Applying the Disaster Cycle to Radiation Accidents

Reem Boudali, Sara McCaughley

Faculty of Nursing, University of Windsor

NURS3990: Intro to Disaster Nursing

LCol Steven D. Pirie

March 23, 2023

Applying the Disaster Cycle to Radiation Accidents

Ionizing radiation is energy emitted from decaying unstable isotopes that, in high doses, can cause damage to human health (Health Canada, 2015). As such, threats to use radiation to inflict harm are concerning to the healthcare system. There are three main types of ionizing radiation: alpha, beta, and gamma. While alpha and beta can cause harm, gamma is the most concerning as it easily penetrates humans and other materials (Health Canada, 2015). In this case study, it is likely that TANGO 15 will use gamma radiation due to its strength, and how prevalent this source is in research labs**,** which someone in TANGO 15's role could easily have access to (Veenema, 2018, p. 571). Radiological exposure devices (RED) are high-dose radiation sources deliberately placed in public areas and radiological dispersal devices (RDD) are explosive devices that disperse radioactive material (Health Canada, 2015; Centers for Disease Control and Prevention [CDC], 2018). Both are methods to induce intentional harm; however, authorities have deemed RDDs to not be a threat in this scenario. Many healthcare facilities and workers are unfamiliar with radiation accidents and how to respond to them, hence it is important to have a disaster plan that is properly communicated to staff (Health Canada, 2015). The focus of this paper is to apply the disaster cycle to the Windsor context and provide recommendations to Windsor Regional Hospital (WRH)'s Hospital Emergency Task Force (HETF) regarding a gamma RED incident.

Articulation of Hazard

As previously mentioned, TANGO 15 will likely obtain a gamma radiation source from his workplace. Based on the intel provided, the estimated date of the attack is 10-15 days (assuming TANGO 15 is not threatened and acts sooner). Due to TANGO 15's motives, an RED will most likely be placed in a high-traffic location or government establishment. In Windsor, this includes city hall, city transit buses, and Devonshire Mall. The radioactive source would probably be sealed in an inconspicuous container under seated areas away from natural gaze, leading people in the area to be exposed to the radiation unknowingly (CDC, n.d.). Gamma rays are invisible to the human eye, meaning they can penetrate the human body and damage health, without an individual being aware of their exposure (Veenema, 2018, p. 570). In the short-term, it causes acute radiation syndrome (ARS) and radiation skin burns and in the long term, cataracts, cardiovascular disease, and fetal development malformations (Kamiya et al., 2015; Yang et al., 2021; Ainsbury et al., 2009; United Nations Scientific Committee on the Effects of Atomic Radiation, 2006; National Research Council, 2006). While it is not a physical health effect, fear from the general public also poses an issue as it can lead to hysteria; therefore, proper communication is important to reduce anxiety (CDC, 2010).

In total, Windsor-Essex has three hospitals (WRH Met/Ouellette campuses and Hotel Dieu Grace [HDG]); however, HDG is not an acute care center and would not be able to handle dealing with patients from a radiation incident (City of Windsor, n.d.). This is a vulnerability of the city as it leaves only two facilities able to admit and care for radiation patients. Another vulnerability lies in the fact that neither facility has an adequately equipped burns unit able to treat radiation burns; the closest Canadian facility is the London Health Sciences Centre, which is two hours away from Windsor (Critical Care Services Ontario, n.d.). A strength of the area is that it borders the United States; in emergent situations, select patients may be sent over to American hospitals (Steele, 2018).

The risk of radiation disasters is extremely low, but when they do occur, they will have tremendous effects on a community. For example, the 1987 Goiania incident, where a gamma radiation source was accidentally spread amongst the population, causing 249 contaminations, 4 deaths, and 112,000 affected people (CDC, 2010). Although Windsor-Essex has a population of 422,630 people—half that of Goiania's in 1987—the whole population could potentially be affected in a deliberate attack (Statistics Canada, 2021; Macrotrends, n.d.). Goiania can be analyzed and applied in the creation of a new disaster plan, specific to the Windsor context.

Mitigation

Assuming WRH will not be dealing with the direct source (i.e, the RED is found off-site, contained, and removed; WRH is just treating patients), the HETF does not need to be concerned with radiation exposure from victims, as radiation is only transmitted from the source, not an exposed individual (Veenema, 2018; Health Canada, 2015). For example, a cancer patient receiving radiation treatment does not have to be isolated from receiving visitors. Mitigation techniques will be geared towards preventing an overwhelmed healthcare system. This will involve communicating and collaborating with the Windsor-Essex County Health Unit (WECHU) and news stations that will help with communication.

The CDC (2010) explains that proper balance of communication with the public is the most important in the face of a disaster: too little will cause anger and backlash, but too much may create fear that will lead people to overseek care when they are not affected. A solution that may solve this could be to only disseminate information about seeking care once the source is found and contained. This would allow officials to know the location of exposure and inform the public to seek care only if they were in that region within a given time frame and are demonstrating symptoms.

Additionally, public health can play a huge role in tracking cases and screening patients (CDC, 2010). Pop-up clinics can be arranged where members of the public can come and get assessed. These could be structured in outdoor tents across the city to make it accessible for all.

Staff from WECHU would be trained on using hand-held survey meters or dosimeters that can detect radiation levels on exposed individuals (Health Canada, 2015). WECHU nurses should also screen the severity of displayed symptoms to see how the population is responding to the exposure; this provides some predictions on how severe of an outcome the HETF should expect.

Although radiation is not the main concern for healthcare workers, when the source is not known, extra safety precautions should be taken. As such, Level C Personal Protective Equipment (PPE)—respirator, safety glasses or face shield, gowns, and gloves—can be used to protect the patients and the nurses (Veenmena, 2018, p. 595). Staff training will occur in the preparedness phase, so that nurses feel confident in recognizing and treating the effects of radiation. Ultimately, both the mitigation and preparedness phases must be done well to prevent an overloaded hospital system.

Preparedness

The time before TANGO 15 attacks is most important to the HETF as this is the period of planning, training, and stockpiling. How well each of these categories is worked on will directly correlate to how successful the response phase can be. As radiation attacks are rare, staff are likely unfamiliar with radiation; this knowledge gap should be minimized (CDC, 2010). The goal of this phase is to have all stakeholders understand the scope of their role.

The most important stakeholder to connect with is the University of Windsor Chemical Control Center (CCC) because they manage all chemical and hazardous materials used on campus (University of Windsor, n.d.). The CCC should remove TANGO 15's access to these materials and also identify the missing substance that TANGO 15 has acquired. Knowing the specific radioactive source will help tailor the response because different sources require different treatments (Health Canada, 2015). For example, radioiodine can be treated with potassium iodide (KI); in which case, pills and liquid solutions would need to be stockpiled (Ministry of Health and Long-Term Care [MOHLTC], 2014a). With gamma radiation and dynamic crowds, the HETF should expect to see larger amounts of externally contaminated patients with low-level exposure (MOHLTC, 2014b).

Continuous discussions with city stakeholders are a necessity as they can provide the HETF with current information and allow governing bodies to support WRH financially or through special policies like increasing the expiry date on nursing licenses to bring in retired staff (Department of Justice Canada, 2022). Potential target areas in the city are discussed, predicting what populations the hospital may receive (e.g., non-English speaking, homeless, young/old). For example, if an immigrant community is targeted, the HETF should prepare translation services. In Windsor-Essex, the most common non-English language is Arabic, so an Arabic translator should be placed in WRH regardless of the area of attack (Statistics Canada, 2016).

Under the Provincial Chemical, Biological, Radiological, and Nuclear (CBRN) Emergency Preparedness Program, Ontario hospitals that provide emergency care are given standardized supplies/equipment including PPE, radiation detection machines, and decontamination equipment (MOHLTC, 2014b). Additional equipment WRH needs includes blood tubes for specimen collection, dressing supplies and topical corticosteroids for radiation burns, anti-anxiety medications, intubation supplies (severe cases or respiratory burns), intravenous (IV) catheters, and IV fluids (MOHLTC, 2014b; Armed Forces Radiobiology Research Institute [AFRRI], 2013). It is important to also stockpile all this equipment in children’s sizes as radiation can affect children more severely (MOHLTC, 2014b).

Specialized staff within WRH (i.e., nuclear medicine) and external sources (e.g., Health Canada, private HAZMAT teams) may be able to provide insight and support during the disaster. The HETF should request they have a team of volunteers on standby if the disaster is severe. The HETF should also connect to London and Detroit facilities to negotiate the intake of patients with extenuating conditions, such as radiation burns, due to WRH's incapacity to treat them. Detailing the finances and logistics of this will be the responsibility of the HETF. Finally, if the disaster overwhelms WRH's capacity, a triage guideline is needed that defers treatment for non-severe conditions and additional staff (internal or external) supporting the provision of acute care (MOHLTC, 2014b).

Training will provide knowledge and teach the team how to respond. Firstly, medical personnel need to be able to identify symptoms of ARS—nausea, vomiting, diarrhea, infection, erythema, blistering of the skin, and hair loss—though labs and diagnostics are more specific (AFRRI, 2013; Health Canada, 2015). There will be an increase in anxiety and mental health crises, so training should involve an introduction to such screening tools (Lindberg, 2021). To dispel safety fear that may drive workers away from being present during the response, staff need to be assured that they are not at risk of radiation exposure when working with a contaminated patient (AFRRI, 2013; Health Canada, 2015).

Response

Even before TANGO 15 attacks the community, the response phase is being executed. The first phase of response actions are completed by ensuring that specific tools are in place that will allow officials to rapidly triage individuals who are in need of care, and to direct medical attention to those who are in need of immediate care (Bailiff et al., 2016). The purpose of triage in a radiological scenario is to separate those who are suffering from anxiety due to the possibility of being exposed, from those who need immediate medical attention due to actual exposure with the radioactive source (Bailiff et al., 2016). This allows medical providers to focus on the patients most urgently needing medical care and allows specialists to focus on the patients in the most need of their attention over those that could be treated by general providers. Along with ensuring specific triage tools are in place, it is also important for methods of communication to be established between all the hospitals and clinics in Windsor-Essex. Communication between all hospitals and clinics is essential not just for the care of patients, but also to be able to create a map of the affected communities, allowing for officials to determine where the rest of the response actions need to be focused.

Once the first patients supposedly exposed to radiation walk through the doors of the hospital, the individuals would be triaged. A big part of this process would be determining the radiation exposure level, as this would determine the level of care. Although the best method is through biological techniques, such as through the analysis of extracted teeth, these methods are not possible in a triage setting, leading to the need to use emergency dosimetry techniques, such as the luminescence of clothing found on the individual, analysis of cell phone components to, or through the use of hand-held survey monitors and dosimeters provided in the MOHLTC’s standardized kits (Bailiff et al., 2016; MOHLTC, 2014b).

Patients in need of immediate care will be admitted to the hospital for medical attention. AFRRI (2013) recommends a complete blood count, serum amylase, C-reactive protein, and other labs to be drawn. Isotonic IV fluids can be given to dilute the source and help flush the body (AFRRI, 2013). In radioiodine exposure, KI would be administered within 4 hours of exposure (MOHLTC, 2014a; AFRRI, 2013). In ARS, treatment may include antibiotics and hematopoietic growth factors like filgrastim (AFRRI, 2013). Any burns that appear on patients will be treated as radiation burns, and as such, be treated with corticosteroids and clean dressings (Veenmena, 2018, p. 586). Other general symptoms would be treated as they normally are.

During this phase of the response, it is also important to gather information about the spread of radiation in the community. Using data collected from physical samples taken from the patients at the hospital or clinic, information about the attack from these patients, and interhospital communication, public health can determine which areas have been more affected by RED placement. These initially identified communities would have wastewater analysis completed in order to confirm where untreated patients may be located. Wastewater analysis is a critical component of the response phase, as it is unlikely that a majority of patients exposed to the RED would visit the hospital in the first 24 hours with radiation symptoms. After this period of time radiation particles pass into urine from the bloodstream, making it easy for public health officials to determine where the affected communities are located (Veenmena, 2018, p. 583).

After the disaster has occurred and immediate response efforts have been undergone, continuous monitoring for radiation remains, as many of the more severe symptoms of gamma radiation do not appear for years or months after the initial exposure (Veenmena, 2018, pg. 571). These actions and the treatment of such conditions overlap with the recovery phase.

Recovery

While treating the acute effects of radiation in the response phase is important, the long-term health conditions and psychological trauma need to be addressed. As previously mentioned, long-term physical health effects of radiation include cancer, cataracts, cardiovascular disease, and fetal development malformations (Health Canada, 2015). Post-disaster, a medical registry of exposed individuals that will provide follow-up medical care will be coordinated by the MOHLTC (MOHLTC, 2014b, p. 39; Health Canada, 2015). Special populations, like pregnant women, should receive proper counseling on fetal effects to warrant a decision regarding abortion (Health Canada, 2015, p. 142; Yoon & Slesinger, 2022). Furthermore, fear and stress are prevalent themes post-radiation disasters as people worry about whether they were ever exposed and fear potential delayed health effects (Health Canada). Initiatives to tackle mental health post-disaster include one-one-on counseling, group support, and increasing public awareness about mental health (Seto et al., 2019).

The final step of the disaster management cycle should be evaluation. Reflection on all aspects of the cycle can highlight strengths and weaknesses, which influence actions to decrease vulnerabilities. For example, one of these vulnerabilities in this situation was TANGO 15's ability to access gamma radiation sources from the University. Reflection identifies this risk, but action is still needed: organizations that handle hazardous materials should tighten security, increase requirements for access, and monitor the location and use of such materials, so that they are not used for harm (UC Santa Cruz, 2019).

Conclusion

In summary, gamma radiation accidents are difficult disasters to plan and respond to, due to their complex and uncommon nature, but strategic steps can still be taken in order to successfully protect communities that could potentially be affected. The stages of the MPRR cycle provide the foundations that allow for a successful response plan to any threat but are especially prevalent when planning for uncommon disasters like radiation events. When all team members are aware of this plan, the amount of fear surrounding these types of disasters decreases. This lack of fear is imperative for frontline healthcare workers to protect patients by providing them adequate and informed treatment. After all, patients trust that nurses will provide them with the best care possible, even in extreme situations.

References

Ainsbury, E. A., Bouffler, S. D., Dörr, W., Graw, J., Muirhead, C. R., Edwards, A. A., & Cooper, J. (2009). Radiation cataractogenesis: A review of recent studies. *Radiation research, 172*(1), 1–9. https://doi.org/10.1667/RR1688.1

Armed Forces Radiobiology Research Institute. (2013). *Medical management of radiological casualties*. http://operationalmedicine.org/TextbookFiles/4edmmrchandbook.pdf

Bailiff, I. K., Sholom, S., & McKeever, S. W. S. (2016). Retrospective and emergency dosimetry in response to radiological incidents and nuclear mass-casualty events: A review. *Radiation Measurements, 94*, 83-139. https://doi.org/10.1016/j.radmeas.2016.09.004

Centers for Disease Control and Prevention. (2010, August 5). *Radiological and nuclear disaster preparedness* [Video]. Youtube. https://www.youtube.com/watch?v=QaOMddzwGGk&ab_channel=CentersforDiseaseControlandPrevention%28CDC%29

Centers for Disease Control and Prevention. (2018). *More information on types of radiation emergencies.* https://www.cdc.gov/nceh/radiation/emergencies/moretypes.htm#red

Centers for Disease Control and Prevention. (n.d.). *Radiological exposure device.* https://www.cdc.gov/nceh/radiation/emergencies/pdf/infographic_radiological_exposure_device.pdf

City of Windsor. (n.d.). *Hospital facilities.* https://www.citywindsor.ca/business/physician-recruitment/work/pages/hospital-facilities-.aspx

Critical Care Services Ontario. (n.d.). *Trauma and burns programs.* https://criticalcareontario.ca/solutions/trauma-burns/

Department of Justice Canada. (2022). *Canada's Emergencies Act*. Government of Canada. https://www.canada.ca/en/department-justice/news/2022/02/canadas-emergencies-act.html

Kamiya, K., Ozasa, K., Akiba, S., Niwa, O., Kodama, K., Takamura, N., Zaharieva, E. K., Kimura, Y., & Wakeford, R. (2015). Long-term effects of radiation exposure on health. *Lancet, 386*(9992), 469–478. https://doi.org/10.1016/S0140-6736(15)61167-9

Lagergren Lindberg, M., Hedman, C., Lindberg, K., Valentin, J., & Stenke, L. (2022). Mental health and psychosocial consequences linked to radiation emergencies-increasingly recognised concerns. *Journal of radiological protection: Official journal of the Society for Radiological Protection, 42*(3), 10.1088/1361-6498/ac7d19. https://doi.org/10.1088/1361-6498/ac7d19

Macrotrends. (n.d.). *Goiania, Brazil Metro Area Population 1950-2023.* https://www.macrotrends.net/cities/20214/goiania/population

Ministry of Health and Long-Term Care. (2014b). *Radiation health response plan.* https://www.health.gov.on.ca/en/pro/programs/emb/rhrp/docs/radiation_health_response_plan.pdf

Ministry of Health and Long-Term Care. (2014a). *Potassium iodide (KI) guidelines.* https://www.health.gov.on.ca/en/pro/programs/emb/rhrp/docs/ki_guidelines.pdf

National Research Council. (2006). Health risks from exposure to low levels of ionizing radiation: BEIR VII phase 2. *National Academies*. https://doi.org/10.17226/11340.

Seto, M., Nemoto, H., Kobayashi, N., Kikuchi, S., Honda, N., Kim, Y., Kelman, I, & Tomita, H. (2019). Post-disaster mental health and psychosocial support in the areas affected by the

Great East Japan Earthquake: A qualitative study. *BMC Psychiatry, 19*(261). https://doi.org/10.1186/s12888-019-2243-z

Statistics Canada. (2016). *Focus on geography series, 2016 Census of population: Windsor, Census metropolitan area.* https://www12.statcan.gc.ca/census-recensement/2016/as-sa/fogs-spg/Facts-cma-eng.cfm?LANG=Eng&GK=CMA&GC=559&TOPIC=5

Statistics Canada. (2021). *Focus on geography series, 2021 Census of population: Windsor, Census metropolitan area.* https://www12.statcan.gc.ca/census-recensement/2021/as-sa/fogs-spg/page.cfm?dguid=2021S0503559&topic=1&lang=E

Steele, K. (2018). *Heart attack patients in Windsor will be sent to Detroit or London this weekend.* Windsor Star. https://windsorstar.com/news/local-news/heart-attack-patients-in-windsor-will-be-sent-to-detroit-or-london-this-weekend

Toney-Butler, T. J., Thayer, J. M. (2022). Nursing process. In *StatPearls.* StatPearls Publishing.

UC Santa Cruz. (2019). *Security of hazardous materials.* https://ehs.ucsc.edu/programs/research-safety/hazmat-security.html

United Nations Scientific Committee on the Effects of Atomic Radiation. (2006). *UNSCEAR 2006 report volume I: Effects of ionizing radiation.* https://www.unscear.org/unscear/en/publications/2006_1.html

University of Windsor. (n.d.). *Welcome to the CCC.* https://www.uwindsor.ca/chemical-control-centre/

Veenema, T. G. (2018). *Disaster nursing and emergency preparedness: For chemical, biological and radiological terrorism, and other hazards* (4th ed.). Springer Publishing Company, LLC.

Yang, X., Ren, H., Guo, X., Hu, C., & Fu, J. (2020). Radiation-induced skin injury: Pathogenesis, treatment, and management. *Aging*, *12*(22), 23379–23393. https://doi.org/10.18632/aging.103932

Yoon, I., & Slesinger, T. L. (2022). Radiation exposure in pregnancy. In *StatPearls.* StatPearls Publishing.