Implications of Chemical Biological Terrorist Events for Children and Pregnant Women

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ABSTRACT

During the past decade, the world has become more aware that chemical and biological weapons could be used on civilians as terrorism and that casualties could include children. It is essential that nurses who care for children and pregnant women know how to recognize the effects of this type of weapon on the population and how to alleviate or mitigate their impact. This article reviews key aspects of chemical-biological agents, the consequences of their use, the potential impact of a chemical-biological attack on children and pregnant women, and issues to consider in the event of such a catastrophe.

Key Words: Environmental and public health; Disaster planning.

With the advent of possible biochemical terrorist acts and an increasing number of industrial toxicants, a revival of nursing's role in environmental health is under way. By becoming more aware of the proliferation and effects of biological and chemical agents, nurses can be better prepared, which can translate into better healthcare during and after a terrorist event.

Chemical and biological emergencies increasingly threaten the health and safety of people worldwide and are designed to create fear and cause harm to the general population.

Children and pregnant women are particularly vulnerable to the effects of these agents because of their specific physiologic characteristics. Although acts of terrorism can consist of the use of biological, chemical, radiologic, or explosive agents, this article addresses only biological and chemical agents.

Developing Local Resources and Community Partners

Nurses must now be prepared to respond at all levels of a biochemical terrorist event. At the community level, planning for chemical-biological catastrophes begins with the development of local health resources and mobilization of community partners. Nurses in all healthcare settings, including community health, hospital, long-term care facilities, home health, personal care homes, industry, and other areas, need to partner in order to plan and address the issues related to a chemical-biological terrorist event. Public health organizations may have the lead in planning and managing bioterrorism events. Community and hospital nurses and other personnel, such as individuals who work for the emergency health service system responsible for evacuation, stabilization, and redistribution of victims, require education in order to recognize contaminated regions and the method of transport and have protocols in place for isolating and decontaminating victims, mobilizing additional staff, and using secondary care sites, such as schools, churches, stadiums, and sports arenas (Foltin, Schonfeld, & Shannon, 2006).

- Use protective gear properly, including clothing and respiratory gear, to protect the healthcare provider while he or she is caring for a contaminated patient. Protective gear, which includes self-contained breathing apparatus, splash-resistant clothing, hood, gloves, hardhat, boots, booties, two-way communication, and cooling systems, should be available in adequate supplies (Veenema, Benitez, & Benware, 2007)
- Appropriately triage pediatric and pregnant patients.

The Strategic National Stockpile

Certain designated antidotes, antibiotics, vaccines, and oth-

er pharmaceutical agents play a key role in treatment and prophylaxis after chemical-biological events. Although local sites have been designated for stockpiling these agents, an inadequate supply persists. In the event of a biological terrorist attack or other public health emergency, plans call for Department of Health and Human Services officials to distribute medicines and supplies from the Strategic National Stockpile (SNS) to any state in need within 12 hours. The Centers for Disease Control and Prevention's (CDC's) SNS has large quantities of medicine and medical supplies to protect the American public if there is a public health emergency (such as terrorist attack, flu outbreak, earthquake) severe enough to cause local supplies to run out. Once federal and local authorities agree that the SNS is needed, medicines are delivered to any state in the United States within 12 hours. Each state has plans to receive and distribute SNS medicine and medical supplies to local communities as quickly as possible (CDC, 2005) Each state is working with the CDC and Homeland Security to identify locations for stockpiling antidotes, antibiotics, and other pharmaceuticals and has a plan to distribute the SNS materials as quickly as possible.

The high vapor density of gases such as sarin and chlorine places their highest concentration close to the ground, in the lower breathing zone of children.

Issues in Relation to Children and Biochemical Terrorism

Children could be disproportionately affected by chemical and biological toxins because of their particular anatomical, physiological, and immunological characteristics, including the following:

- Anatomical differences (size, more pliable skeleton, larger exposure surface)
- Physiological differences (higher relative metabolism, higher minute ventilation, increased skin permeability)
- Immunological differences (immature immunologic system, higher risk of infection, inability to repel toxins) (American Academy of Pediatrics [AAP], 2000).

Pulmonary

The higher number of respirations per minute in children results in exposure to a relatively greater dosage of a toxin with aerosolized agents (organophosphates or anthrax). The high vapor density of gases such as organophosphates places their highest concentration close to the ground, in the lower breathing zone of children, thereby increasing the dose that children can acquire (AAP, 2000).

Integumentary

The more permeable skin of newborns and children along with a larger surface-to-mass ratio results in greater exposure to transdermal toxicants (Bernardo, 2007). It is important to help decontaminate children's skin by showering, but this treatment must be tempered with the knowledge that children lose heat quickly because of their relatively larger body surface area, and showering may result in hypothermia (AAP, 2000). To counteract the loss of heat, use warm water to shower children and have warm towels available immediately after the shower (Bernardo, 2007).

Immunologic

Exposure to environmental toxicants may disrupt and even cause permanent damage to the developing nervous, immune, and respiratory systems of young children (World Health Organization [WHO], 2005). Because children are no longer immunized against smallpox, they are particularly susceptible to a biological attack of this sort (Bernardo, 2007).

Gastrointestinal

Because they are smaller, children receive higher doses of toxicants per pound of body weight and are at greater risk when ingesting contaminated food or water (ATSDR/CDC, 2003). Children are less able to detoxify or excrete ingested or inhaled toxins, and children who experience vomiting or diarrhea from a biologic agent are at risk for dehydration and subsequent cardiopulmonary failure if untreated (Bernardo, 2007).

Psychological

Children who witness death and destruction can lose the notion that their home, school, and community are safe places to live and that people are trustworthy. These notions can create a loss of security, bringing with it fear, anxiety, and horror (AAP, 2000). Some general suggestions to counteract psychological harm include the following:

- Infants: Provide physical comfort and maintain routines as much as possible.

The CDC's strategic national stockpile (SNS) has large quantities of medicine and medical supplies to protect the American public if there is a public health emergency severe enough that local supplies run out (such as in case of a terrorist attack, flu outbreak, or earthquake).

- Preschoolers: Avoid separations from parents and give plenty of verbal reassurance and physical comfort.
- School-aged children: Provide physical comfort and reassurance; however, set gentle but firm limits for acting-out behavior. Provide structured but undemanding home chores.
- Adolescents: Encourage them to participate in community recovery work should they so desire (Plum, 2007).
- All ages: Restrict overexposure to the media; it is unwise to allow children or adolescents to view footage of traumatic events over and over. Children and adolescents should not watch the television alone (AAP, 2000).

Issues in Relation to Pregnant Women and Biochemical Terrorism

Vulnerabilities to biochemical agents begin when the fetus is in utero (ATSDR/CDC, 2003). Because human reproduction involves a complex, integrated series of neurophysiologic events, toxins may adversely affect successful reproduction at any stage of fetal development (WHO, 2005). In developmental toxicology, maternally mediated effects on development are effects that occur secondarily as a result of some effect on the pregnant mother. One such example would be the acidosis that the mother can experience if she is exposed to chemical agents such as phosgene and biologic agents such as anthrax. Biological agents such as anthrax and tularemia affect the respiratory system of the mother and the oxygenation of the fetus through transplacental transfer from mother to fetus (Foltin et al., 2006).

Chemical Agents Used in Terrorism

Chemical agents used as terrorism include nerve agents and respiratory and mucocutaneous agents. Chemical agents can be categorized based on the predominant symptom they cause: (a) neurologic (nerve agents), (b) respiratory (phosgene), or (c) mucocutaneous syndromes (vesicants). Table 1 describes the chemical and biological agents that should be of most concern to nurses as they plan for the necessary care of pregnant women and children during a terror emergency.

Nerve Agents: Organophosphates

The release of the nerve agent sarin in a Tokyo subway in 1995 focused the world's attention on the reality of chemical weapon use on a civilian population. In that incident, the intentional use of this nerve gas resulted in injury to more than 5,000 adults and children, with 12 deaths (Veenema et al., 2007). Additionally, 10% of responders, such as police and paramedics, experienced symptoms of nerve agent poisoning as a result of exposure to the victims and the environment (AAP, 2000). Nerve agents are organophosphorous compounds similar to the organophosphate insecticides used in agriculture but are far more toxic. They are quickly lethal and hazardous by any route of exposure, whether ingestion, inhalation, or dermal absorption (Veenema et al., 2007). Four compounds are regarded as nerve agents: tabun, sarin, soman, and VX (Venom X). The toxic effects of nerve agent vapors depend on the concentration of the agent inhaled and the time of exposure to the agent. See Table 1 for details regarding symptoms, protection, and treatment.

Respiratory Agents: Phosgene

Phosgene is commonly known as a pulmonary, inhalational, or choking agent. Phosgene is heavier than air, which poses an increased risk for children who are exposed near the ground level. It has the appearance of a white to pale-yellow cloud and smells of newly mown hay or green corn (Veenema et al., 2007). Exposure by ingestion, inhalation, or skin/eye contact typically leads to immediate onset of symptoms, but onset may be delayed by 48 hours (see Table 1).

Mucocutaneous Agents (Vesicants): Sulfur Mustard

The term *vesicant* is commonly applied to chemical agents that cause blistering of the skin, eyes, and respiratory tract. Sulfur mustard has been the most widely used of all chemical warfare agents over the last century, most recently in the Iran-Iraq conflict (Foltin et al., 2006). Mustard gas may be

Table 1. Biological and Chemical Agents of Concern

Nerve agents (organophosphates) (tabun, sarin, soman, and VX)	
Time for Initial Signs and Symptoms	Few minutes after exposure
Presenting Symptoms	• Copious respiratory and oral secretions • Diarrhea and vomiting • Sweating • Altered mental status • Generalized weakness progressing to paralysis and respiratory arrest
Protection	Nurses need to wear full protective gear and a self-contained breathing apparatus
Treatment and Management	• Begin with safe, topical decontamination with soap and water or dilute bleach • Airway and ventilatory support and aggressive use of antidotes, particularly atropine, are essential • Use new FDA-approved forms of Atropen (atropine autoinjector) for children and adolescents exposed to certain nerve agents or insecticides • Doses approved for use in children and adolescents with mild symptoms of nerve agent poisoning include 0.5 mg for children weighing between 15 and 40 lb, 1 mg for children weighing between 40 and 90 lb, and 2 mg for adults and children weighing over 90 lb • For children with severe symptoms of nerve agent poisoning, doses of up to three times these doses may be given (U.S. FDA, 2003) • Pregnant women have been successfully treated for commercial organophosphate poisoning with atropine and pralidoxime in the second and third trimesters of pregnancy and have delivered healthy newborns (Steward, 2006)
Respiratory agents (phosgene)	
Time for Initial Signs and Symptoms	Immediate onset after exposure
Presenting Symptoms	• Within 30 seconds: skin pain and blanching surrounded by red rings • Hives within 15 minutes • Eyes: severe pain and irritation, tearing, possible temporary blindness • Respiratory: immediate irritation (Foltin et al., 2006)
Protection	Full protective gear
Treatment and Management	• There is no antidote • First treatment is decontamination and removing the victim from the source to fresh air • Decontaminate eyes and skin with water immediately • Ensure a patent airway • Administer warm, moist air and supplemental oxygen • Management is primarily supportive
Mucocutaneous agents (vesicants)/Sulfur mustard (mustard gas)	
Time for Initial Signs and Symptoms	Symptoms occur 2-48 hours after exposure; ocular symptoms occur in 4-6 hours with pain and irritation, followed by photophobia, worsening conjunctivitis, corneal ulceration and perforation of the globe with severe exposures
Presenting Symptoms	• Erythema that resembles a sunburn • Pruritus • Yellowish blisters within 24 hours, coalescing to form bullae
Protection	Full protective gear
Treatment and Management	• Decontamination with soap and water • If the mustard is predominately in solid form, scrape the agent from the skin using absorptive agents such as flour followed by rinsing with water • Once sulfur mustard penetrates tissues, its effects are irreversible • Flush the eyes with copious amounts of water • Skin lesions treated like burn victims • Aggressive ventilatory management in children • Teratogenic and mutagenic

Smallpox	
Time for Initial Signs and Symptoms	• Incubation 7-17 days • Initial symptoms (duration: 2-4 days) • Early rash (duration: about 4 days) • Most contagious
Presenting Symptoms	• Prodromal phase (2-4 days): • High fever (to 104°F) • Malaise • Severe headache, backache • Pustular rash beginning on the face, progressing rapidly to forearms, trunk, and legs
Protection	Contact and airborne droplet precautions
Treatment and Management	• Notify health department immediately • No effective antiviral therapy • Supportive care • Isolation of patient, disinfecting of room • Vaccination up to 4 days after exposure may prevent or significantly ameliorate illness; **VACCINATION IS NOT SAFE FOR PREGNANT WOMEN** • Vaccinia immunoglobulin (VIG) was used in the past to prevent or modify smallpox when administered within 24 hours of a known exposure • Administer intramuscularly in a dose of 0.6 mL/kg of body weight • Because the dose is large (e.g., 42 mL for a person weighing 70 kg), give intramuscularly in divided doses over a 24- to 36-hour period • The CDC is the only source of VIG in the United States (Foltin et al., 2006)
Anthrax	
Time for Initial Signs and Symptoms	• Incubation period 1-7 days • Up to 2 weeks after exposure
Presenting Symptoms	**Three types of anthrax:** 1. Cutaneous (the most common type, which can show symptoms within 1 day of exposure, and can be cured with antibiotics). 2. Inhalation (more severe and identified in ten patients associated with bioterrorism). About 50% of cases end in death. Symptoms usually occur within 2 weeks of exposure but can be delayed up to several months (CDC, 2008a). 3. Digestive involvement is characterized by an acute inflammation of the intestinal tract. Incubation 1-7 days. Intestinal anthrax results in death in 25%-60% of cases. **Symptoms:** 1. Cutaneous: small papule leading to a vesicle followed by painless, necrotic ulcer and black eschar 2. Respiratory: sore throat, mild fever, muscle aches, and malaise; progresses to nonproductive cough, chest pain, shortness of breath, and respiratory failure 3. Digestive: initial signs of nausea, loss of appetite, vomiting, and fever are followed by abdominal pain, vomiting of blood, and severe diarrhea
Protection	Not contagious
Treatment and Management	• Early treatment with antibiotics can cure anthrax • Antibiotics: 60-day course of ciprofloxacin, levofloxacin, doxycycline, or penicillin • Use in pregnancy needs to be determined individually • Supportive therapy • Vaccination exists but is not available to the general public • **PREGNANT WOMEN SHOULD NOT BE VACCINATED**
Tularemia	
Time for Initial Signs and Symptoms	Incubation period: 1-14 days after exposure
Presenting Symptoms	• Fever • Headache, chills and rigors, body aches, coryza, and sore throat • Progresses to severe respiratory illness, pneumonia, and systemic infection
Protection	Not contagious
Treatment and Management	• Report suspected cases to the local health department • No isolation needed • Streptomycin and gentamicin are first-line defense treatments • Supportive therapy • Vaccine is available for laboratory workers exposed to tularemia

used to injure skin, eyes, and nasal mucosa, producing severe pain and incapacitation (AAP, 2000). Mustard is mutagenic, carcinogenic, and teratogenic. Dividing cells are the most sensitive; therefore, it would be most damaging to women pregnant in their first trimester (CDC, 2008b; Steward, 2006). The effects of mustard depend on the duration of exposure and the concentration of the agent, but the time from exposure to onset of skin manifestation is shorter in children than in adults. As a result, children may be overrepresented in the initial index cases. Because mustard vapor is denser than air, it tends to settle close to the ground, which makes is more serious for small children. In addition to more common facial and eye involvement, pulmonary involvement can be more extensive in children because of the lower breathing zones and increased respiratory rates of children (CDC, 2008b). Therefore, intubation may be needed earlier, and more aggressive ventilatory management may be necessary in children with lower respiratory tract symptoms.

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Fluid replacement also may need to be more aggressive in children because of the greater potential for dehydration aggravated by their lower volume reserve (Foltin et al., 2006) (see Table 1).

Biological Agents Used in Terrorism

Biological terrorism is the deliberate use of any biological agent against people to cause disease, death, destruction, or panic. Biological weapons are referred to as a "poor man's nuclear bomb" because they are easy to manufacture, can be deployed without sophisticated delivery systems, and have the ability to injure thousands of people. In contrast to chemical weapons that generate immediate effects, biological agents are associated with a delay in the onset of illness, from hours to days (AAP, 2000). The CDC states that Category A agents are organisms that pose a risk to national security because they

- can be easily disseminated or transmitted from person to person,
- result in high mortality rates and have the potential for major public health impact,
- might cause public panic and social disruption, and
- require special action for public health preparedness.

Smallpox

Variola, the virus that causes smallpox, is among the largest and most complex viruses known. In 1980, WHO declared that smallpox had been successfully eradicated worldwide; the last naturally occurring case of smallpox occurred in Somalia in 1977. The United States discontinued routine childhood immunization against smallpox in 1971. Since then, only military personnel and other high-risk groups have received smallpox vaccinations (Dudley & McFee, 2005). If used as a biological weapon, smallpox would represent a serious threat to civilian populations; its case fatality rate is 30% or more among unvaccinated persons, and there is no treatment. The deliberate reintroduction of smallpox as an epidemic disease would be an international crime of unprecedented proportions, but it is regarded as a possibility (Pigott & Kazzi, 2007). Diagnosis of variola virus can be made by detection in pustular fluid by culture (Pigott & Kazzi, 2007). The virus can cross the placenta, but incidence of congenital smallpox is not high. If anyone is suspected of having smallpox, contact and airborne precautions should be implemented immediately, the patient should be isolated, and state and local health departments should be alerted at once (Foltin et al., 2006). All household members should be vaccinated immediately. Rooms vacated by patients should be decontaminated using standard hospital disinfectants, such as sodium hypochlorite or quaternary ammonia solutions. Laundry and waste should be discarded into biohazard bags and autoclaved. Bedding and clothing should be washed in hot water with laundry detergent followed by hot-air drying or they should be incinerated (Foltin et al., 2006).

Vaccination administered within the first few days after exposure (and perhaps as late as 4 days) may prevent or significantly ameliorate subsequent illness. Vaccination has been administered successfully and safely to persons of all ages, from birth onward. Pregnant women, however, are at high risk for smallpox vaccine complications

and should not be vaccinated (see Table 1) (Pigott & Kazzi, 2007).

Anthrax

Anthrax is a serious disease caused by *Bacillus anthracis,* a bacterium that forms spores that are dormant but may activate in the right conditions. Anthrax is not contagious and is classified as a Category A agent. The three types of anthrax are listed in Table 1. There is a vaccine to prevent anthrax, but it is not yet available for the general public. In the event of an attack using anthrax as a weapon, the stored vaccine would become available (CDC, 2008a). Little is known about anthrax infection during pregnancy (Steward, 2006). Treatment after infection with ciprofloxacin, levofloxacin, doxycycline, or penicillin is usually a 60-day course of antibiotics. Success depends on the type of anthrax and how soon treatment begins (Foltin et al., 2006). The clinical evaluation of patients suspected of having inhalational anthrax should include a chest radiograph and/or CT scan to evaluate for widened mediastinum and pleural effusion (Foltin et al., 2006).

Special Considerations During Pregnancy

Regarding treatment during pregnancy, the teratogen information system concluded that therapeutic doses of ciprofloxacin are unlikely to pose a substantial teratogenic risk, but the data are insufficient to state that there is no risk (U.S. Food and Drug Administration [FDA], 2001). Ciprofloxacin is excreted into breast milk but is considered as "usually compatible with breastfeeding" by the American Academy of Pediatrics (AAP, 2000). Ciprofloxacin can have some severe neurologic side effects, such as restlessness, nightmares, hallucinations, manic reaction, irritability, tremor, ataxia, convulsive seizures, anorexia, phobia, depersonalization, depression, paresthesia, and grand mal convulsions (RX List, 2007). Penicillins as a class are generally considered safe for use in pregnancy and are widely used in the treatment of various infections in pregnant women. The use of doxycycline during pregnancy has historically been discouraged because of the knowledge that tetracyclines cause cosmetic staining of the primary dentition in fetuses exposed during the second or third trimester of pregnancy and are believed to depress fetal bone growth (U.S. FDA, 2001).

Preliminary results of a recent, unpublished, retrospective study of infants born to women in the U.S. military service worldwide in 1998 and 1999 suggested that the anthrax vaccine (BIOTHRAX) may be linked with an increase in the number birth defects when given during pregnancy. Pregnant women should not be vaccinated against anthrax unless the potential benefits of vaccination have been determined to outweigh the potential risk to the fetus (Anthrax Vaccine in Pregnancy and Breastfeeding, 2002).

Tularemia

Tularemia is caused by the bacterium *Francisella tularensis* found in animals (especially rodents), rabbits, and hares. If used as a weapon, the bacteria would likely be made airborne for exposure by inhalation. Release in a densely populated area could result in an abrupt onset of large numbers of cases of acute, nonspecific febrile illness beginning in 3 to 5 days (incubation range, 1-14 days). *Francisella tularensis* can infect humans through the skin, mucous membranes, gastrointestinal tract, and lungs. Tularemia sometimes can be fatal but is not contagious (Dennis, 2001). Since rapid diagnostic testing for tularemia is not widely available, the first indication of tularemia might follow recognition by public health authorities of a clustering of acute, severe respiratory illness with unusual epidemiological features (Dennis, 2001). Suspicion of inhalational tularemia should be promptly reported to local or state public health authorities (Dennis, 2001). Isolation is not recommended for tularemia patients, given the lack of human-to-human transmission (see Table 1).

Children can be given streptomycin or gentamicin as treatment. For pregnant women, short courses of gentamicin are likely to pose a low risk to fetuses. Rare cases of fetal nerve deafness and renal damage have been reported with other aminoglycosides but have not been reported with gentamicin. The benefits of gentamicin in treating pregnant women with tularemia are expected to outweigh any potential risk to fetuses (Foltin et al., 2006).

Conclusions

It is a major challenge to prepare for an unknown event against undisclosed threats. The key to successful outcomes is planning, identifying resources, developing relationships with nurses in other settings, and participating in rehearsals. Nurses play an important role in recognizing and caring for patients during a terror biochemical event and should seek leadership positions in preparation for such events. By acting in this capacity in institutions and public health agencies, nurses can serve as advocates for communities, particularly for vulnerable populations such as infants, children, and pregnant women (Lavin, Slepski, & Veenema, 2007). Nurses also should consider joining or collaborating with organizations such as the American Red Cross to be prepared to provide relief to

victims in disasters. As nurses reach out to community groups such as local government, business, labor unions, faith-based organizations, and voluntary agencies, they can identify resources, negotiate roles, gather and share vital information, and seek ways to ensure a coordinated and efficient response to all disaster events (Yeater & McKelvey, 2007).

Nurses play a key role in identifying sentinel cases of illness after a chemical-biological release (AAP, 2000). Preparation for this role involves having knowledge of the agents most likely to be used, the symptoms of the illnesses they cause, the pharmaceutical and medical supplies most likely to be clinically needed, and the supply needs of the population where the nurse works. It is important to understand what each community has planned for emergencies such as these and who to call to report a suspected case of bioterrorism, because each city, county, district, and state has such a contact number. If in doubt, the nurse can always contact the local county health department. Nurses also must know how to take care of themselves during a chemical event. Up-to-date information is always available at the CDC's bioterrorism Web site (www.bt.cdc.gov/bioterrorism/). ✣

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www.bt.cdc.gov/stockpile/

Centers for Disease Control and Prevention (Emergency Preparedness and You)
www.bt.cdc.gov/preparedness/

Centers for Disease Control and Prevention (Environmental Health)
www.cdc.gov/Environmental/

Agency for Toxic Substances and Disease Registry
www.atsdr.cdc.gov/2p-emergency-response.html

U.S. Food and Drug Administration
www.fda.gov/oc/opacom/hottopics/bioterrorism.html