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Biosecurity

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Abstract

Biosecurity is a term widely used in a number of different fields, particularly in agriculture, human health, research, and national/international security. However, the meaning may differ slightly, depending on the context. In this discussion, it is broadly defined as "*The management of risks from invasive species to human and animal health*, *the natural and built environments, and agriculture.*" This occurs through prevention, surveillance, preparedness, and response activities, supported by appropriate capacity and capability. A wide range of ethical issues arise, including prioritization of activities based on resources and risk assessments; uneven investment in global biosecurity, with rich countries dictating associated policies; fears around bioterrorism and emerging infectious diseases; trade rules and inconsistency of implementation; application of the precautionary principle in decision making; the impact of biosecurity activities on individuals for the public good; animal health, welfare and rights; and the impact of humans globally on the distribution of invasive species.

Keywords

Biosecurity; Bioterrorism; Animal health; Human health; Quarantine; Infectious; Trade; Invasive species; Emerging diseases; Pests; Risk management; One health

Introduction

The control of human and animal diseases has long been a societal concern. Control of agricultural pests and diseases has also been important for our food production. Recently, we have recognized that invasive pests can have devastating environmental impacts, seen new diseases emerge and recognized that disease agents can be used in harmful ways by humans. A range of international and national systems and regulations have evolved over time to manage this broad area that we now call biosecurity. In this chapter, biosecurity is described in general terms, and some of the range of ethical issues that arise from its practice are elaborated.

History and Development

Biosecurity is a relatively new term, first used in the 1990s in the context of preventing and controlling pests and diseases in the agricultural community (Koblentz 2010). Throughout the twentieth century this discipline evolved, particularly in the more developed countries, from an activity mainly concerned with

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controlling endemic pests and diseases that impact on agricultural production or human health into a broader concept. The latter includes preventing the impact of pests and diseases exotic or foreign to the country in question, associated impacts on international trade, as well as issues involving new and emerging diseases.

Since the early 1980s, there has been a series of emerging infectious disease threats, including those posed by the human immunodeficiency virus (HIV), severe acute respiratory syndrome (SARS), bovine spongiform encephalopathy (BSE), Ebola, Hendra, Nipah, and several types of avian influenza viruses. This has brought together animal and human health disciplines into a concept known as "One Health," which represents the collaborative effort of multiple disciplines – working locally, nationally, and globally – to attain optimal health for people, animals, and our environment. Much of this effort is focused on the human, animal, and environment interface because most of the emerging infectious diseases that threaten human health have emerged from animal reservoirs (Jones et al. 2008), often as a consequence of human encroachment or new interactions with the natural environment.

These broader concepts required the use of a new term that is more descriptive than those in use to that point, such as "preventive medicine," "animal health," "plant health," or "quarantine," as well as one that embodied the principle of risk management, which in turn implies consideration of costs, benefits and probability. Hence, the application of the term "biosecurity" has also emerged and evolved.

As a term, biosecurity was introduced into the international security sector some time after its adoption within the agricultural sector. This arose out of efforts to prevent harm to human health, infrastructure, and the environment from both intentional and unintentional release of organisms through pathways such as:

- Bioterrorism, involving the deliberate dissemination of biological pathogens
- Laboratory biosafety, where biological pathogens may be unintentionally released
- Amateur biology, where people conduct molecular biology and synthetic biology research outside of normal institutional arrangements and controls
- Dual-use research, which is legitimate biological research but where the results may be misused and thus pose a biological threat

In these contexts, biosecurity focuses on the physical security of a designated list of dangerous pathogens, called "select agents" in the USA. This list contains well-recognized diseases such as anthrax, as well as some with the potential to be used as bioterrorism agents.

In recent years, biosecurity has provided a focus for interaction between previously disparate disciplines, for example, plant and animal agriculture, agriculture and human health, agriculture and environment. Biosecurity in its broadest context is still evolving and there are multiple drivers for ongoing work ranging from: production and trade impacts in agriculture; to the impact that invasive species may have on the environment; to the impacts of global warming and changing human demographics on patterns of pests and diseases; to the social impacts of new and emerging diseases; and to the threat posed by bioterrorism.

Conceptual Clarification/Definition

Owing to the evolving nature of this field, and the multiple sectors that have been using the term, unsurprisingly, there are multiple definitions (Koblentz 2010). These can be separated broadly into:

- *Agriculture*, where biosecurity is concerned with managing risks in the areas of food safety, animal and plant health, including associated human health and environmental risks.

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- *Security*, where biosecurity refers to preventing the malicious use of dangerous pathogens.
- *Laboratories and research*, where biosecurity is often used interchangeably with the term "biosafety" and refers to accidental or deliberate escape of organisms or infection of laboratory workers. Some make the distinction that biosecurity in this context should be restricted to deliberate diversion of such organisms for malicious purposes.
- *Environment*, where biosecurity is about managing risks to the natural environment from invasive species. A smaller area of biosecurity is concerned with risks to the built environment, for example, timber pests.

For the purposes of this discussion, biosecurity will be considered in its broadest context and is simply described as: *The management of risks from invasive species to human and animal health, the natural and built environments, and agriculture*. Here, *invasive species* encompasses the broad range of infectious or invasive biological organisms, from the causative agents of infectious diseases (including parasites, bacteria and toxins they might produce, viruses, and prions), to higher order pests through to invasive plants and animals. The following examples illustrate the breadth of the term and the context within which it is used in biosecurity:

- A species may exhibit adverse, invasive characteristics in some environments or under some circumstances, but not in others. *Didymosphenia geminata* (known as Didymo), is a freshwater algae normally present at low levels in its native range in the Northern Hemisphere. It has been inadvertently introduced into New Zealand and Chile, is highly invasive, and is causing significant damage to natural environments in these countries.
- Emerging infectious diseases are infectious diseases that are either newly recognized in a population, or at substantially increasing incidence or range in a previously infected population. Nipah virus, which is naturally occurring in fruit bat populations in Asia, normally causes no apparent harm to the bat species involved. Under certain circumstances, triggered by human actions or behavior, there has been a "spill-over" of infection from the natural reservoir into farmed animal and human populations causing significant mortalities, but still within its natural range.
- Existing invasive species previously under control may change or mutate into new, more virulent forms. For example, the wheat stem rust race known as Ug99 identified in 1999 in Uganda now presents a risk to wheat production worldwide. Similarly, evolving influenza viruses present a constant threat of new human pandemics.
- Emergency animal or plant pests and diseases are those that require an emergency response, particularly to protect domestic animals or plant crops. They may be exotic or foreign, having penetrated quarantine barriers, or be a previously unrecognized emerging disease, or a re-emerging disease known to occur, but now spreading more widely due to some change.
- Scientists have recently developed the ability to synthesize new pathogens in the laboratory. The broader issue of genetically modified organisms is discussed in detail in other chapters.
- Diseases, previously thought to be under control may re-emerge as a serious issue. This may involve quite complex interactions, such as human tuberculosis waxing with HIV and waning with better nutrition.
- Abnormal prion proteins that can be transmitted between individuals causing various forms of the spongiform encephalopathy, are not living organisms as such, but would generally be considered a biosecurity issue.

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Many published definitions of biosecurity also encompass elements of "how" and "why" biosecurity is practiced. These have been deliberately removed from our simple definition, but are accommodated below.

The Practice of Biosecurity

The following description of how biosecurity is practiced is mainly derived from the agricultural arena, but is described in broad terms that can be applied to other areas of biosecurity.

Prevention

Much of biosecurity deals with preventing the removal, escape or transfer of invasive species either from one geographic area to another or from one host/agent to another. This is most obvious as the basis for quarantine and border controls between countries, but includes a range of other strategies, for example, bans on within-country practices such as the feeding of certain products to animals; biosafety guidelines and processes within laboratories; education of people to take preventive actions or not undertake certain actions; and vaccination programs. Many preventive strategies rely on regulatory controls, although education is also an important component. Research and development is also critical in developing new methodologies.

Surveillance

Within the biosecurity arena, the objectives of surveillance depend on the context:

- *In the absence of an invasive species*, surveillance may aim for early detection of an incursion. An important biosecurity principle is that the earlier an incident can be detected, the more readily it can be dealt with. For example, a breach in laboratory biosafety that is detected quickly while it has only infected one person can be much more easily dealt with than if that person had unknowingly spread it to other people within the community. On a population scale, an economic assessment of the impact of a foot-and-mouth disease (FMD) outbreak in California estimated losses of between USD 2 to 69 billion depending on time to detection from 7 to 22 days respectively (Carpenter et al. 2011).
- *In the presence of an invasive species*, surveillance is conducted to determine incidence, prevalence, and/or geographic distribution, for informing policy decision makers and prioritizing actions. An understanding of the presence of pests and diseases is particularly important to support quarantine controls and international trade decisions. Under the World Trade Organization's *Agreement on the Application of Sanitary and Phytosanitary Measures* (SPS Agreement), technical barriers to trade, for example, enhanced quarantine controls, must be scientifically justifiable.

Surveillance is most frequently a continuous activity, and generally implies that some action will be taken following detection. Surveillance may be passive, such as recording and analysis of routine diagnostic tests, or active, for example, structured surveys. Surveillance of people's actions may also be important for bioterrorism. The cost of surveillance varies considerably depending on context and is generally higher when the target is at low prevalence. Hence, surveillance programs must always seek an appropriate balance between levels of investment and sensitivity of detection.

Preparedness

Agencies that have biosecurity responsibilities, for example, agriculture, health, and homeland security, typically spend considerable effort in being prepared for a biosecurity incident, such as an outbreak of a foreign, invasive species. Preparedness can encompass a wide range of actions and activities, including: policy development, planning strategy, funding and logistics, management systems, analysis and

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intelligence systems, operational and laboratory surge capacity, staff training, simulation exercises, and establishing stakeholder relationships. Good preparedness means that incidents can be brought under control more quickly, thus minimizing the impact. Planning also needs to consider recovery from the incident.

Response

Responses to new incursions of invasive species are often managed in a similar fashion to other emergencies such as natural disasters using preagreed technical and management plans. Of critical importance is adequate staff capacity and capability. In the absence of preagreed plans, emergency planning principles, refined through previous experience, can be applied.

Ongoing Management

For invasive species that are already endemic or where eradication of a disease is considered unfeasible, ongoing management systems may be implemented to minimize their ongoing impact. A wide range of measures may be used, ranging from management treatments, to vaccination, to biological controls.

Supporting Systems

Each of the above elements of biosecurity practice may require supporting systems to enable them to function. These include:

- Risk analysis and policy development to determine appropriate approaches. There are many threats that need to be prioritized, so that resources can be allocated to the highest risks and the most cost-effective measures.
- Scientific research to inform policy decision making, to ensure that strategies are technically sound and to develop new strategies and tools, including diagnostic tests.
- Legislation to support strategies where there is recognized market failure in relying on individuals to act for the public good. In this context, the public good is seen to override the rights of the individual.
- Communication and education to ensure that everyone understands and plays their part.
- Tracing systems for carriers or hosts of pests and diseases.
- Information systems to manage, analyze, and communicate the large volumes of data commonly associated with such issues.
- Human capacity and capability to manage the various technical and logistical aspects.
- Diagnostic capability and capacity.
- Funding to provide ongoing certainty.
- Management systems. Biosecurity incidents are typically managed as emergencies and sometimes constitute crises. As such, emergency management principles are applied.
- Within country and international rules and principles for biosecurity and trade to ensure consistency across jurisdictions.

Around the world, biosecurity exists in various stages of development. In developing countries, the focus tends to remain on endemic pests and diseases that impact on agricultural production and human disease, while increasingly more sophisticated approaches are being implemented. Arguably, the USA is most advanced in the area of security, while the island nations of New Zealand and Australia have embraced the biosecurity concept for environmental and agricultural protection, including using the term in legislation. International collaboration embracing the "One Health" concept has been enthusiastically applied with a focus on Southeast Asia, where many emerging infectious diseases have arisen.

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Ethical Dimension

The authors are not aware of significant discussion in the international literature of the bioethical aspects of biosecurity. Hence, the following discussion is drawn from our experience working in the field and ideas contributed by a range of colleagues and considers the bioethics of biosecurity within a number of dimensions.

Prioritization and Resource Allocation

Generally, biosecurity involves making decisions about resource allocation within a risk management framework. Risk weighing will often depend on the background of the people making the assessments, as well as their responsibilities, for example, agriculture or the environment or human health. Risks considered high for one group may be low for another, and trade-offs are made between them. Further, action thresholds can result in choices being made that allow for some losses or varying efficiency. The strategies chosen will influence how much personal liberties are compromised, including freedom to move, right to enter land, freedom to trade, destruction of property, destruction of animals, compulsory treatment such as vaccination, or use of chemicals (discussed later in the chapter).

Global Dimension

The most obvious global aspects to biosecurity are the attention given to biological weapons and emerging infectious diseases, including those with the potential to cause pandemics. These have all received considerable attention in recent years.

Investment in each of these areas would appear to be prudent for the international community. However, there are those who consider the risks to be overinflated and that there are higher-level global risks more deserving of investment. Further, it is in the interests of those working in these fields to emphasize the risks to ensure ongoing funding. While this may be true on some level, it is normal for people to be passionate about their chosen field and ongoing attention in this area is warranted, given historical precedents such as the 1918 influenza pandemic.

Using influenza as an example, there is ongoing uncertainty around influenza strains, particularly avian ones, cocirculating and swapping genetic material at unprecedented levels (World Health Organization 2015). Owing to concerns by developed countries around potential influenza pandemics, there have been massive investments by international donors in the surveillance and response capacity of affected developing nations. However, the impact of these diseases on the population under surveillance has been very small in comparison to other, more immediate health threats, such as malaria, tuberculosis, HIV, dengue, and foodborne diseases (Woolhouse and Gaunt 2007). There is frequently, a disconnect between the attitude of the developing country, where the biosecurity event is occurring, and the donor country, that wishes to see progress to protect itself from later incursion. This may lead to suspicion and issues of what has been termed "viral sovereignty" around capacity development in vaccine industries and access to new vaccines (Supari 2008). Further, social distancing measures, quarantine, and who should have access to limited prophylactic and treatment resources, are key considerations in pandemic preparedness planning. Triage decisions will determine who should live and die in extreme scenarios.

Research into or action on individual diseases is not always based on criteria related to the present impact of the disease. For example, the USA has provided significant funds in recent years for research into the two bat-associated disease agents, Nipah virus and Hendra virus owing to their potential to be used for bioterrorism. Together these diseases have killed less than 1,000 people. Similarly, enormous sums of money have been expended to control BSE, which has killed under 200 people world-wide since its emergence. At the same time, malaria and rabies continue to kill over 500,000 and 55,000 people per annum respectively. While expenditure on emerging diseases, and BSE in particular, was important, it is

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likely that a similar result could have been achieved at much lower cost. For example, huge sums of money were expended in Europe on surveillance of classes of livestock at very low BSE risk, specifically to allay public fears. This equated to €1.56 million per BSE case detected from testing of healthy slaughter animals compared with €70,000 per BSE case detected from testing at-risk animals (Anon 2005). Key determinants for prioritization of investment in the past have been the affluence of the countries where the disease occurs, where it is perceived as a risk and public perception of risk. The ethical dilemma is how to allocate resources more equitably at a global level.

Only two infectious diseases have been eradicated on a global scale, smallpox and rinderpest. While no one seriously questions the ethics of deliberately rendering these unique species extinct, ethical issues have been raised around the keeping of otherwise extinct pathogens within laboratory collections. Some argue for ongoing research in the event of re-emergence, given the risk of either laboratory escape or the presence of the virus outside of known collections. Others argue that keeping the virus represents an unnecessary risk.

A related issue has been consistent global regulation of science to ensure that new techniques and technologies do not lead to the development of biological weapons, or the manufacture of disease agents that could potentially escape into the general population. This can occur via both dual-use research and the synthesis of new pathogens using molecular biology. An example is the recent public furor around avian influenza gain-of-function experiments (Duprex et al. 2014). Unfortunately, the pace of scientific progress has made it difficult to generate ethical discussion and achieve consensus ahead of scientific advances. This is an important ethical challenge over the coming years as technology becomes more sophisticated.

The SPS Agreement lays down the basis for countries to make phytosanitary rules for importation of, primarily, agriculture products and as such tries to remove unnecessary nontariff barriers to trade. In effect, this international policy framework is seeking to even the playing field based on science. However, people, industries, and countries still try to gain an advantage within this system. Tactics include overly complicated import risk assessment processes, delaying the conduct of assessments, overplaying the disease risks and using unproven science. Industry leaders often go on the offensive publically regarding proposed changes to import approvals based on biosecurity grounds, while the hidden agenda for opposition is protection of market share. Governments are often responsive to industry's views and hence there is pressure to use some of the aforementioned delaying tactics. There are winners and losers in this game, which is often determined by how sophisticated and how well resourced individual countries are in this area, as well as the ethical standards practiced within domestic governments. There may also be varying levels of protection applied at the border, depending on factors such as the perceived importance of individual industries.

On a broader human scale we need to question the impact of humanity itself on biosecurity. Anthropogenic climate change will influence the natural distribution of many invasive species, given that temperature and rainfall patterns are two of the most important determinants. Climate change will thus affect the potential distribution and intensity of many invasive species infestations, both positively and negatively. Similarly, the ever-expanding overlap between human presence and natural ecosystems is one of the factors contributing to new and emerging diseases. This encompasses huge ethical issues for us collectively in terms of how to address unsustainable resource usage, increasing population, global demand for food, and associated environmental impacts, particularly when at the time of writing the need for change is not universally recognized. Further detailed discussion can be found in the chapter on Climate Change and Health.

Nation Level Issues

Biosecurity standards vary enormously between countries. Rich, generally western, countries are able to implement high standards, with their citizens enjoying high standards of public health and security, and

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access to food that is both safe and of good quality. Further, wealthy countries are generally able to dictate agricultural policy, in part as a consequence of improved biosecurity. As one example, FMD is extremely influential in the international trade in ruminants and ruminant products, with trade flows often dependent on the FMD status of exporting countries. In large part, western countries are able to maintain FMD freedom. This has proven more difficult for poorer countries. As a consequence, these latter countries are very limited in their ability to export similar product (Paton et al. 2010). This tends to protect the local industry in wealthier countries, representing essentially a nontariff, or technical, barrier to trade.

Several options exist to provide a more equitable trading environment, however, at some cost and/or risk to countries that are currently free. FMD can be controlled through vaccination, although this does depend on factors such as the disease strain and suitability, availability, and cost of vaccine. FMD virus also survives poorly in bovine muscle tissue, and a combination of preslaughter and slaughterhouse measures will substantially reduce, but possibly not eliminate, the infection risk associated with importation of deboned meat from countries that are not FMD-free (Paton et al. 2010). Perhaps for the overall benefit of all nations, it would be better to simplify trade rules and rely more on vaccination, or at least allow more trade in lower risk products such as deboned meat. However, it is unlikely that the presently wealthy nations will agree with such egalitarian action.

Varying standards also occur within nations, prompting fierce debates about whether this is justifiable. These variations often follow provincial lines for legal and social reasons. For example, a state/province/region of a country may declare itself free of a particular plant pest, which provides it with certain trading advantages, such as access to international markets. This is generally known as zoning. Protocols are set up to control movements of host species into the area, which significantly increase within country costs and inflates the cost to consumers of the product. Overall, it can be debated whether there is a benefit to the nation as a whole.

The reverse also happens when phytosanitary protocols prevent the importation of food products that can be grown less expensively elsewhere. This protects an established, local industry from invasive pests, but also from competition, thus maintaining higher prices to consumers. The question is whether imports should be permitted, together with their associated pests and diseases, with encouragement of local farmers to grow an alternative crop. This is a complex question involving economics, the ethics of industry-wide impacts on individual farmers and also the need to consider national food security issues. A further consideration is the broader issue of globalization of pests and diseases, that is, to what degree should we allow this to happen and on what criteria do we try to limit spread?

Ethical issues arise when an invasive species enters a country and decisions need to be made around how to respond. For many countries, resources are not available to respond to all biosecurity incidents, noting that these may occur at regular intervals. For some invasive species, no effective control method is available, and therefore an effective response is not possible. However, the decision making can be complex, even when methodology is available and eradication would appear to be worthwhile. Many countries conduct formal cost-benefit studies in anticipation of an outbreak for higher risk invasive species, or after an introduction to guide decision making. Often the capacity to fund a response, trade-offs with resourcing of parallel responses, political considerations or other factors play a part. At other times, it is not known what impact the invasive species will have in the new environment.

In all of these cases, the moral and ethical consideration of the issue should take into account both the precautionary principle and the fact that these decisions are often irreversible. So, if there exists a plausible risk of causing harm through the species becoming established, and no scientific consensus exists otherwise, then a precautionary approach should be taken if possible. These considerations become more difficult when the degree of risk is unknown. At the same time, it should be realized that a decision to not respond may well be irreversible, as eradication may no longer be possible once the

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species has become widely established, thus committing future generations to dealing with the pest on an ongoing basis.

A related issue is who should pay for the response. Many governments are increasingly favoring the beneficiary pays principle, particularly in agriculture. This may influence whether a government responds or not. The situation is particularly complex in countries where industry plays a key role in national decision making. In these countries, industry is under increased pressure to act, but potentially without the necessary skills and experience to effectively assess and manage risks. This complicates the question for government in terms of where the public/private beneficiary line lies. In particular, how much action is enough to protect the public interest, without eroding the responsibility of private beneficiaries, given that the industry may not be sufficiently sophisticated at an individual producer level to manage risks?

Further, where an industry demands action, governments could legitimately ask whether the industry has taken sufficient prior action to prevent the outbreak from occurring. At the same time a double standard may exist, with an industry taking insufficient preventive action on home soil, whilst simultaneously demanding that government enforces strong quarantine regulations in relation to imports.

Biosecurity emergency responses are also very demanding on staff. If a government has invested insufficiently in preparedness or response capacity then ethical issues arise when staff bear a personal cost in terms of overwork and stress, such as occurs when working with individuals on the ground who are personally affected by an emergency.

Environmental Considerations

Earlier, examples were provided where humanity is being confronted with challenging new emerging diseases, partly at least because of human impacts on biodiversity and encroachment on natural environments. Prevention of harm to people thus becomes another moral argument in support of increased care of the environment. For some, this might be a more compelling moral argument than simply respect of preservation of the environment.

An importation issue that has previously had wide-ranging ethical and practical dimensions is biological control. After some early successes, there were some disastrous results associated with biological control of pest species when "pests of the pest" were introduced with inadequate prior testing. The biological control agent became a pest in its own right, sometimes worse than the original pest in question. An example is the spectacularly successful control of prickly pear cacti in Australia through introduction of the moth, *Cactoblastis cactorum*. Yet, the same moth that was also introduced into the Caribbean nations is a major reason why the Florida, USA's semaphore cactus is in danger of extinction. Generally speaking, good protocols have now been established around this issue.

Biosecurity, particularly in agriculture, often deals with the biological security of species that are themselves introduced into the country and could on some level be considered invasive species in their own right. Often, agricultural species are invasive when they escape out of the farming environment. For example, camels, pigs, and horses are all major environmental pests in many remote parts of Australia. Escaped garden plants are also a significant source of environmental pests and illegal introduction into a country has become easier with the advent of internet trading of seeds.

Similarly, natural species in a particular geographic region may pose a risk to the introduced, farmed species. Plague locusts are a good example. This raises the ethical issue of whether it is appropriate to control an indigenous population to protect an introduced population, including people. What are the overall impacts on biodiversity, especially considering that there may be other species relying on the target species for food? On a broader level, what rights do humans have to decide which species are protected and which are not? Human perceptions of "what is indigenous" or "what constitutes a pristine environment" are generally based on a point in time, with most environments continuously evolving, many under

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the influence of human activity. The deciding factor generally seems to center around whether species are beneficial to humans, either directly or indirectly via the environment.

One final environmental issue is the impact of the chosen control strategy. For example, burying large numbers of destroyed livestock may contaminate water tables and use of methyl bromide to fumigate termite-affected buildings may have significant atmospheric effects.

Individual Issues

When dealing with pest and disease incursions, control strategies often involve a level of destruction of private property, or at least restrictions to trade. The most common strategy is destruction of livestock or plants when they are diseased and preemptive in some circumstances. In a number of countries, compensation schemes are in place, providing a safety net for affected farmers, as well as incentives for early reporting and sound biosecurity practices (OECD 2012). An important consideration is how much compensation is appropriate for each individual. However, in many developing countries there is no associated compensation or it may be slow in coming, leaving poor farmers severely affected. Compulsory removal of such property is generally illegal without fair compensation, posing a moral dilemma for impoverished governments. In these countries, farmers may hide infection, thus creating a risk to disease control and in some cases, public health.

While more advanced biosecurity response systems include compensation for property destroyed, this seldom accounts for the losses consequential to these actions, for example, lost production. The consequences for individuals must be weighed against the overall benefits to the industry or community of a successful response. There are examples where efforts to control particular diseases have failed because the rights of individuals were weighed too heavily. This may depend on the immediacy of the need to control the disease. For example, for FMD, international trade may cease totally until disease freedom is regained, hence there is a greater urgency.

A related issue is the disease control strategy chosen by the relevant regulatory authorities. Traditional disease control strategies tend to be very harsh, with little concern for the impact on individuals. However, this is changing in recognition that recovery from a biosecurity incident is also important. There are often alternative control strategies that will still be successful, perhaps over a longer time period, but with a lesser impact. Regulatory authorities increasingly are learning the importance of working with stakeholder groups to achieve an appropriate balance in this regard. This also significantly influences how quickly an industry may recover from an incident. A good example is the contrast between the approaches taken by different countries to eradicate FMD in 2001. The UK primarily used slaughter of infected and at-risk groups, while the Netherlands primarily used vaccination (Pluimers et al. 2002).

Another related issue is rights versus responsibilities. While individual rights are well recognized in most countries, people also have responsibilities. Few would question the right of individuals to undertake international travel. However, we all have a responsibility to ensure that we don't take actions that spread invasive species between regions or countries. Similarly, farmers might have the right to farm the land in a way that they choose. However, they also have a responsibility, often called a duty of care, to ensure that they don't farm in a way that increases biosecurity risks to others farmers. This is increasingly being incorporated into legislation in some countries, with a shift in emphasis from government regulation and compliance monitoring, towards recognized codes of practice. If failure to follow the code results in a biosecurity incident, then liability for the consequences may ensue.

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Animal Welfare, Animal Rights, and Disease Control

It is increasingly recognized that humans have a duty of care to the animals that we are exploiting for food, fiber, and other products. This is not a black and white issue, with community expectations constantly evolving around the need to balance human and animal interests and the relative importance that we apply to these drivers.

When it comes to biosecurity, particularly when responding to disease events, a range of animal welfare/rights issues arise:

- Broadly, public health and animal biosecurity practitioners have traditionally taken very different approaches. In public health the ratio of individual human versus population need is relatively higher than that of individual animals versus herd needs under the more utilitarian approach generally taken by animal biosecurity practitioners. However, even within animal biosecurity, we treat species differently. Although both are sentient herbivores, we are much less inclined to slaughter horses for disease control than cattle. Further, we have even less compunction to slaughter chickens, or higher mammals when they have become pests, for example, feral pigs. We may also be more inclined to slaughter animals where they pose a disease risk to humans.
  - Culling of groups of animals for disease control is a commonly used strategy, particularly for highly infectious diseases like FMD. However, culling is increasingly being questioned as the default strategy, owing to the large numbers of animals that have been slaughtered during high profile outbreaks and broader, unexpected societal impacts. Vaccination combined with a more controlled culling policy is gradually gaining more favor (Orsel and Bouma 2009).
  - Further, while slaughter of animals or groups that are actually infected may be accepted, pre-emptive culling of animals that are at risk of becoming infected or to create host free buffers, as well as so-called welfare culling, is also being questioned (Whiting 2003). Welfare culling accounted for 35 % of the total of nearly 6 million animals slaughtered in the 2001 UK FMD outbreak (Anon 2002). In the same year, Uruguay had a similarly sized outbreak but used vaccination as its primary disease control strategy and only around 7,000 animals were slaughtered. In 2014, both countries were considered free of FMD by the World Organization for Animal Health, either with (Uruguay) or without (the UK) vaccination.
  - Animal ethical issues also arise when large numbers of poultry are culled following detection of low pathogenic avian influenza strains, owing to concerns that circulation of the virus within poultry populations may give rise to pathogenic strains for humans and/or poultry.
  - In addition to questions concerning whether it is appropriate to cull animals, the culling methods themselves are also important. While much work has been done in this area, more needs to be done to ensure that animals die humanely and without distress.
  - The impact of quarantine controls on animals, even without slaughter, can also be a significant issue that needs to be managed, for example, growing pigs confined within limited spaces within piggeries soon run out of space if they can't be sent to the abattoir.

Laboratories

In addition to the issues of dual-use research and the synthesis of new organisms, there are ethical issues associated with more routine laboratory activities. Large numbers of laboratories around the world hold collections of a range of pathogens and invasive species. An obvious issue is the personal ethics of laboratory workers to ensure that procedures are followed and laboratory escapes are prevented (Owens 2014). Given, the level of global collaboration that occurs between laboratory researchers, there is always the temptation to share resources, including pathogens. From a global perspective, who should decide on

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these issues and under what conditions? Various codes, some voluntary, have been developed to handle such issues.

Conclusion

The concept of biosecurity and the application of related methods will continue to evolve. Whilst the greatest improvements may come with increased cooperation across relevant disciplines, together with improvements in technology, it is hoped that the associated ethical issues will also be increasingly recognized and given due consideration. There is no doubt that more ethical issues will arise as biosecurity evolves and technology changes to meet the demands of the global risks at hand. We urge biosecurity practitioners to formally consider ethical issues during the normal course of their work, perhaps in a similar way that animal ethics is considered in research involving animals.

Cross-References

► Agricultural Ethics
► Animal Ethics
► Animal Research
► Animal Rights
► Animal Welfare
► Anthropocentrism
► Applied Ethics
► Biodiversity
► Common Good
► Compassion
► Disease
► Dual Use
► Empathy
► Epidemiology
► Exploitation
► Future Generations
► Genetic Modification (GMOs): Animals
► Health: Global
► Pandemics
► Responsibility: Social
► Risk
► Values
► Veterinary Ethics
► Zoocentrism

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