobial stewardship, decontamination, healthcare-associated infection, hospital hygiene, infection control.

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## Introduction

Infection control faces radical challenges at the beginning of the third millennium.<sup>1</sup> Infection remains the second most common cause of death worldwide, with healthcare-associated infection (HAI) affecting at least 1 in 10 patients admitted into hospital. Advanced healthcare increases the risk of infection – with invasive technologies and immunosuppression – while fuelling high patient expectations of modern medicine.<sup>2</sup> Most countries are experiencing ageing populations, along with continued restrictions on healthcare resources.<sup>3</sup> Healthcare tourism, along with migrant workers, refugees, business and holiday travellers illustrate the ease by which pathogens traverse the aptly named 'global village'.<sup>4</sup>

These socioeconomic, medical and population issues have coincided with the present backdrop of steadily-increasing antimicrobial resistance.<sup>3,5,6</sup> Some pathogens are termed multi-drug resistant (MDR), with a few treatment choices; others, with one major drug class available, are classified 'extreme-resistant' (XDR); and finally, there are organisms termed 'pan-resistant' (PDR), because there are no remaining agents with which to treat patients.<sup>7</sup>

Additional organisms attract attention by virtue of pathogenic determinants and/or superlative transmission ability. These include *Clostridium difficile* and a wide range of viruses.<sup>3,8</sup> Resistance issues have already been heralded with *C. difficile* (low-level resistance to metronidazole) and some influenza strains appear to be developing

resistance to oseltamivir.<sup>9,10</sup> As for norovirus, new genotypes regularly appear, causing a wave of outbreaks across a region, which then spread elsewhere.<sup>11</sup> Such genomic plasticity illustrates a persistent threat, because it means that viruses could mutate into a strain impossible to contain, particularly if combined with exceptional virulence.<sup>12</sup> Indeed, all microbial categories have this capacity for mutation.

Despite current concern over resistance, antimicrobial development and immunotherapy appear to have frozen.<sup>13,14</sup> There are economic reasons for this, since short-term anti-infectives do not generate much profit, but it is possible that there are only a finite number of microbial targets accessible for antimicrobial exploration.<sup>15</sup> It is also the case that regulatory bodies are not necessarily helping smooth the tortuous pathway from drug discovery to licensing.<sup>16</sup>

With diminishing options for treating infection, control of transmissible pathogens has ignited international interest.<sup>17</sup> Multiple organisations have begun to formulate policies, but these efforts are challenged on every level by national, political, criminal and economic restraints.<sup>5,17–19</sup> Without international recognition and collaboration, successful interventions in one part of the world will ultimately be compromised by control deficits in another. This article highlights current problems with microbial pathogens and offers a range of strategies for the future delivery of infection control. A return to the pre-antibiotic era, when normal healthy people died from infection, is not inevitable, even if

### Implications

- This opinion piece summarises current challenges for the prevention and control of infection.
- It proposes a range of novel strategies and technologies aimed at protecting us against untreatable infection.
- We need to prepare for a world without antibiotics.

a 21st century solution for treating infection takes its time to emerge.

## Current problems with control methods

### *Healthcare*

Solutions for controlling healthcare-associated infection are not all possible, practical, affordable, acceptable or even evidence-based.<sup>20</sup> The usual response is to implement a 'bundle' of infection-control strategies, and hope that the overall effect will have the desired result.<sup>20–22</sup> Exactly what effect each individual strategy has against a particular pathogen is usually unknown because we lack this level of evidence. Post-outbreak analysis often only provides a cause-and-effect relationship rather than data supporting single interventions. Thus, designing infection-control studies is fraught with confounders as well as being subject to ethical constraints.<sup>23</sup>

Formulating guidelines and policies on infection control has never been so popular but stating what we should do, and doing what is stated, can be a world apart on a busy ward.<sup>24,25</sup> When clinical staff are overstretched, time for patient care is compromised, and integral to this is infection control.<sup>26,27</sup> Good practice is reliant on personal choices. The 'zero tolerance' policy aimed at healthcare workers and their hand hygiene practices has not necessarily resulted in 100% compliance and there are compelling reasons for its failure.<sup>28,29</sup> In addition, the success of antimicrobial stewardship programs depends on support by committed prescribers.<sup>30</sup>

Outside of outbreak situations, routine infection control remains low priority, since it is impossible to cost something that may not happen.<sup>31,32</sup> By its very nature, infection prevention conflicts with the priorities of managers, keen to lower the overheads of their organisations.<sup>33,34</sup> Running a hospital at 100% bed occupancy, for example, or underestimating staffing levels, is an invitation for pathogens to spread.<sup>33,35</sup> Infection-control practitioners must engage with management and convince them of the importance of early implementation of control activities.<sup>36</sup> It is unacceptable that avoidable fatalities have to occur before anyone takes any notice of hygiene deficits. Ultimately, the responsibility of determining the quality of healthcare rests with governing bodies at national level.<sup>37</sup>

Whilst many hospitals have set up epidemiology and surveillance programs to aid infection control, the

components of these may lack definition, which means that surveillance data cannot be compared between countries, or even between regions.<sup>3</sup> Similar problems exist at molecular level, where strain types may be disputed by international agencies and impede global attempts at monitoring spread.<sup>38</sup>

### *Community*

Poor infection control encourages and concentrates pathogen reservoirs in hospitals, which eventually permits spillage into the community. Since the street between the hospital and the community runs both ways, patients colonised or infected with hospital organisms then return them back to hospital.<sup>2,39,40</sup> Carriers contaminate the healthcare environment, which serves as a reservoir for others.<sup>41</sup> In contrast, pathogens originating in the community are capable of spreading through hospitals following introduction by both staff and patients.<sup>42</sup> Resistant coliforms can be acquired through different community reservoirs and carried long-term in the gut, particularly amongst the elderly.<sup>40,43</sup> Older patients do not retain immunological defences capable of eradicating these microbes, which results in an accumulation of pathogens among people who frequently, and ultimately, require healthcare.

Patients not only desire the best and most modern of treatments, they also expect a 'pill for every ill', which makes it difficult to withhold antimicrobial drugs for the worried well. Time constraints in community clinics do not permit the explanation, reassurance and education required for non-infected patients, especially parents who want something for a sick child.<sup>44</sup> Indeed, rigid stewardship in the community occasionally compromises the management of a patient who really does need timely antimicrobial therapy.<sup>45</sup> This is compounded by poor access to diagnostic microbiology laboratories, which forces clinicians to prescribe broad-spectrum therapy and ultimately encourages antimicrobial resistance.<sup>46</sup>

There seems to be a current trend for waging war on the germs.<sup>47,48</sup> Germs are a 'buzzword' for a danger that people wish to eliminate from their surroundings.<sup>47</sup> This has resulted in a flourishing market of antibacterial products for use in the community.<sup>49,50</sup> Antibacterial products were developed to prevent transmission of pathogens among patients, particularly in hospitals, but they are now being added to products used in healthy households, even though additional health benefits have not been demonstrated.<sup>51</sup> Some antibacterial agents promote resistance and cross-resistance antibiotics.<sup>52,53</sup> We should remember that 'nature abhors a vacuum and will fill it up if she can'; this means that using microbiocidal products might remove susceptible microbes, but the space created could attract a new population of something worse.<sup>46,48</sup> We cannot rid ourselves of bacteria.

Whilst affluent countries exercise their choice of disinfectant, there are places in the world which lack even basic sanitation and clean water. This compromises hygiene, facilitates infection and furthers the spread of resistant pathogens.<sup>54,55</sup> Underfunded or inaccessible healthcare also

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