Food biosecurity in the United States

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Introduction

The events of 11 September 2001 highlighted the vulnerability of US citizens and the US society in general to terrorist attacks. Since then, numerous governmental agencies and scientific bodies have emphasised the need to enhance the biosecurity of the US food supply.

Food biosecurity is the prevention of intentional contamination of food with hazardous biological agents through tampering or other malicious, criminal or terrorist actions or threats [1]. As part of the nation's response to this issue, Congress passed the *Public Health Security and Bioterrorism Response Act* of 2002 [2]. Title III of the *Bioterrorism Act* includes a number of provisions designed to improve the food safety efforts of the Food and Drug Administration (FDA), including new authority to protect the food supply against terrorist acts and other threats.

The issue

Significant cooperation between industry, government, academia and consumers in the area of food safety, has resulted in a tremendous public-private partnership in the US. Prior to 9/11, the main focus in the US was on preventing food safety problems via implementation of Hazard Analysis Critical Control Point (HACCP) systems in the food processing sector of the food system. The focus was on unintentional contaminants that were *"reasonably likely to occur"* and hazardous biological agents that were typically *not* detected in real time.

After 9/11, it became apparent how vulnerable the US was to an intentional terrorist attack and the potential magnitude of such attacks. According to a report published recently in *The Lancet* by officials from Centers for Disease Control and Prevention (CDC), the US is increasingly vulnerable to bioterrorism (BT) attacks on its food supply and needs to strengthen its public health system to minimise the danger [3].

Biological terrorism differs from other types of chemical, biological, radiological and nuclear (CBRN) terrorism in that it would impose particularly heavy demands on the nation's public health system. The public health system is the first line of defence in the event deterrence or prevention fails. Ultimately, the public health system is called on to mitigate and ameliorate the consequences of a terrorist attack using biological weapons [4].

The US is now taking a much broader, multi-disciplinary approach to risk reduction throughout the food system and focusing more on intentional contaminants. In addition, it has become clear that hazardous biological agents must be detected in real time to allow a more rapid response and containment should a food BT event occur. CDC has identified the leading food-borne BT agents, which include a variety of infectious and toxigenic microorganisms (Table 1).

The problem

It is widely acknowledged that the US food system is vulnerable to intentional attack with biological agents and that the outcomes would be potentially devastating. Economic damage could be very significant as agriculture is the largest US industry, with farm sector assets of greater than $US 1 trillion [5].

The food system in the US is increasingly complex due to the number of sectors (production, processing, distribution, retail, institutional foodservice, restaurants etc) and to an increasing multitude of different foods that are now available to consumers, including a large and increasing volume and range of imported foods. As a result, a high rate of transmission of a BT agent is possible through this ready-made complex food system.

Another trend that has the potential to increase the magnitude of a BT attack is the mass production of food at centralised processing facilities in the US with very wide national and global distribution. All of the above factors result in numerous targets for food BT and the potential for a large food BT event in the US [6].

A few BT events have occurred in the past and give just a glimpse of the potential threat. In 1984 a religious cult contaminated a salad bar in Oregon with *Salmonella typhimurium*, a relatively mild food-borne pathogen; 751 people developed salmonellosis. Reportedly, this was only a trial run before a planned larger effort with possibly a more deadly agent (*Salmonella typhi*) to disrupt elections. In 1996, a reference strain of *Shigella dysenteriae* was used by a lab worker to infect colleagues using contaminated food [3].

The level of food BT risk appears to increase from production to processing, with two of the weakest links being the large and growing importation and transportation sectors of the food system [7]. Millions of planes, trains and trucks constantly transport huge quantities of food in the US and thus represent high risk targets. This potential was highlighted in 1994, when the largest unintentional Salmonella outbreak in US history was linked to *Salmonella*

Table 1. Leading food-borne biological terror agents and selected characteristics[3].

Agent	Availability	Minimum infectious dose, secondary transmission	Clinical syndrome	Case fatality	Other characteristics of microbe or illness
Botulinum toxin	Organism ubiquitous in environment; cultures need anaerobic conditions	LD_{50}=0.001µg/kg[14]	Descending paralysis, respiratory compromise	5% (treated)[16]	95% of patients need hospitalisation; 60% of patients need intubation
Salmonella serotypes (excluding *Salmonella typhi*)	Clinical and research labs, culture collections, poultry, environmental sources	10^3 organisms[22] Limited secondary transmission	Acute diarrhoeal illness, 1-3% chronic sequelae	>1%[23]	Organism hardy, lengthened survival in the environment
Salmonella typhi	Clinical and research labs	10^5 organisms[22] Secondary transmission possible	Acute febrile illness, protracted recovery, 10% relapse, 1% intestinal rupture	10% untreated, 1% treated[23]	Clinical syndrome unfamiliar in the USA; long incubation period (1-3 weeks); produces asymptomatic carrier rate in 3% of cases
Shigella spp.	Clinical and research labs	10^2 organisms[25] Secondary transmission possible	Acute diarrhoea, often bloody	For most common species in US, <1%[23]	
Shigella dysenteriae type 1	Clinical and research labs	10-100 organisms[24] Secondary transmission possible	Dysentery, seizures	Up to 20% (treated)[22]	Causes dysentery, toxic megacolon, haemolytic-uraemic syndrome, convulsions in children
Escherichia coli 0157:H7	Clinical and research labs, bovine sources, farms	>50 organisms[26] Secondary transmission possible	Acute bloody diarrhoea, 5% haemolytic-uraemic syndrome (HUS), longer-term complications	1%[27]	Long-term sequelae: hypertension, stroke, renal insufficiency/failure, neurological complications[27, 28]
Vibrio cholerae	Clinical and research labs	10^8 organisms[29] Secondary transmission possible	Acute, life-threatening, dehydrating diarrhoea	Up to 50% untreated, 1% treated[29]	Historically, causes massive water-borne epidemics in areas with poor sanitation

enteritidis contamination of ice cream due to an improperly washed and sanitised tanker truck that had previously been used to haul raw liquid eggs. This truck was used to haul pasteurised ice cream mix to an ice cream processing plant where it did not undergo repasteurisation prior to manufacture of ice cream. Likewise, large outbreaks due to imported foods have also occurred recently in the US. If an intentional food BT event does occur in the US, there is the real potential for a large number of cases being disseminated over wide geographical areas.

There are numerous potential ramifications of a food BT event. The first is physical loss of life. *Clostridium botulinun*, a potential food BT agent, produces a neurotoxin which is the most lethal substance known, with an LD50 of 0-0.001 µg/kg.

Economic destabilisation is another potential outcome. Two examples include υCJD, which is linked to Bovine Spongiform Encephalopathy (BSE) and Foot and Mouth Disease (FMD), which have caused huge financial losses in a number of countries recently even though relatively few and no human deaths occurred, respectively.

Two food-borne pathogens that do cause significant human mortality, *E. coli* O157:H7 and *Listeria monocytogenes*, have caused massive recalls due to contamination of various foods, resulting in multi-million dollar losses.

Another ramification of a food BT event is social instability. *E. coli* O157:H7 and *Staphylococcus enterotoxin* outbreaks in Japan resulted in a general loss of confidence in government and the food industry in Japan.

Biological weapons are thought to be popular with terrorists because they are: easy to obtain; low in cost; easy to disseminate and; a small risk to terrorists themselves because they are easy to hide. In addition, BT agents have the potential for a multiplier effect due to secondary transmission of disease. BT agents targeted to civilian populations could also create panic and threaten civil order. As a result, BT agents possess the potential for maximum physical, economic, social and political damage with minimal effort.

Biological weapons also have the potential to overwhelm health care systems, especially if the agent is highly infectious [4]. An outbreak with a large number of cases and deaths could put a severe strain on, or even collapse, a health care system designed to handle unintentional outbreaks.

Complicating matters further is the fact that it is often difficult to distinguish between a BT agent and an unintentional contaminant. Hundreds of unintentional outbreaks occur every year in the US, many with symptoms similar to BT agents. Thus it is difficult to tell whether one is dealing with a security or safety issue, a malicious threat caused by people or a natural hazard, and whether the risk is real or perceived. In this latter regard, it should be realised that the public often respond to risk based on their perceptions of risk, rather than on factual components of risk, such as likelihood and severity. This explains the world-wide public reaction to the recent discovery of one cow with BSE in the US, even though to date it has not caused any known illness or death.

Developing a strategic framework and strategic plan

Currently, one of the main problems in dealing with food biosecurity is the lack of a strategic framework for risk reduction and insufficient means of judging the efficacy of existing programmes [4]. The main goals of a strategic framework should include prevention, surveillance and detection, response, and recovery.

Prevention

The first step in developing an effective food biosecurity system is prevention. Simple security measures can have a significant deterrent effect. They can be described as the three Ps – Personnel, Product and Property [8]. They include background checks, training and monitoring of employees, installing security and surveillance systems within the plants, and establishing quality controls on ingredients and products.

Risk assessment and HACCP are two systems-based, risk-reduction tools that have been implemented effectively in the US to reduce food safety risks [8]. These two tools should also be adapted to identify and monitor vulnerable points/processes to prevent loss of biosecurity [9,10]. In addition, transportation and distribution of foods are critical links in the food biosecurity system [11] (Table 2).

Detection and surveillance

Identification of the causative agent, vehicle of transmission, and manner of contamination are critical for food safety and remain the most important aspects of a food BT investigation [12]. Detection or recognition of a food BT event is the responsibility of the public health system, specifically CDC and the federal-state-local public health network.

To meet the challenge of both intentional and unintentional contamination of foods, public health laboratories must be robust and connected. To this end, CDC has established a Bioterrorism Preparedness and Response Program (BPRP) (http://www.bt.cdc.gov/) and the National Laboratory Response Network (LRN). The goal of LRN is the development and use of standardised methods that provide real-time, accurate, reproducible, rugged and sensitive detection of BT agents.

Surveillance for BT agents has four main elements: collection of information on the health of the population; establishing a network of providers of that information; agencies who monitor the data received; and systems to exchange data between providers and users.

Forensic tracking of BT agents is also important. Forensics is needed to identify the source of a BT agent and bring the attacker to justice. Forensic methods rely on good databases and must be epidemiologically relevant and amendable to routine use.

The need to shorten the time between an outbreak and identification of the source has resulted in the recent development of many different molecular methods. Fragment based fingerprinting methods include PFGE and PCR-based methods. PFGE is currently the gold standard for molecular subtyping of food-borne pathogens; PulseNet, a computer network system utilising this technology, has been implemented in various countries around the world.

Sequenced-based methods include Multi-Locus Sequence Typing (MLST), which can be used to develop signature sequences for specific pathogens. Recent development of Multi-Virulence Locus Sequence Typing may increase discriminatory power by targeting rapidly evolving virulence genes of food-borne pathogens instead of more highly conserved house-keeping genes [13].

Response

The Incident Command System (ICS) allows command, control and coordination of a response and provides a means to coordinate the efforts of individual agencies as they work toward the common goal of stabilising the incident and protecting life, property and the environment [14].

The Federal Bureau of Investigation (FBI) is responsible for crisis management in a BT event. The Federal Emergency Management Agency (FEMA), supported by the Department of Defense (DoD) is responsible for consequence management. State and local emergency management teams also are critical partners and first responders during a BT event [4].

Medical management is critical for appropriate response to a BT event. Hospitals and medical professionals must be part of developing the response plan and must receive appropriate training in

Table 2. Transportation and distribution in food security (USDA [9]).

Transportation safety system

- Identify vulnerable points and develop a comprehensive sanitation and safety plan.
- Train personnel to judge potential risks, take appropriate preventive and corrective actions, and ensure effective monitoring and supervision to prevent intentional and unintentional contamination.

Storage food safety system

- Design and maintain a storage and warehousing food safety system.

Vehicles

- Design and construct vehicles to protect products.
- Use dedicated transport vehicles.

Pre-loading

- Loading and unloading areas should be configured, cleaned, disinfected and properly maintained to prevent product contamination.
- Examine vehicles before loading.
- Stage loads to facilitate proper stowage and minimise exposure during loading and unloading.

Loading

- Protect products from exposure to environmental contaminants.
- Maintain the cold chain.
- Use appropriate loading procedures and equipment.
- Use special care with mixed or partial loads.

In-transit

- Establish procedures to check integrity of the load during transit.
- Establish procedures to ensure product safety during interim storage.

Unloading

- Carefully examine incoming products.
- Move product into cold storage immediately.

prophylaxis, treatment, triage and logistics. A key to any response is determining the thresholds for triggering a response; false alarms place a great strain on the system and tend to reduce people's confidence in the system. CDC has many assets at its disposable for responding to a BT event including rapid response teams, case control studies and the Health Alert Network (HAN)[15].

Initial responses to a BT event would be containment of the agent, and tracing, recall and disposal of suspect foods. Therefore, proper lot identification (coding) of foods, preferably throughout the food system, is essential. It is important that proper recall procedures be in place before a BT event occurs. Subsequent responses may include declaration of a localised disease emergency and finally large-scale mobilisation if the threat continues to escalate.

Recovery

The DepartmenF of Health and Human Services (HHS) is responsible for recovery from a BT event.

Other important components

Verification that the biosecurity system is working properly is essential, as well as ongoing training of personnel and the establishment of lines of communication. It is important to take advantage of electronic technology for rapid exchange of critical information.

Finally, organisation and coordination are essential for food biosecurity. The Incident Command System (ICS) was developed to deal effectively with emergency situations. Within days after the attacks on the World Trade Center and the Pentagon, National Food Processors Association (NFPA) helped launch the Alliance for Food Security. This government/industry alliance helps to facilitate coordination and commun-ication among all stakeholders to minimise all threats to the US food security[8].

PrepNet (Food Threat Preparedness Network) functions across Federal departments to ensure effective coordination of food security efforts throughout the Government. (www.fsis.usda.gov/OA/background/biosecurity.htm). The focus of this group is on preventive activities to protect the food supply, as well as on rapid response. PrepNet has established three subgroups that will focus on: emergency response, laboratory capability, and efforts aimed toward prevention and deterrence.

Agencies also need to work together to prevent illegal shipments from coming into the country. FSIS currently works closely with FDA, the CDC, and the Environmental Protection Agency (EPA), as well as with State and local health agencies, to coordinate biosecurity efforts and share information about illnesses.

What is needed for the future?

To prevent and respond to food BT, it is necessary to build on past partnerships and successes in food safety. A comprehensive food biosecurity plan should be developed between all players in the food system. The command and control system should be simple and clear to everyone in the food system. Emphasis should be placed first on developing the front-end of the system – deterrence, prevention, detection and on shoring up major weak links such as distribution, transportation and imports.

Communication networks should be secure, rapid and employ appropriate IT tools that help all players in the system share information rapidly. Better use should be made of mass media to get correct information out before and after a BT event occurs, so that consumers don't over or under-react, and so they have enough information to make informed decisions.

Research should be conducted on how consumers perceive food security issues so that we can communicate with them more effectively before, during and after a food BT event. Research should also be conducted to develop better, more affordable detection tools for real-time detection of BT agents in food and for rapid identification and tracing of specific BT agents.

Finally, we need to keep working to develop better collaboration, cooperation and coordination between government, industry and academia and between federal, state and local health departments. We should realise that much progress has been made in the area of food safety by everyone working together. If done correctly, efforts toward increasing food biosecurity will also improve food safety and consumers' overall confidence in the safety and security of the food supply.

Conclusions

The events of 9/11 have made Americans realise how vulnerable they are to terrorism. Given the size, complexity and importance of the US food system and the nature of biological weapons, it has become clear that the US food system is especially vulnerable to BT.

As a result, there has been an expansion of our focus from just food safety and unintentional contaminants to biosecurity and intentional biological agents. The latter could have a disastrous effect on our safety, economy, society and political stability.

To be better prepared, it is necessary to comply with the *Bioterrorism Act* of 2002 and develop and continually update risk management plans which include specific actions to be taken to prevent, detect, respond to and recover from a food BT event. Players within the system need to know who to contact and who has command and control for the various goals of prevention, detection and surveillance, response and recovery.

Movement should continue toward fully automated real time detection and sharing of food biosecurity information. Scientific societies and trade associations have played and will continue to play vital roles in implementing science-based, cost-effective biosecurity strategies.

The public must not lose confidence in the ability of the private sector and government to provide safe and secure foods. Therefore information and communication are critical and the right people must be provided with the right information at the right time. Rapid, consistent and accurate information via the media will foster a sense of trust in the safety and security of the US food system.

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