How modern day biosecurity relates to the plague village

In the history of public health, Eyam, a picturesque but otherwise obscure village in the Midlands of England, has a remarkable story to tell. 350 years ago the people of Eyam were caught in an outbreak of bubonic plague, so they applied a series of biosecurity measures to limit the spread of the plague from their village to surrounding populations.

At that time there was no understanding of the microbiology behind the plague, so the village's biosecurity was a fortuitous combination of logic, common sense and decisive action.

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Eyam's intuition into limiting the spread of disease was extraordinary and its biosecurity practice was effective – saving thousands of lives because the plague was contained.

Quarantining, social distancing and application of disinfectants comprised Eyam's biosecurity practices. Hundreds of years later, the whole world subscribed to quarantining, social distancing and disinfection as humanity challenged the Covid-19 pandemic. In addition, the quick disposal of bodies close to the immediate area of death has limited the spread of Ebola outbreaks in Africa, another biosecurity measure practiced in Eyam.

Today, antimicrobial measures – biosecurity – are central to prevention of infectious disease and premature death in many settings additional to human health, for example, plant and animal health, biological experiments and bioterrorism. Biosecurity is, unquestionably, important for health and economies on a global scale.

Pathogens need to spread

Humanity remains engaged in an open-ended struggle with disease-causing microbes. The world will continue to battle infectious diseases because the causative microbial and viral agents (pathogens) are ever present and have evolved to spread efficiently among vulnerable host organisms, be they human, animal or plants.

There are viruses that even infect bacteria. In the history of public health, only one pathogen has ever been eradicated by biosecurity programmes – variola, the virus that causes smallpox. On the other hand, 'new' pathogens inevitably emerge and add to the burden of infections in humans, animals and plants.

Despite being relatively 'simple' life forms, pathogens are good at what they do. For example, to remain in a single host is often a dead end for a pathogen, particularly if that host dies from the infection, so passage from an infected host to the next individual is a survival mechanism for many pathogens.

Transmission from one host to the next can occur in myriad ways, often involving processes that are poorly understood by science. The pathogen is at risk of failing to establish infection in the next host when its transmission involves a period of time outside of the host, such as when it is contaminating fomites in the environment or circulating in the air as droplets.

Between hosts the pathogen is vulnerable not least to biosecurity because biosecurity intervention seeks to break the cycle of transmission and protect uninfected individuals from being exposed to the pathogen.

At its most basic, biosecurity may be reduced to this simple question – to what extent can the risk of disease transmission be reduced? That risk reduction is difficult to quantify despite our understanding of how quarantining, social distancing and disinfection work.

A significant reduction in the spread of infectious agents is a truly complex interaction of multiple factors.

However, the evidence tells us that when deployed in combination and to appropriate extents biosecurity measures can indeed be powerful opponents of transmission of infection. They are good at what they were designed to do too.

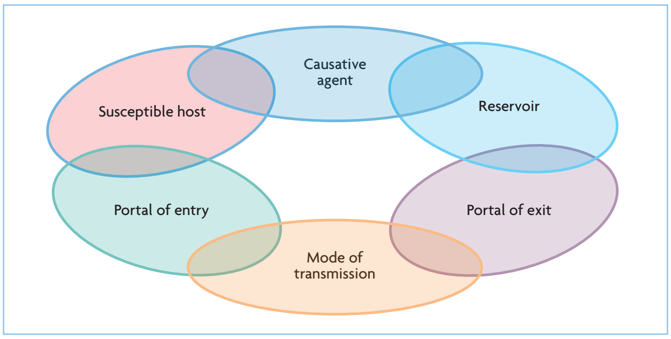

Fig. 1. Schematic definition of the infection cycle.

The role of the environment

While the role of the environment in the transmission of infectious disease has attracted the attention of scientists, microbiologists and public health officials for many years (it was the focus for Eyam too), a detailed understanding of this phenomenon for many human and animal pathogens remains elusive.

If pathogens that are contaminating non-biological spaces during time between hosts remain viable and infectious, they will present a threat of disease transmission – it is a question of the next host encountering the contaminant and allowing its access to susceptible tissue for an infection to be established.

While the relative contribution of a contaminated environment is not, and probably will never be, understood with respect to parameters like incidence of disease, logic demands that the less contaminated with pathogens an environment is, the lower the risk of disease transmission within a host population exposed to that environment.

Here is where disinfectants have a valuable role to play in the biosecurity arsenal. Back in 17th century Eyam, locals immersed coins in vinegar to decontaminate them before passing them to recipients as payment for food.

Nowadays the biosecurity science of microbial decontamination and sterilisation is well established as a wide variety of physical methods and chemical reagents are routinely applied to diverse contaminated environments, specifically to break the chain of pathogen transmission and thus reduce risk of diseases spreading.

Environmental decontamination (the reduction of microbial mass) necessarily needs repeating. Environments become contaminated with dirt and pathogens because of how and why they are used (think animal husbandry); in other words, continued environmental practice perpetuates continual environmental contamination and calls for repeated application of biosecurity disinfection.

Disinfectants need to be good at their job

Simply applying a disinfectant to a poultry shed or hospital ward may only be a partial solution to the biosecurity objective. Disinfectants need to be able to show a highly efficacious performance against a broad spectrum of pathogens. There is no need for the choice and deployment of disinfectants to hygiene-critical environments to be a weak link in the biosecurity chain.

Effectively, albeit periodically, removing pathogens from environments that contain at risk populations of humans, animals and plants will reduce transmission of infection.

Arguably, the better the disinfectant and the more stringent the application, the better the health and economic outcomes as outbreaks appear. ■