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Public Health Management of Radiation Emergencies

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Introduction:

A radiation emergency may be loosely defined as any event in which exposure to radiation has the potential for widespread harm. If causing a medical disaster, radiation emergencies may be characterized by a rapid ability to overwhelm medical resources, or for impacting societies to an extent that normal functioning is significantly altered. Given their medical consequences, radiation emergencies may challenge the very structure of healthcare as well as strongly underscore the need for public health management.

The Context for Radiation Emergencies:

Whether from atomic bomb tests, nuclear reactor accidents, or released industrial or radiotherapy material, the impacts of radiation emergencies may be prolonged and pervasive. The world of the 21st century, a world characterized by globalization, urbanization, and technological interchange, is a time in which human populations have never been at greater risk for radiation disaster. Public health systems for managing and responding to radiation emergencies have become increasingly important for long-term global health stability. This chapter aims to disclose basic principles of radiation exposure, aspects of public health intervention, and general approaches to public health management in a radiation emergency.

Understanding Concepts of Risk:

In the short period of its recognized existence, the threat of radiation emergency has greatly escalated. The rise of this threat can be explained in a manner at least two fold; not only have a higher number of people become placed at greater risk for the likelihood of radiation emergency, but the potential damage associated with these emergencies has increased. Factors of modern society that contribute to escalated risk include technology growth, urbanization, resource concentration, aging populations, and globalization.

While technology growth has helped monitor and contain radioactivity, potentials for damage have also co-evolved with potentials for control. The past decades have seen an increase in the number of operational nuclear power plants, industrial practices involving radioactivity, and nuclear warfare programs being developed or maintained worldwide. Increased prevalence of radioactive facilities will increase elements of emergency risk. Currently, there are 103 active nuclear reactors in 66 power plants in 31 states of the United States (CEH, 2003). Countries such as India, Pakistan, and North Korea have all recently become nations with nuclear arsenal (IAEA, 2004). The risk consequences of these developmental trends must be given serious consideration by global leaders in public health management.

It is currently estimated that close to half of the world population resides in urban areas, and that this percentage is rapidly increasing. Up to 90% of anticipated population growth in developing countries is projected to be urban (IFRC, 2004). With human population numbers still accelerating at an exponential rate, and a greater proportion of these numbers becoming more and more concentrated in major metropolitan centers around the world, exposure to industrial sources of radiation and targets of warfare or terrorism all constitute major factors for increases in risk. If a population is of higher density, a higher number of people are placed at greater risk of exposure in one area. High proportions of elderly or disabled individuals and limited or concentrated resources also affect disaster risk, both impacting societal resistance to emergency conditions.

Finally, frequency of legal and illegal marketing combined with increased capacity for international travel may encourage an increase in trade or exchange of radioactive materials. The exchange of material may be for purposes as diverse as weapons production, economic gain, belief that a source is of precious nature, or a source becoming unknowingly lost. Regardless of its origin, timely and effective public heath management of a radioactive emergency or incident should be sensitive to the nature of a threat as well as the underlying factors contributing to the threat.

Chapter Table of Contents:
The FOUR-POINT-PLAN for CBRN (chemical, biological, radiation, nuclear) emergency management

Radiation Specific Management:

PREVENTION

Threat Awareness:

Consideration and awareness of possible threats, both in magnitude and in likelihood, should occur not only for public health officials, first responders, and healthcare professionals, but also for the public which is being served. The very first of responders to an incident in a public arena are likely to come from the public sector. A public that is aware of its threats may become less prone to panic, and in a critical situation where a disaster can be averted by quick action or sound thinking, this difference can be of crucial importance.

In order to avert or reduce the likelihood of an emergency situation with radiation, it is important to first establish, identify, and understand the potential threats of this hazard. The fist step of prevention resides in simple recognition that there may be a hazard. Many health incidents have occurred as a result of poor or misguided threat awareness (Turai et al, 2004).

Education:

Once a viable threat to radiation has been acknowledged, timely and effective educational programming is of high priority. Radiation is an intangible hazard, invisible to the eye and undetectable to other primary senses. Enough exposure can result in rapid vomiting, severe burns, and death. Although not every exposure results in observable injury, educational programming should not be insensitive to the fears associated with radiation along with the underlying logic for grounding these fears. Education has the potential to break down excessive fear, as well as prevent the formation of unnecessary stigma for persons who have been exposed. Potential health benefits of therapeutic radiation, diagnostic X rays, and nuclear medicine should be remembered.

If educational programming can illustrate the nature of radiation harm, it is also likely to be successful in lowering preventable injury. An improved public response may be anticipated if a public body understands why particular actions may be necessary in an emergency scenario.

Different response approaches should be encouraged respective to different types of ionizing radiation. The five known types of ionizing radiation are alpha and beta particles, X and gamma rays, and neutrons. Although alpha particles may cause significant damage where they come in contact with human tissue, the particles can be shielded off by a piece of paper. Beta particles may be stopped in a thick layer of clothing, while gamma rays may take a solid foot of concrete (HPS, CDC online). While removal of outer clothing may be important with particulate radiation contamination, shelter in secure buildings would be more important for non-massive radiation.

Another aspect of radiation that may affect management decisions is the fact that radioactivity decreases with time. Some radionuclides are relatively short lived, while others have half-lives of many years. The differences in decay rate may alter decisions regarding the decontamination of affected areas.

Removal or Restriction of Hazard:

The mere existence of nuclear facilities, concentrated radioactive sources, and nuclear weaponry ensures a sustained potential for radiation emergency. The likelihood of these emergencies may be reduced, however, with increased security and regulatory practices, as well as the elimination of loosely guarded sources.

Unlike chemical or biological emergencies, incidents with radiation may not be readily isolated or contained. Difficulties in identification, decontamination, and environmental restriction all promote prevention as a favorable approach to hazard mitigation. For these reasons, organizations such as the Nuclear Non-Proliferation Treaty and the Comprehensive Test Ban Treaty play important roles in present existence of radiological hazards (IAEA, 2004).

Surveillance:

Active surveillance of radiological threat and threat development is a cornerstone for prevention. Successful surveillance must be both highly sensitive and specific; sensitivity ensures accurate detection of true cases, while specificity prevents inclusion or misclassification of false cases that may appear as radiation incidents. Medical unfamiliarity with radiation injury increases the likelihood of these injuries being misdiagnosed. Examining the possibility for exposure along with symptom formation and any patterns in symptom occurrence can help distinguish a radiation exposure outbreak from other types of outbreaks.

While various laws and regulations may be enacted for the protection of a public's health, these actions should be mindful of a population's human and civil rights. The violation of civil liberty and democratic principal by a democratic government to prevent a terrorist act may elicit elements of terrorism in and of itself (Gofin, 2005).

PREPAREDNESS

Risk Address:

Between the years of 1944 and 2002, there have been at least 420 reported "incidents," in which elements of radiation emergency have been employed, worldwide (Turia et al, 2004). In terms of average incident counts, the world is now observing a rate of roughly seven and quarter per year. Archive lists of radiation incidents demonstrate a persistent and evolving history for the management of radiation incidents

(Johnston's website). Although not all researchers would agree that radiation emergencies compose enough of a threat to be allotted significant public health concern (Buscombe, 2004), it is difficult to argue that radiation incidents are irrelevant to current trends in public health.

One underlying consideration for assessing radiation risk is the fact that not all people, and not even all human tissue, have equal susceptibility to radiation damage. Standard units of exposure for an absorbed dose include the "rad" and the international "gray" (100 rad). One rad is approximately observed in a typical X-ray or nuclear medicine diagnosis (Bross et al, 1979). Separate units, however, are designated for an effective dose of an exposure, since one rad may have different effects when applied to different parts of the body. Both the "rem" and the international "sievert" (100 rem) reflect the biological effects of a radiation dose. Under most conditions, one rem is about equal to one rad. Tissues of particularly high susceptibility to radiation include tissues in which cells are rapidly dividing with low differentiation, such as in the reproductive system.

Children in general are much more susceptible to radiation injury than adults. Children have disproportionately higher ventilation rates, which allows for greater internal contamination with radioactive gases. Having the majority of a lifespan and physical growth ahead of them, children are at much higher risk for future developments of cancer. Finally, psychological injury has been observed to be of greater concern for children than adults (CEH, 2003). Both children and elderly persons should be considered more vulnerable as a result of reduced capacity for mobility and self-protection, and susceptibility to post-traumatic infection (Gofin, 2005). Increased vulnerabilities should be given high priority in any disaster planning risk assessment.

Established Communication Network:

Whether accidental or intentional, the CDC is the U.S.'s designated chief public health entity in a radiological incident. If an incident appears to be intentional, the FBI assumes a lead role as an organization. Large disasters would likely also include U.S. Department of Homeland Security, Environmental Protection Agency, Federal Emergency Management Agency, Nuclear Regulatory Commission, Department of Energy, and Department of Justice (CEH, 2003).

Routes of communication should be established within state and local health departments to ensure cooperation between the various sectors of service professionals that are likely to be involved. Routes of communication should also enable quick and effective transmission of information, allowing a "chain response" where communication does not significantly delay a response process.

Communication networks should address command and control issues, aspects of organizational responsibility, levels of notification criteria, and public broadcast announcements. They should address the type and quantity of resources that might be needed for various scenarios, and should be geared for affective administration of action such as evacuation implementation. Maximum protection should be given to people, animals, food and water supplies from radioactive contamination in the structure of emergency communication (Mettler et al, 2002).

Plan of Action:

It is estimated that humans are exposed to approximately one mrem (one thousandth of a rem) of radiation per day from background sources of cosmic radiation, radon, cigarette smoke, medical devices, pharmaceutical agents, and home appliances such and smoke detectors (CEH, 2003). Current recommendations for public exposure are not to exceed 5 rem per year. Guidelines for the Environmental Protection Agency stipulate a dose limit for healthcare workers to be 5 rem per event, but up to 25 rem per event for "lifesaving" activities, where entrance into exposed area may save a human life

(Mettler et al, 2002). The Nuclear Council on Radiation Protection and Measurements suggests 50 rem as a "life-saving" dose limit, while the North Atlantic Treaty Organization allows up to 150 rem for the same scenario (Mettler et al, 2002), (HPS, CDC online).

Regardless of the limits set for health provider exposure, it is important for a healthcare provider to always place his or her own safety and well-being before the patient, so that another patient is not created. Different healthcare providers will naturally have different levels of comfort regarding radiation, resistance to injury, and propensity for risk taking. The underlying consideration guiding radiation emergency action planning should be sustaining normal function of service. Mundane healthcare or service delivery should not be neglected in considerations of radiological threat.

An important resource to utilize in the preparation of an emergency plan includes all persons who deal with radiation on an occupational basis. Hospital workers, university researchers, military specialists, and anyone else working for a laboratory, industry, or agency involving radiation are potentially valuable volunteers. Additionally, the availability of Geiger counters or dose-rate meters from their respective institutions should not be overlooked.

Training:

Training can be broken into training applicable to emergency responders and training applicable to a general public. In both cases, training should be pragmatic, integrative, and repeatable. Drill based training is of high preference, as it combines physical and working memory with cognitive memory and rationale. Training should be maintained on a comprehensive level that corresponds with likely involvement; people living in close vicinity to a nuclear power plant or individuals on special response teams should be trained in a manner of respectively increased comprehension and updated quality.

RESPONSE

Recognition:

Nausea, vomiting, diarrhea, headache, weakness, and lymphocyopenia are all symptoms that may be attributed to a wide range of causes. Given a potential for radiation exposure, however, these symptoms may be important indications of Acute Radiation Syndrome.

In general, the higher a received radiation dose to the whole body, the faster and more severe the reduction of blood cell counts. Ionizing radiation can have both acute as well as delayed medical effects. Early recognition can be of substantial impact in improving the clinical outcomes of many delayed symptoms (Turai et al, 2004).

Clinical signs for typical radiation injury of the skin include erythema, depilation, dry and moist desquamation, blistering, ulceration, and necrosis. Local injury and skin burns often result from unrecognized source exposure, such as placing a source inside a clothing pocket. The quicker a source of radiation injury can be recognized, the more patient formation may be reduced.

If a terrorist action were to contaminate drinking water supplies or stocks of food, symptoms of illness are likely to occur in highly identifiable geographical patterns. A public health response should utilize epidemiologic methodology and give considerations for statistical probabilities.

Assessment and Cooperation:

Assessment of a radiation incident must be made quickly, but not in haste. It is important for assessments to be made accurately and on a continual basis. Initial assessments by first responders are likely to gauge the efficiency of subsequent responder arrival. Professional or expert assessment of radiation contamination is always desirable, but should not be a cause for significant delay. A successful assessment process triggers the involvement of appropriate institutions in a timely manner.

As more institutions become involved in the response of a radiation emergency, cooperation becomes increasingly pivotal. Cooperation in a radiation incident is a multi-sectorial affair. The ability of different legal, technical, and health organizations to work collaboratively for a mutually beneficial outcome is essential to the well being of all persons involved, both as responders and patients.

Containment and Intervention:

A major goal for a public health response to a radiation emergency would be to monitor and control a contaminated area (Mettler et al, 2002). It should be noted that a contaminated area may range from several feet surrounding a radioactive source to hundreds of miles from radioactive fallout.

Radioactive contamination of clothing and skin usually does not constitute a medical emergency. With particulate radiation, removal of clothing can easily eliminate up to 90% of contamination (Mettler et al, 2002). Removal of clothing and showering with soap and water generally constitute the essence of decontamination. Consideration should be given to containment and disposal of contaminated materials, given the scenario and ability to do so.

In addition to decontamination procedures, radioactive intervention includes controlling access to contaminated sites, appropriately directing people to either stay indoors or to efficiently evacuate, providing respiratory protection, administering potassium iodide, restricting certain foods, or decontaminating property all where it is necessary to do so. If a patient has sustained significant physical trauma in addition to radiation injury, ordinary stabilization should always be the primary objective, with decontamination following after (Mettler et al, 2002).

Early blood counts, nostril or oral cavity swabs, and urine or feces samples can all be collected to assess the severity of patient exposure. In this way, exposure assessments can determine both extent and route of exposure (Turai et al, 2004).

Facility Triage:

It is estimated that a 12.5 kiloton nuclear explosion at ground level in a port equal to New York City might kill 52,000 people instantly, cause 44,000 cases of direct radiation illness with one quarter being fatal, kill another 200,000 people by radioactive fallout, and create several hundred thousand other cases of radiation illness (Helfand et al, 2002). At the same time, about 1,000 hospital beds would be destroyed by the blast, and 8,700 beds would be in areas of radiation exposure high enough to cause radiation illness. Local medical facilities would likely be rapidly overwhelmed.

Regardless of the severity of an incident, medical triage is an integral aspect of the management response. Triage is also a continuing process; changes in a patient's status may occur and more developments of exposure could unfold. The initial phase of triage management entails on-scene decisions with the transport of patients to emergency rooms. Various allotments of space should be designated to differing groups of patients, all depending on the nature of an incident.

For large scale incidents, significant amounts of space may be necessary for treating patients of relatively minor medical symptoms, or symptoms of psychological etiology. Ideally, known community centers may be utilized under these circumstances. In the case of hospitals not being able to cope with the scale of a large disaster, facilities such as airports may become useful for treatment purposes.

RECOVERY

Information Share:

A public will want to be informed of a radiation incident promptly and accurately. Significant psychological trauma may be naturally and unavoidably occurring in the process of a radiation emergency. This trauma should not be complimented with intentionally misleading or false information.

The disclosure and sharing of information should be prompt, but more importantly it should be timely. Being fast is important, but not the only time consideration. A spokesperson should not be overly rushed; as in any emergency, it is important for persons in position of lead to take the time they need to gather their thoughts and think rationally and clearly. A timely correspondence does not rush to conclude what is yet to be ascertained and will attempt to reduce sensations of panic where possible.

Healthcare:

A hierarchical approach to healthcare treatment should not be dogmatic in placing medical care apart and above mental health care; both medical and mental health care are simultaneous processes of an emergency that are initiated and cared out from the very first interactions between patient and healthcare provider.

Visible symptoms of Acute Radiation Syndrome are likely to begin in the range of 100 rem. Exposure symptoms and fatality rates may vary up to 1000 rem, where 100% fatality is probable even with supportive care (HPS, CDC online). Treatment of Acute Radiation Syndrome may include treatment for such conditions as hypotension, cerebral edema, sepsis, electrolyte imbalance, and gastrointestinal de-epitheliation.

Symptoms associated with Acute Radiation Syndrome such as nausea, vomiting, fatigue, and disorientation may become difficult to detect if severe psychological symptoms mimic those of the radiation exposure. It is estimated that the detonation of a nuclear device could result in 75 percent of affected survivors having observable psychological symptoms (Mettler et al, 2002), (Walker et al, 1989).

Professional Service Integration:

The interplay of medical and mental healthcare is one of but many provider overlaps that occur in radiation emergency responses. The success of a response may be largely contingent upon successful integration of all relevant professional services and needs.

Treatment needs often follow phases in an emergency, ranging from acute, late, and post phases respectively. In the first phase, crude mortality rates and case-fatality ratios are accumulating. This is a time of very basic healthcare interventions, delivery of basic needs, and establishing control over the destructive process. The second phase is one in which death rate has declined, and stabilization, security, and utilization of resources take precedence. The final stage has a focus of long term health stabilization, and supports efforts in caretaking that are sensitive to a patient's self-sufficiency and personal recovery. Each stage must necessarily integrate different healthcare services and resource providers.

Follow Up:

Radiation incidents can result in medical and mental effects that are both profound and long lasting. Periods of dramatic change or damage often require very long periods of recovery. Post-incident phases should include a continued availability of healthcare services, considerations for material or economic support, and informational exchange.

One potential resource for questions about radiation exposure and injury includes the U.S. Department of Energy, available for contact on a 24 hours a day basis at the Radiation Emergency Assistance Center / Training Site (REAC/TS) in Oak Ridge, Tennessee (telephone number, 865-576-1005).

Radiation Emergency Case Histories and Responses:

The following events represent a sample of radiation incidents and emergencies in which the International Atomic Energy Agency (IAEA) has published specific reports to summarize and assess individual emergency responses. In all of these instances, it is important to understand not only what happened but also how the responses may be improved in future scenarios. Each report entails an in depth review and analysis, and links to each full text should be provided.

Of note is that each of these events has occurred in the post 1986 Chernobyl era, an era in which many major events in radiation incident history such as nuclear weapons deployment, extensive nuclear weapons testing, and major incidents with nuclear submarines are excluded. The following events are meant to reflect emergencies common to recent history, and are likely to ill represent the incidents of greatest concern in emergency preparedness. The sample incidents portrayed include: Goiana (1987), Tomsk (1993), Gilan (1996), Sarov (1997), Istanbul (1998), Yanango (1999), Lilo (2000), Samut Prakarn (2000), Cochabamba (2002), Bialystok (2004).

1. Goiana, Brazil (1987)

A teletherapy source that had been improperly disposed of was found and spread as a result of an admired bight and pretty color.

http://www-pub.iaea.org/MTCD/publications/PDF/Pub815_web.pdf

2. Hanoi, Viet Nam (1992)

An irradiation room was entered at an electron accelerator facility, allowing significant X ray exposure.

http://www-pub.iaea.org/MTCD/publications/PDF/Pub1008_web.pdf

3. Tomsk, Russia (1993)

Contamination occurred when an accident blew the concrete off of a reaction vessel in a plutonium extraction facility.

http://www-pub.iaea.org/MTCD/publications/PDF/Pub1060_web.pdf

4. Tammiku, Estonia (1994)

A radioactive waste site was entered by local individuals, and a radioactive source was removed.

http://www-pub.iaea.org/MTCD/publications/PDF/Pub1053_web.pdf

5. Lilo, Georgia (1997)

Sealed industrial radiation sources were abandoned by a previous owner and left to later expose surrounding individuals.

http://www-pub.iaea.org/MTCD/publications/PDF/Pub1097_web.pdf

6. Istanbul, Turkey (1998)

A teletherapy source was broken down and sold as scrap metal.

http://www-pub.iaea.org/MTCD/publications/PDF/Pub1102_web.pdf

7. Yanango, Peru (1999)

A welder picked up an industrial radiography source and placed it in a pant's pocket for several hours.

http://www-pub.iaea.org/MTCD/publications/PDF/Pub1101_web.pdf

8. Samut Prakarn, Thailand (2000)

A teletherapy head was dismantled, and parts were left in an insecure storage location. Parts were later sold as scrap metal.

http://www-pub.iaea.org/MTCD/publications/PDF/Pub1124_web.pdf

9. Bialystok, Poland (2001)

Accidental overexposure occurred as the resulted of improperly calibrated radiotherapy.

http://www-pub.iaea.org/MTCD/publications/PDF/Pub1180_web.pdf

10. Cochabamba, Bolivia (2002)

An industrial source was transported by way of a fully loaded passenger bus for an eight hour trip from Cochabamba to La Paz.

http://www-pub.iaea.org/MTCD/publications/PDF/Pub1199_web.pdf

Overview of Radiation Emergencies and Nuclear Concerns:

While many incidents and emergencies have been observed in recent decades, the field of radiation preparedness is still incipient, evolving, and largely untested. Although evidence of improved measures may exist since cases such as the scare of nuclear meltdown in Three Mile Island, Pennsylvania, 1979, the state of modern preparedness in relation to modern technologies of communication, surveillance, and healthcare delivery is predominantly unknown. Incentives for preparation may be currently challenged by infrequent activity on a massive scale. Furthermore, integration of services for a large scale event remains a variable as individual fields become more and more specialized.

In terms of large scale radiation events, nuclear war and terrorism generally hold a spot light compared to nuclear power plant or reactor meltdown. Many simulation and preparedness models utilize a bomb of comparable size to the weapon dropped on Hiroshima, judging that a low yield weapon may be the most likely nuclear weapon for terrorist attainment. In the event of any nuclear war, yields of nuclear weapons would likely be much greater.

Weapons held today by either the U.S. or Russia could be, at the very least, *three or four thousand times more destructive* than the weapon dropped in Hiroshima (NAS, 1997). Although a 50 Mt bomb may be the largest weapon officially reported to have been constructed, weapons of common prevalence are typically in the range of 300 to 475 kt, of which the U.S. has some 13,000 and Russia has about 11,000. The Cold War may have seen accumulations as high as 60,000 to 80,000 (NAS, 1997). China, England, and France may each possess 1% or 2% the number of weapons currently found in the U.S. or Russia. Warheads are typically contained in missiles which combine eight to ten warheads.

Final Conclusion:

A large scale radiation emergency or a nuclear disaster would be likely to reflect fundamental features of society and culture, including interpersonal communication, relationships, and core values through the intensity of impact and stress of recovery (Oliver-Smith, 2002). The ability to cope, recognize vulnerability, and assist recovery in emergencies of radioactive nature may be tools of invaluable importance for the management of public health in the modern world. Both response and prevention are concepts that should be molded to the features of a society most germane to its fundamental well being and continued self-sufficiency.

Bibliography:

Internet Resources and Associated Publications:

Armed Forces Radiobiology Research Institute (AFFRI)
http://www.afrri.usuhs.mil
Centers for Disease Control and Prevention (CDC)
http://www.bt.cdc.gov/radiation
Database of Radiological Incidents and Related Events (compiled by R. Johnston, updated 5 Jan. 2005)
http://www.johnstonsarchive.net/nuclear/radevents/radaccidents.html
Emergency Management Research Institute (EMRI)
http://www.cbrnemergencymanagement.com
Federal Emergency Management Agency (FEMA, within DHS)
http://www.fema.gov/hazards/nuclear/radiolof.shtm
International Atomic Energy Agency
http://www.iaea.org/
International Federation of Red Cross and Red Crescent Societies
http://www.ifrc.org/what/disasters
National Council on Radiation Protection and Measurements (NCRP)
http://www.ncrponline.org/
Oak Ridge Institute for Science and Education (REAC/TS division)
http://www.orau.gov/reacts
U.S. Department of Homeland Security (DHS)
http://www.dhs.gov/dhspublic/interappp/editorial/editorial_0566.xml
U.S. Department of Veterans Affairs: Clinical Practice Guidelines, Office of Quality and Performance
http://www.oqp.med.va.gov/cpg/BCR/BCR_Base.htm
World Health Organization
http://www.who.int/ionizing_radiation/a_e/en

Texts:

American Association of Physicists in Medicine Report No. 53 (1995). *Radiation Information for Hospital Personnel.* Woodbury, NY: American Institute of Physics, Inc.

Baum, A. (1987). Toxins, Technology, and Natural Disasters. In G. R. a. B. VandenBos, B.K. (Ed.), *Cataclysms, Crises, and Catastrophes: Psychology in Action* (Vol. 6). Washington, D.C.: American Psychological Association.

Blatz, Hanson (1964). *Introduction to Radiological Health.* New York, NY: McGraw-Hill Book Company.

Button, G. V. (2002). Popular Media Reframing of Man-Made Disasters: A Cautionary Tale. In Oliver-Smith, A. and Hoffman, S. (Ed.), *Catastrophe and Culture: The Anthropology of Disaster*. Santa Fe: School of American Research Press.

Golding, D; Kasperson, J; Kasperson, R; Goble, R; Seley, J; Thompson, G; Wolf, C (1992). *Managing Nuclear Accidents.* Boulder, CO: Westview Press.

Healy, R. J. (1969). *Emergency and Disaster Planning*. New York: John Wiley and Sons, Inc.

National Academy of Sciences: Committee on International Security and Arms Control. (1997). *The Future of U.S. Nuclear Weapons Policy*. Washington, D.C.: National Academy Press.

Oliver-Smith, A. (2002). Theorizing Disasters: Nature, Power, and Culture. In Oliver-Smith, A. and Hoffman, S. (Ed.), *Catastrophe and Culture: The Anthropology of Disaster*. Santa Fe: School of American Research Press.

Organization for Economic Cooperation and Development. (2003). *Emerging Risks in the 21st Century: An Agenda for Action*. Paris, France: OECD Publications.

Paine, R. (2002). Danger and the No-Risk Thesis. In In Oliver-Smith, A. and Hoffman, S. (Ed.), *Catastrophe and Culture: The Anthropology of Disaster*. Santa Fe: School of American Research Press.

Pan American Health Organization. *Emergency Preparedness and Disaster Relief Coordination Program*. Accessible: http://www.paho.org

Stephens, S. (2002). Bounding Uncertainty: The Post-Chernobyl Culture of Radiation Protection Experts. In Oliver-Smith, A. and Hoffman, S. (Ed.), *Catastrophe and Culture: The Anthropology of Disaster*. Santa Fe: School of American Research Press.

VandenBos, G. R. a. B., B.K. (1987). Preface. In G. R. V. a. B. K. Bryant (Ed.), *Cataclysms, Crises, and Catastrophes: Psychology in Action* (Vol. 6). Washington, D.C.: American Psychological Association.

Journals:

Benger, J. (2004). Response to Radiation Incidents and Radionuclear Threats: Medical Treatment Should Be Given Only When Safe To Do So. *British Medical Journal, 328*, 1074.

Bross I.D., Ball M., and Falen S. (1979). A Dosage Response Curve for the One Rad Range: Adult Risks from Diagnostic Radiation. *American Journal of Public Health. 69*(2) 130-136

Buscombe, J.R. (2004). Response to radiation incidents and radionuclear threats: other threats may be more serious. *British Medical Journal*. May 1; *328*(7447):1074

Committee on Environmental Health. (2003). Radiation Disasters and Children. *Pediatrics, 111*(6), 1455-1466.

Forrow, L., Sidel, V. W. (1998). Medicine and Nuclear War. *JAMA, 280*(5), 456-461.

Gofin, R. (2005). Preparedness and Response to Terrorism: A Framework for Public Health Action. *European Journal of Public Health, 15*(1), 100-104.

Helfand, I., Forrow, L., Tiwari, J. (2002). Nuclear Terrorism. *British Medical Journal, 324*, 356-359.

Holdstock, D., Waterston, E. (2004). Response to Radiation Incident and Radionuclear Threats: Renunciation of Nuclear Weapons Could Lesson the Threat. *British Medical Journal, 328*, 1074.

Mettler, F. A., Jr., Voelz, G. L. (2002). Major Radiation Exposure - What to Expect and How to Respond. *The New England Journal of Medicine, 346*(20), 1554-1561.

Muirhead, C. R. (2001). Cancer After Nuclear Incidents. *Occupational and Environmental Medicine, 58*, 482-488.

Ricks R. *REAC/TS Registry of radiation accidents, 1944-2000*. Oak Ridge: REAC/TS, 2001

Smith, R. (2004). "Doctor, Come Quickly. There's Been a Nuclear Incident". *British Medical Journal, 328*, 7439.

Tan, G., Fitzgerald, M. (2002). Chemical-Biological-Radiological (CBR) Response: A Template for Hospital Emergency Departments. *Medical Journal of Australia, 177*(19), 196-199.

Turai, I; Veress, K; Gunalp, B; Souchkevitch, G. (2004). Medical Response to Radiation Incidents and Radionuclear Threats. *British Medical Journal, 328*:568-572
http://bmj.bmjjournals.com/cgi/content/full/328/7439/568