The importance of the psychological aspects of weapons of mass destruction (WMD) increasingly has been recognized. WMD commonly refer to chemical, biological, radiological, nuclear, and explosive (CBRNE) weapons. However, the term “weapons of mass destruction” is misleading, because only nuclear and explosive weapons cause mass destruction. What is similar in all these agents is their ability to cause mass disruption of society. Thus, the acronym WMD more accurately should refer to “weapons of mass disruption.”
Before the events of September 11, 2001, psychological aspects of these weapons were given mostly lip service. Since then, the idea of psychological effects has become much better recognized. A number of good reviews of psychological aspects already exist, so this article closely examines three examples involving chemical, biological, and radiological incidents or attacks.

Because there have been few terrorist attacks using chemical, biological, radiological, or nuclear weapons, only one example will be from an actual terrorist attack — the sarin attack in the Tokyo, Japan, subway system in 1995. The radiological accident in Goiania, Brazil, in 1987 may help us better understand an attack with a radiological weapon. Although the anthrax attacks on the United States had potent psychological effects, very little has been written in the literature about these attacks. Therefore, this article will use the outbreak of severe acute respiratory syndrome (SARS) during 2002 and 2003 to illustrate some of the psychological effects of biological weapons.

RADIOLOGICAL AGENT

In September 1987, two scavengers removed a cesium-137 (Cs-137) teletherapy unit from an abandoned radiotherapy institute in Goiania, the capital of Goias State in Brazil. While dismantling the unit, they accidentally ruptured the source capsule, which contained radioactive Cs-137 powder. The scrap metal was sold to a junkyard owner, who noticed the blue glow of the Cs-137 powder. Many people were exposed to large external and internal doses of radiation due to handling and consumption of the powder. Persons who had handled the source received high doses of radiation but their symptoms initially were not diagnosed correctly by physicians, although 11 were sufficiently ill to be hospitalized.

When a local physicist discovered the accident and reported it to authorities, more than 2 weeks after the incident, Brazil’s National Nuclear Energy Commission immediately sent a team of experts. They set up in a local soccer stadium and scanned people who lived in the area of contamination, followed by people who lived in adjacent areas and had contact with the victims.

When the radiation accident became public, the perceived threat of radiation exposure caused more than 120,000 people — approximately 10% of the city of 1.2 million people — to be screened during a 6-month span for possible contamination. Residents and others who happened to be in the city at that time felt sufficiently at risk that they took leave from work or came on weekends to wait in line to be scanned.

However, despite the fears of the populace, only 249 people were contaminated either internally or externally. Of these, 120 had light surface or clothing contamination, which was easily decontaminated, and 129 had moderate to severe internal or external contamination. For the latter, 79 were treated as outpatients and 50 required close medical surveillance. Twenty of these 50 were hospitalized, and four died within 4 weeks of hospital admission. Approximately 5,000 (8%) of the first 60,000 people screened presented with symptoms that mimicked acute radiation sickness (eg, rash around neck and upper body, vomiting, diarrhea), but none of these people was contaminated.

The 11 most seriously affected victims previously had been hospitalized but were moved to one hospital. Unfortunately, the medical personnel were not trained for treatment of radiation victims and, as a result, these patients were left unattended by doctors or nurses until a medical team from the National Nuclear Energy Commission arrived. Due to immunosuppression, patients were kept confined and isolated, and medical personnel wore protective masks. Both measures increased stress in patients. Of the 20 hospitalized patients, most suffered from depression and anxiety. Uncertainty about their future increased stress, as did the lack of information concerning the duration of their treatment and long-term prognoses.

Lack of information and education caused other difficulties as well. Many people erroneously thought that contamination from radiation was contagious, which led to stigmatization not only of casualties, but also of people living in Goiania, and even the state of Goias. More than 8,000 residents asked for official certification that they were not contaminated. Goiania residents were stigmatized and were refused admittance to hotels, airplanes, and buses. A public-opinion poll reported that more than 70% of Goiania residents had suffered some kind of discrimination. The economic consequences were devastating. Conventions in Goiania were canceled or rescheduled for other communities, hotel occupancy dropped by 40%, and the value of Goias’ agricultural products dropped 50%.

According to the media, the general population of Goiania was in “a state of panic.” However, the media itself was responsible for agitating fear and anxiety in the public through irresponsible and sensational journalism. A public opinion poll in Goiania of people who
lived near the affected area and controls who lived away from the area demonstrated that the press was overwhelmingly the primary source of information about the accident. Unfortunately, the same poll showed almost 50% of the sampled Goiania residents had no knowledge about radioactivity.

The large number of people (approximately 10,000) who lived or worked within 300 meters of the contaminated area exhibited fear, psychosomatic reactions, fear about the future, insecurity, and disbelief toward the effectiveness of remedial measures the government took. A public-opinion poll found two-thirds of both affected Goiania residents and a control group living away from the contamination believed Goiania was still contaminated. Research conducted 3 years after the accident showed stress parameters were still increased and performance was decreased both in nonirradiated people with perceived exposure (those living within 1 kilometer of Abadia, the area where contaminated waste from the incident had been stored) and in irradiated people from Goiania.

CHEMICAL AGENT

In March 1995, terrorists released sarin, a nerve agent, in the Tokyo subway system during the morning rush hour. More than 5,500 people visited 280 medical facilities that day and the following week. Of these, 1,046 were admitted as patients and 12 died, 10 within 48 hours. St. Luke’s International Hospital saw the most patients, 641 on the first day and 349 in the following week. Of the 641 patients admitted to the St. Luke’s emergency department on the first day, 111 were admitted to the hospital (4 severe cases, 107 moderate cases), and 530 mild cases were observed for 6 hours and then released. The mild cases suffered mainly from eye problems. Most of the victims (541) arrived on their own, by foot or nonmedical vehicle, with the remainder arriving by medical vehicles.

Most of the casualties were office workers going to work in central Tokyo. Despite the crowded conditions of the morning rush hour and the limited escape routes, there were no reports of mass panic. One fireman reported a “perplexing silence” at the accident scene — no talking, just the coughing of the victims as they waited for medical assistance. Some survivors reported guilt because they had not helped the more seriously affected people.

A postal questionnaire was sent 1 month after the attack to 610 patients treated at St. Luke’s. Of these, almost 60% reported suffering from postincident symptoms, including fear of using the subway, sleep disturbances, flashbacks, depression, nightmares, irritability, headaches, and malaise. The result of follow-up questionnaires at 3- and 6-month intervals showed little decrease in the percentage reporting symptoms.

A study of 45 hospitalized patients conducted 1 month after the attack reported similar symptoms and frequen-
cy of reporting symptoms. Unfortunately, it is difficult to determine to what extent these symptoms were psychological effects and to what extent they may have been sequelae to the cholinergic effects of sarin exposure. Given that most of the casualties from St. Luke’s were mild cases, suffering mainly eye symptoms, it is possible that many of the postincident symptoms were psychological effects.

According to follow-up studies conducted 3 and 5 years after the accident by the National Police Agency and the National Research Institute for Police (33% to 39%), dim vision (23% to 26%), and difficulties focusing (17% to 21%). Physical symptoms (eg, tiredness, fatigue, muscle ache, headache) also were common.

The surveys found most of the psychological symptoms remained stable during the three time periods, with rates of 10% to 16% still being reported at the 5-year point for memory difficulties, depressed mood, avoidance of accident reminders, flashbacks, and fear in the subway or at the attack site. Posttraumatic stress disorder (PTSD), as determined by criteria in the Diagnostic and

**SIDEBAR.**

**Probable Effects of WMD Attacks**

- Mass panic may be overanticipated, but mass anxiety will be prevalent.
- Information hunger will be intense, and most people will get their information from the mass media.
- There will be a range of acute psychological effects, with some symptoms mimicking those of chemical, biological, or radiological agent exposure.
- Psychological casualties may outnumber physical casualties.
- Some people will experience long-term effects, including medically unexplained physical symptoms and a decrease in health-related quality of life.

Science, reporting of somatic complaints — eye strain, weakened eyesight, and easy fatigability — remained relatively stable from the acute stage through both follow-up periods. Posttraumatic stress symptoms still reported by 14% to 18% of studied survivors included flashbacks, fear of the subway, intense distress at exposure to reminders of the attack, and avoidance of thinking about the attack.

The patients treated at St. Luke’s were surveyed 2, 3, and 5 years after the attack, using a questionnaire asking about 14 physical symptoms, eight eye symptoms, and 11 psychological symptoms, including avoidance, hyperarousal, and re-experiencing. The most common symptoms across all time periods were eye symptoms — eye strain

---

**BIOLOGICAL AGENT**

The SARS outbreak began as an unusual atypical pneumonia in Guangdong Province, China, in November 2002 and emerged as the first pandemic of the 21st century. The World Health Organization put out a global alert in March 2003, but by then the outbreak had already spread to Hong Kong, Vietnam, Singapore, Taiwan, Canada, and elsewhere. By the fall of 2003, SARS had infected more than 7,000 people and killed 774 in 26 countries.

Although SARS was an emerging infectious disease and not an intentional act of biological terrorism, the pandemic may serve as a useful model for the psychological effects of a contagious biological warfare agent. Smallpox and pneumonic plague are two biological warfare agents that are contagious as respiratory droplets — as is SARS — but little historical data cover psychological aspects of smallpox or pneumonic plague epidemics.

The most common presenting symptoms of SARS are fever, headache, muscle ache, and malaise. Cough is common, and most patients develop shortness of breath. SARS is transmissible from person to person through respiratory droplets or fomites, and each case, on average, leads to two to four secondary cases. A few “hyperspreaders” were responsible for a large number of transmissions, including one outbreak involving more than 300 people in an apartment building in Hong Kong. The SARS outbreak required an extraordinary public health response because of its rapid transmission and concentration in hospital or healthcare settings, as well as the large number of healthcare and hospital staff who became infected.

The outbreak of a new and emerging infection created much fear and anxiety because the cause was unknown, the disease was potentially fatal, and restrictive infection control techniques were need-
ed. In Beijing, schools and universities were closed, hundreds of companies closed their doors, and some surrounding villages isolated themselves. Rumors of neighborhoods being quarantined led to people racing to grocery stores and stockpiling food. Despite official appeals to avoid travel, thousands of provincial businessmen, migrant workers, and college students tried to leave Beijing by bus or train. In Taiwan, 160 doctors and nurses quit various hospitals because they were afraid of contracting SARS and thought that infection control measures were inadequate. At one hospital that became reserved for SARS patients only, 25 staff members refused to come to work.

The economic effect on Asia was tremendous, costing an estimated $15 billion from reduced retail sales and tourism. Airline and hotel chains were hurt the most, but stores and restaurants in Hong Kong, Singapore, and Toronto, Ontario, Canada, saw sales plunge. In addition, because the outbreak began in Asia, people in other parts of the world became fearful of people who appeared Asian, regardless of their nationality or risk of being a carrier. In the United States, the Chinatown districts in New York, NY, and San Francisco, CA, suffered a dramatic loss of business.

SARS required isolation of infected patients and quarantine of patient contacts. The application of quarantine during the SARS epidemic became an important issue that had varied psychological effects. In Singapore, the government instituted a 10-day quarantine for all people who came in contact with a probable SARS patient. The quarantined homes were monitored for compliance and violators were forced to wear electronic bracelets. Taiwan prohibited entry of noncitizens from China, Hong Kong, or other affected areas and required citizens returning from affected areas to stay at home for 10 days. Unfortunately, compliance was low, ranging from 21% to 42% of people who registered with local health authorities. In early May 2003, more than 23,000 people were in home quarantine.

In Toronto, 2,000 students in a large school were quarantined after discovering a student with symptoms had been attending classes for 2 days. Other incidents included an infected nurse traveling on two commuter trains and an infected doctor who attended a funeral.

One hospital in Canada reported that SARS patients, who had to identify recent contacts, often felt guilty and fearful for their friends and family. SARS patients often spent hours in isolation between contacts with staff and were deprived of family visits, leading to complaints of sadness, anxiety, boredom, loneliness, and nonspecific anger and frustration. Fear and anxiety often waxed and waned with fever.

Many healthcare workers had a perception of personal danger heightened by uncertainty, the known lethality of SARS, and the intense media coverage of the outbreak. Social support became a
problem in one Toronto hospital because of requirements for wearing masks while in the hospital, lack of meetings with colleagues outside the hospital, and lack of staff meetings. Often, hospital staff avoided identifying themselves on the outside as hospital workers because they feared stigmatization within their communities. Peter A. Cameron, an Australian physician working in Hong Kong at the time, wrote, “No one wanted to come near me for fear of getting the disease ... Even in the carpark, people would skirt around me to avoid close contact.”

Staff with potential contact with SARS were quarantined for 10 days in one Toronto hospital, which led to fears about safety of self and family, stigmatization, and feelings of isolation. On the SARS isolation unit, staff members experienced spikes of anxiety in association with changes in isolation procedures, healthcare workers entering quarantine or treatment, and discharged patients being readmitted with fever. Reports of fatigue, insomnia, irritability and decreased appetite were common in SARS staff. Dr. Cameron wrote, “I was worried about going home in case I would infect my family. When I did get home, I felt physically exhausted and emotionally drained, and didn’t really want to talk to anyone. I would not and could not touch my wife or children for fear of giving them the disease. I slept in a separate bedroom; I ate separately.”

One study measured the psychosocial effects of SARS on hospital staff in a Toronto hospital using questionnaires. Almost two-thirds of the respondents reported concerns for their own or their family’s health. Factors identified by logistic regression analysis for significant association with increased concerns were perception of a greater risk of death from SARS, living with children, effects on personal or family lifestyle caused by the SARS outbreak, and being treated differently by people because of working in a hospital. Emotional distress (as measured by the General Health Questionnaire) was found in almost 30% of all respondents but was 45% in nurses, who were most at risk for infection. Factors identified for significant association with emotional distress were being a nurse, part-time employment status, effects on lifestyle caused by the SARS outbreak, and effects of precautionary measures on the ability to do one’s job.

In a contagious disease outbreak, information becomes extremely important. The public is eager for information and needs to know what precautionary measures should be taken. One study in Hong Kong found most respondents actively sought SARS information on a daily basis, relying on television (90%), newspapers (71%), and radio (27%), but not many (less than 10%) sought information from medical professionals, friends, or the Internet. Another telephone survey done in Hong Kong at an advanced stage of the SARS epidemic revealed substantial misinformation and false beliefs in adults, despite constant media and public service announcements. Lack of understanding of transmission routes led to a deficit in adapting some of the precautionary measures. Specifically, only one-third of respondents avoided direct contact by touch with contaminated objects (fomites), and less than half practiced at least five of the seven recommended precautions.

In addition, recommended measures were not practiced uniformly. Both Hong Kong studies found that the majority of respondents wore facemasks and washed their hands with soap frequently, while in Singapore, most practiced hand washing, but only 46% wore facemasks. All three studies found age and gender differences associated with taking precautionary measures: women were more likely than men, and older people more likely than younger people, to take precautions.

Two of the studies also found increased level of education increased likelihood of taking precautions.

DISCUSSION

Several lessons about the probably effects of attacks using these weapons can be learned from reviewing these three events (Sidebar, see page xxx). One similarity across all three cases is the lack of any sort of mass panic (ie, “an acute fear reaction marked by loss of self-control which is followed by nonsocial and nonrational flight”). Previous reviews have commented on the low likelihood of mass panic. Media mention of “mass panic” more likely refers to mass anxiety.

It is also important to distinguish taking perceived protective measures from exhibiting irrational behaviors. In this context, the mass screening of 10% of the Goiania population would reflect precautionary measures taken by an uninformed (or misinformed) public. Similarly, the stockpiling of food and the flight from Beijing are rational acts of people trying to protect themselves.

In Goiania, Singapore, and Hong Kong, people relied on mass media for information on what to do and on what was happening. In Goiania, the public was ill-served by the media; whereas in Hong Kong and Singapore, the information was much more accurate and helpful. However, even in Hong Kong, the information took time to be comprehended, as evidenced by an increased perception of the true modes of SARS transmission over the length of the outbreak. Age, gender, and level of education were factors that influenced differences in following recommended personal safety measures.

Acute psychological effects should be expected following a terrorist attack. Numerous acute psychological effects were reported in each of the three cases.
discussed previously, but fear and anxiety are to be expected in any event. In some cases (e.g., nerve agents such as sarin), it may be difficult initially to distinguish a psychological effect from an agent-induced effect. Approximately 12% of the Goiania people initially screened presented with symptoms consistent with radiation sickness, but none had been exposed to radiological contamination.4

The number of psychological casualties may be much larger than the number of physical casualties. Unfortunately, the term “worried well” has been used widely to describe psychological casualties. This is inaccurate, as symptomatic patients are not well and should not be dismissed without proper triage and observation. In Tokyo, about one in five patients were admitted to the hospital. However, the patients not admitted were not necessarily psychological casualties, as most of these patients probably had eye signs and symptoms from exposure to sarin vapor.8

The initial Scud missile attack on Israel by Iraq in 1990 is instructive: there were 22 physical injuries, 172 stress casualties, and 171 people who self-injected atropine for fear that the missiles contained nerve agents.8 Thus, for every physical casualty, there were 16 psychological casualties. During the anthrax attacks in the United States in 2001, emergency departments in the metropolitan Washington, DC, area were overrun by patients with minor symptoms.13 Most needed to be reassured by hearing a doctor say that they did not have anthrax. Some were admitted to the hospital, although none tested positive for anthrax infection.

Long-term psychological effects were seen in both Goiania and Tokyo. Several studies have documented psychological distress and PTSD in Tokyo sarin victims.9,10 No PTSD has been reported in Goiania victims, but the appropriate studies may not have been done. Nevertheless, chronic stress has been documented in the survivors.7 Long term psychological distress and PTSD were also seen after the 1986 Chernobyl, Ukraine, nuclear power plant accident.32

At this point, no long-term psychological effects have been reported from the SARS outbreak. However, PTSD and decreased health-related quality of life were reported in survivors of an outbreak of Legionnaires’ disease in the Netherlands15 and has also been reported in survivors of acute respiratory distress syndrome.14 A terrorist attack using biological warfare agents will result in of acute respiratory distress syndrome and intensive care unit treatment, so long-term psychological effects and PTSD should be monitored after any such attacks.

Multiple unexplained physical symptoms (MUPS) have been seen following the Tokyo sarin attack and the Goiania radiation accident. The presence of MUPS in sarin victims has led some to propose a new type of PTSD.10 Many of
the surviving anthrax victims continue to suffer from MUPS — fatigue, shortness of breath, chest pain, and memory loss.\textsuperscript{35} MUPS have also been seen in many of the Chernobyl survivors.\textsuperscript{32} Studies in acute respiratory distress syndrome survivors have suggested a decreased health-related quality of life, which may represent the presence of MUPS.\textsuperscript{33,34} MUPS will almost certainly be a long-term effect following an attack using weapons of mass destruction or disruption. However, more research must be done to determine to what extent MUPS may be a reflection of psychological distress.

REFERENCES