Learning Objectives

• Describe how U.S. drinking water is produced as a prototype for the water, food, and medication systems
• Use past incidents of water, food, and drug contamination to identify system vulnerabilities and potential agents of concern
• Describe system-wide changes or legislation resulting from past accidental or terrorist events
• Identify resources detailing measures used to protect the US water, food, and drug supplies

Water Treatment

• State / federal EPAs regulate public drinking water safety (Safe Drinking Water Act) in US
• Common treatment steps:
  – Coagulation / Flocculation
  – Sedimentation
  – Filtration
  – Disinfection
Chemical Agents of Opportunity for Terrorism: TICs & TIMs

Filtration

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Disinfection

Chemical Agents of Opportunity for Terrorism: TICs & TIMs

Water System Vulnerabilities

The Water System,
• Is essential for health & safety
• Comprises spatially diverse elements
• Is susceptible to intrusion
• Provides numerous attack sites
• Is difficult to protect against backflow attacks
• Contamination is difficult to trace
Maple Leaf Reservoir (Seattle, WA)

- Sept 10th, 2002
- Breach of fence around 60,000,000 gal finished water reservoir reported.
- 15 foot garden hose found near cut in fence.
- First noted 2 days earlier but not reported to supervisors.

Questions
When water supply adulteration is suspected,
- What chemicals should we test for?
- Who can run STAT tests for significant chemical contaminants?
- What criteria do you use to say the water is safe to drink?

Maple Leaf Reservoir (Seattle, WA)

- Tests on hose and reservoir water negative
- No claims of responsibility
- No clusters of illness identified
- Reservoir water disinfected and reprocessed
Module 5 - Chemical Contamination of Food, Water, & Medication

### The Ideal Drinking Water Contaminant

- Resists water treatment
- Is difficult to detect
- Is difficult to clean
  - Pipes, reservoirs, etc
- Causes illness:
  - Delayed onset
  - Difficult to diagnose
- Readily available
- No odor & taste
- Colorless
- Water soluble
- Stable in water
  (i.e., resistant to hydrolysis)
- Unexpected
- Low LD50

### Relative Water Toxicity

$R = \text{Solubility/Lethal Dose} \times 1000$

<table>
<thead>
<tr>
<th>Compound</th>
<th>$R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botulinum Toxin</td>
<td>10,000</td>
</tr>
<tr>
<td>VX</td>
<td>300</td>
</tr>
<tr>
<td>Sarin</td>
<td>100</td>
</tr>
<tr>
<td>Nicotine</td>
<td>20</td>
</tr>
<tr>
<td>Cyanide</td>
<td>9</td>
</tr>
<tr>
<td>Amanion (OP)</td>
<td>5</td>
</tr>
<tr>
<td>Na Fluoroacetate</td>
<td>1</td>
</tr>
<tr>
<td>Arsenite, arsenite</td>
<td>1</td>
</tr>
</tbody>
</table>

Clark: J Contingencies Crisis Management 2000

### Cyanide Calculations

Cyanide salts as potential contaminants:

- Individual:
  - 250 mg Lethal Human Dose (oral)
  - $250 \text{ mg} / 0.5 \text{ L} = 500 \text{ mg/L} = 0.5 \text{ g/L}$
- Water System:
  - $0.0005 \text{ kg/L} \times 200,000,000 \text{ L} = 100,000 \text{ kg} = 220,000 \text{ lb} = 110 \text{ tons}$
Botulism Calculations

- 0.00003 µg/kg LD50 Mice
- 70 µg Lethal Human Dose
- 70 µg/0.5 L = 140 µg/L
- 140 µg/L x 200,000,000 L = 28,000 g
- 28 kg for 200,000,000 L Reservoir!
Module 5 - Chemical Contamination of Food, Water, & Medication

Cross-Connections

- Mix of non potable with potable water
- Distribution system pressure ≥ 20 psi
- Backpressure: external>system pressure
- 1970-01: 459 events, 12,093 illnesses
  - Avg 1 line break/yr 1,000 person system
  - Potential Contamination Due to Cross-connections and Backflow and Associated Health Risks

Cross Connection / Backflow Threats

One sociopath who understands hydraulics and has access to a drum of toxic chemicals could inflict serious damage pretty quickly to a water supply system in a neighborhood or a pressure zone without detection in most communities. - Denileon: JAWWA 2001

Cross Connection Example

North Carolina (1997)
- 60 gal. retardant foam pumped into hydrant
- No local labs for testing
- Water use ban on 40,000 households
- 90 million gallons used to flush system
- No drinking water for 39 hrs

Krouse: Opflow 2001
Chemical Agents of Opportunity for Terrorism: TICs & TIMs

Drinking Water: Terrorism Detection

Detection Scenarios:
- Caught in the act (cameras, security, or eye witness reports)
- Online/Field detection & monitoring
- Water quality observations (odor, color, ...)
- Mass illnesses (often nonspecific)
  – ED/Public Health Surveillance Systems

Early Detection

- Online Phys/Chem Monitors
  – Chlorine, pH, Turbidity, Total Organic Carbon, Pressure, Radioactivity
- Rapid Field Testing Kits
- Online Biosensors

Online Biosensors

- Daphnia Toximeter®
- Algae Toximeter®
- Mosselmonitor®
- Fish Stations
Module 5 - Chemical Contamination of Food, Water, & Medication

More Information

Available Online at: www.epa.gov/safewater/security

Response Protocol Toolbox:
Planning for and Responding to Drinking Water Contamination Threats and Incidents

Physician Preparedness for Acts of Water Terrorism
An On-Line Training Course
www.waterterrorism.org

Which of the following statements regarding US drinking water standards is correct?

1. FDA enforces standards set by the EPA
2. EPA sets and enforces standards either
3. USDA enforces standards set by the
4. EPA specifies the methods used to
5. EPA enforces standards set by the FDA
6.
7.
8.
9.
10.
Chemical Agents of Opportunity for Terrorism: TICs & TIMs

Protecting Food: FDA vs USDA Roles

• USDA regulates meat, poultry, eggs, & processed egg products
• FDA regulates all other foods (~ 80% of US food supply)
• FDA & USDA, high risk foods:
  – large batches
  – uniform mixing
  – short shelf life
  – ease of access

Factors Enhancing Food System Vulnerability

• Concentration of primary production in large, monoculture farms/stockyards
• Raw goods from small suppliers combined
• Concentration of commodity food-processing in large centralized facilities
• Quality control not designed to detect unanticipated contaminants/poisons

Botulism Threat

• Potency: “Most Lethal Substance”
  – 70 ug Lethal Oral Dose
  – 70 gm Could Kill 1,000,000 People
• Prolonged ICU Requirement
  – May Exhaust Supply of Ventilators
• Easy to Mass Produce
  – Russia, Iraq, Iran, Syria, North Korea
  – 1991 “Iraqi Stockpile”: 19,000 L
Botulism: Toxic Mechanism

Botulinum toxin inhibits acetylcholine release.

[Arnon: JAMA 99]
Botulinum Contaminated Milk

- Toxin placed in holding tank at farm, tanker truck from farm or raw milk silo at plant
- Without detection
  - $< 1$ g toxin $\rightarrow$ 100,000 poisoned persons
  - 10 g $\rightarrow$ 568,000 poisoned persons
- Early symptomatic detection:
  - 2/3 cases avoided yet
  - 10 g $\rightarrow$ 100,000 poisonings
- Children would form a larger percentage of the victims with lower doses of toxin

Inactivating Botulinum Toxin

- Botulinum toxin cannot be completely inactivated by radiation or any heat treatment that does not adversely affect the milk’s taste.
- Ultrahigh-temp pasteurization (UHT) can inactivate botulinum toxin but has not been embraced by U.S. consumers.

Maine Arsenic Poisonings

- 1 died, 15 others were sickened following Sunday services in 2003
- Next day, maintenance man died of gunshot wound to chest
- Victims shared coffee and food
- Arsenic was found in the coffee pot.
Chemical Agents of Opportunity for Terrorism: TICs & TIMs

Toxic Oil Syndrome
(Spain 1981)
- Illegally marketed cooking oil
- Rapeseed oil denatured with 2% aniline
- 20,000 poisoned, 12,000 hospitalized
- > 340 died
- Toxic Oil Syndrome
  - Pneumonitis
  - Eosinophilia
  - Pulmonary hypertension
  - Scleroderma-like changes
  - 50% Peripheral neuropathy, myopathy

How Safe are US Medications?
- Drug production is a complex process
  - Synthesis → Delivery to the patient
  - Multiple steps for interference
- Depending on the circumstances, the results can be devastating:
  - Primary Impact (fatalities, illness)
  - Fear/Uncertainty
  - Economic Impact

Tylenol Murders (Chicago, 1982)
- 7 died from KCN laced Tylenol
- 1-2 bottles per store
- <10 tampered/ deformed looking capsules/bottle
- Capsules filled with KCN (100-150mg)
Copycat (1986)

- Woman in WA state killed her husband with cyanide-laced pain killer
- Attempted to cover her tracks by placing packages of poisoned Excedrin and Anacin capsules on the shelves of 3 stores
- Nickell was sentenced to 90 years in prison.

The Tylenol Bill

1983

"Tylenol Bill" made malicious tampering with consumer products a federal offense.

1989

FDA established a national requirement for tamper-resistant packaging of over-the-counter products.
- Triple-seal, tamper-resistant packaging now the norm.

Diethylene Glycol (DEG)

Mysterious Cases of Renal Failure (Haiti)
- 86 cases of acute renal failure:
  - Nov 1995 to June 1996 (8 months)
  - Children aged 3 months – 13 years
- Traced to DEG-contaminated pain medication
- DEG was used to dissolve an early antibiotic causing >100 deaths
- Led to passage of the Food, Drug, and Cosmetic Act (1938)
- Epidemics of renal failure and death due to DEG still occur
Heparin Contamination

- FDA announced increased allergic reactions and deaths related to the use of heparin in 2008
- Samples contained 5-20% of an inexpensive non-heparin ingredient that mimicked heparin
  - Oversulfated chondroitin sulfate
- The implicated ingredient originated in China

Other Aspects of Medication Quality Control

- Dietary Supplement Health and Education Act of 1994
  - Excludes supplements from FDA oversight, unless harm shown
  - Issues of safety, efficacy, contents, and purity are responsibility of manufacturer
  - Asian patent medicine and other ethnic medications
  - Ephedra-containing products
  - Examples of raw ingredient mixing errors
- Fraudulent prescription medicines via Internet
  - Particularly from other countries

Conclusions

- Numerous past incidents reveal vulnerabilities
- Potentially very injurious
- Difficult to prevent, detect, mitigate
- Toxicity, availability determine likelihood
Module 5 - Chemical Contamination of Food, Water, & Medication

Chemical Agents of Opportunity for Terrorism: TICs & TIMs

Questions

Training Support Package