2013

Reception Centers in Response to Radiological Hazards: Correctly Triaging Survivors

Ameer Matariyeh
Wright State University - Main Campus

Reception Centers in Response to Radiological Hazards: Correctly Triaging Survivors

Ameer Matariyeh

Wright State University

Acknowledgments

First and foremost, a special thanks to Dr. Donald Brannen for inspiring me to take a special interest in the field of emergency preparedness. I would also like to thank Dr. Nikki Rogers for providing her expertise on scientific writing.

Table of Contents

Abstract

A disastrous incident involving radiological materials has the potential to cause mass casualties exceeding several thousand. Early diagnostic screening and triage at community reception centers (CRC) are excellent tools to keep communities safe from unidentified radiological material. Community receptionists quickly screen survivors with portable radiation detectors before triaged first aid survivors are transported to a nearby hospital. Screening for radiation immediately upon arrival to a community reception center reduces internal and external radiation dose levels, as well as the chance of chronic radiation illness. This culminating experience sought to determine if different CRC flow charts affect survivor triage.

Keywords: chronic radiation illness, emergency preparedness, first responders, radiological disaster, first aid stations

Reception Centers in Response to Radiological Hazards: Correctly Triaging Survivors

A single exposure to a radiation dose that exceeds twice the acceptable annual natural background radiation exposure of 6.2 millisieverts (mSv) is a health hazard (Gale & Lax, 2013). Natural background radiation comes from the sun and terrestrial radionucleotides from the Earth's crust (Gale & Lax, 2013). In cases of dangerously high levels of individual exposure to non-natural sources of radiation, resources ranging from first response Emergency Medical Services (EMS) to a Hazardous Materials Response Unit (HMRU) may be used to diagnose and treat survivors (Caspary, 2012). *External radiation* exposure occurs when part of or the entire body is exposed to a radiation field (Caspary, 2012). This type of radiation exposure can be absorbed by the body or clothing and requires a soap and water wash to ameliorate the danger (Centers for Disease Control [CDC], 2012). *Internal contamination* means that radioactive material has been ingested in the form of gas, liquid, or solid (Gale & Lax, 2013). Contamination detected around the breathing zones such as the nose and mouth may indicate internal contamination. When internally contaminated, a survivor enters a registry after initial treatment and baseline dose assessment and receives follow-up appointments with medical specialists to track the path of the internal contamination within the body (CDC, 2012). Internal radiation dose assessments continue until radiation is either eliminated over time or manifests into cancer (CDC, 2012).

In a large casualty disaster the number of affected persons can quickly deplete available on-site resources such as radiation decontamination wash. A large catastrophic incident involving radiological materials or devices, such as a man-made "dirty" explosive containing Cesium-137 isotopes, has the potential to cause radiological and non-radiological related mass casualties exceeding several thousands (Gale & Lax, 2013). Such disasters therefore require a method of early screening to accurately differentiate and identify contaminated survivors so resources can be used efficiently from the start of services, and to increase the duration of supplies. The current Centers for Disease and Control (CDC) model for emergency services places radiation screening after triaging survivors with non-life threatening injuries to first aid and treatment. Screening before triaging survivors is a novel idea that has the potential to become a common practice of every radiological response plan (CDC, 2012). While radiation screening is addressed in the CDC model, this project focused on a flowchart that addresses screening before first aid triage (CDC, 2012).

The “screen before triage” model would provide many health benefits. Tools such as hand-held radiation detectors and walk-through screening portals can provide early assessments of the affected population before they display radiation exposure symptoms such as sudden-onset nausea (Caspary, 2012). This would allow early treatment and help in preventing and reducing the severity of near-future health impairments which include diarrhea, vomiting, seizures and coma (Caspary, 2012). It is crucial that survivors who are likely to develop health morbidities be quickly evaluated in order to receive immediate intervention including radiation dose assessments and decontamination washes. Early actions also guide healthcare professionals (nurses, physicians, technicians, etc.) to immediate and successful treatments when triage has occurred.

When considering exposure to radiological hazards and number of survivors, accidents that involve a small number of treatable people at a hospital make post-triage follow-ups simple and straightforward. However, in mass disaster cases the large number of survivors requires use of additional local and/or regional medical resources. Survivors may be examined and treated at a number of emergency medical facilities across the area, yielding a significant challenge for survivor tracking and follow-up. To alleviate these logistical challenges for medical facilities, early diagnostic screening and triage at community reception centers (CRC) *before transport* to the local/regional medical centers is a useful tool for treatment (Brannen, Schmidt, & McDonnell, 2011). It can also ensure proper screening of many more survivors, including those who may choose to self-transport to medical facilities or to leave the area if they have not received life-threatening injuries.

A Community Reception Center (CRC) is a local response strategy for conducting population monitoring in response to an emergency. It is a temporary response center set up with administrative and allied healthcare assistants and volunteers responsible for emergency care delivery to “all hazards” survivors. CRCs have been public health-lead and coordinated by local and state officials since they were introduced in 2005 (CDC, 2012). These reception centers are designed to provide initial sorting, first aid, contamination screening, decontamination washes, radiation dose assessments, and registration for civilians in time of public emergency. Figure 1 displays where CRCs are located in context to the radiation hazard site. The focus of this Culminating Experience (CE) is the process within CRCs in radiological events. Figure 2 shows the standard CDC protocol which focuses on first aid and transportation to a nearby medical center prior to radiation screening and decontamination. Figure 3 shows the triaging flowchart developed by Principal Investigator (PI) Ameer Matariyeh and Research Assistant (RA) Donald Brannen. The difference between this process and the standard CDC protocol (Figure 2) is that radiation screening and decontamination are placed *prior to* first aid and transport to treatment centers. This amended process (flowchart) is designed to prevent cross-contamination between contaminated survivors and others they come in contact with after radiation exposure.

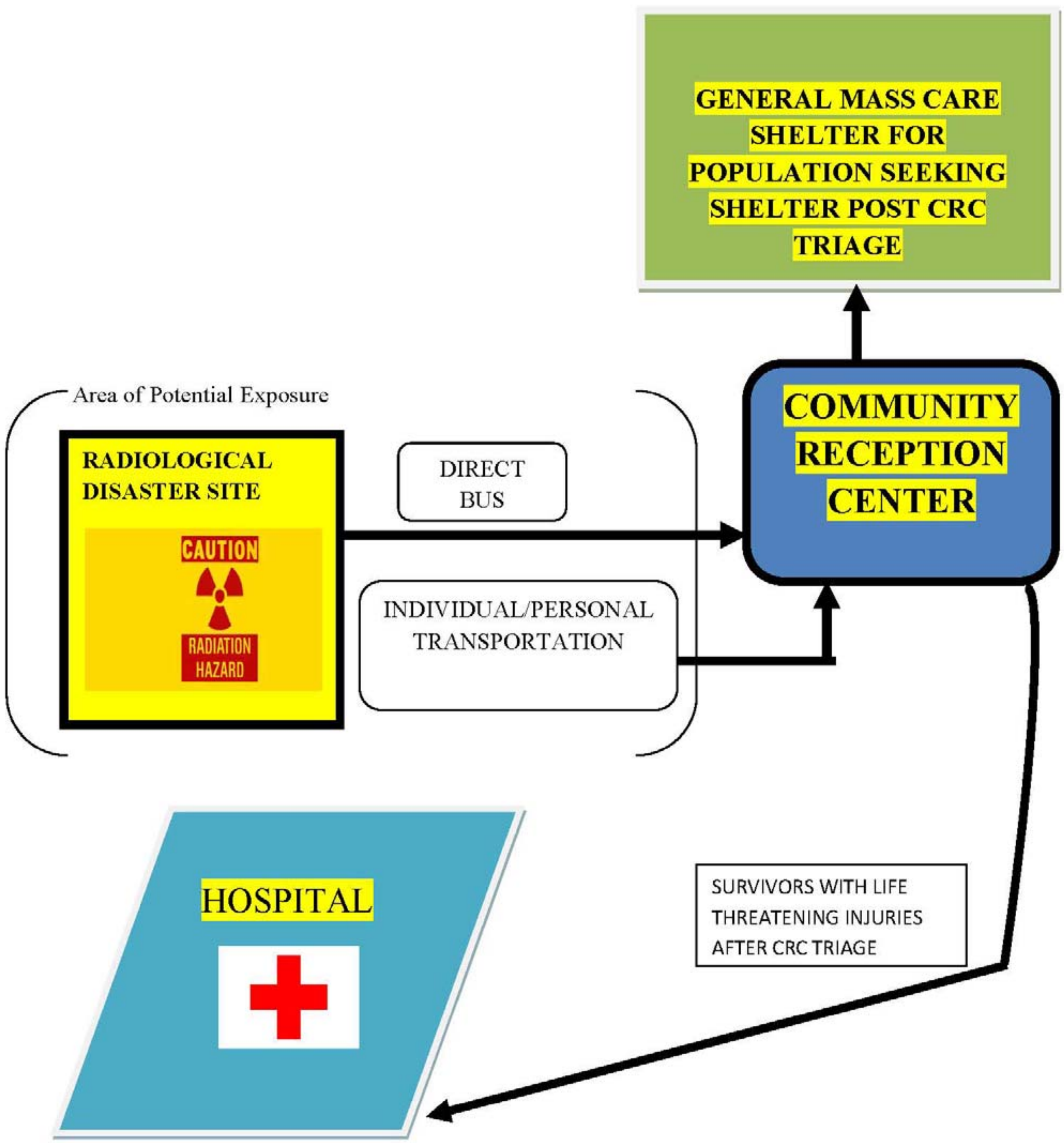

Figure 1. Macroscopic Scale of Radiological Disasters and Community Reception Centers (CRC)

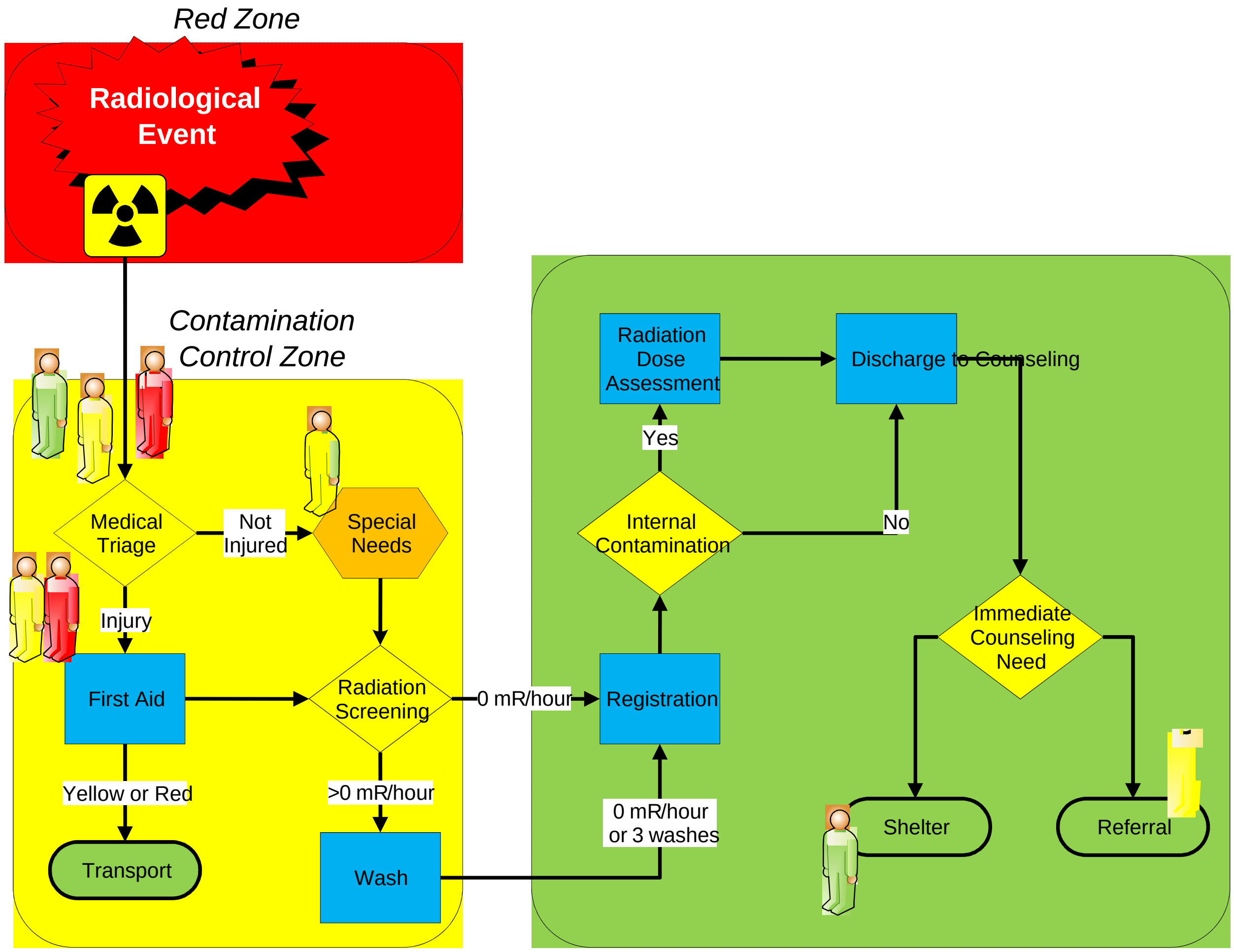

Figure 2. Standard Operating Procedure CRC Flowchart with First Aid and Triage made available before Radiation Screening. Zero (0) mR/hour indicates that the survivor is no longer radioactive. Yellow indicates that survivors have injuries that are moderately life-threatening, and Red indicates that the survivors have severely life-threatening injuries. Survivors are transported to a nearby hospital.

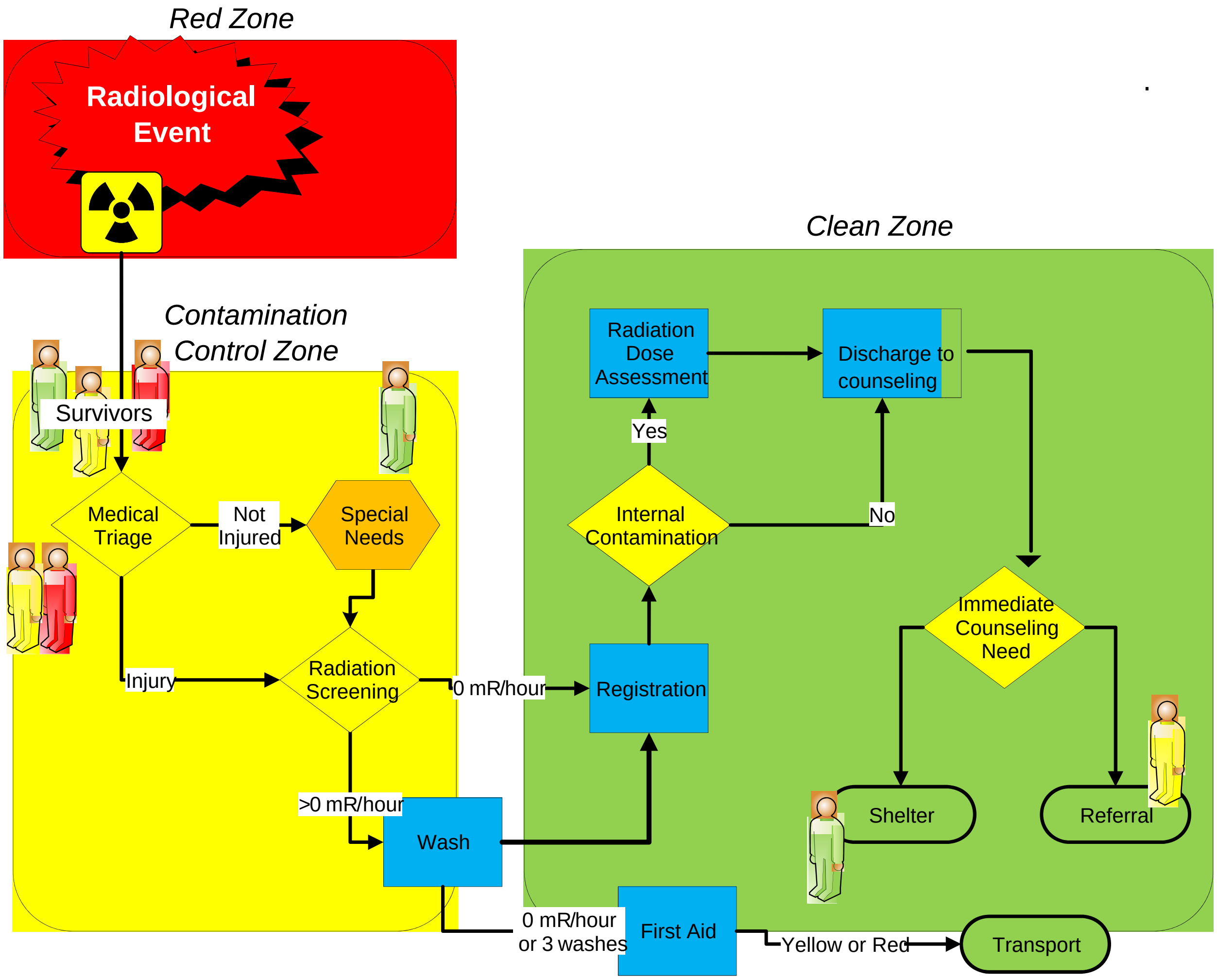

Figure 3. The Community Reception Center Process Flowchart Developed by the Principal Investigator and Research Assistant. 0 mR/hour indicates that the survivor is no longer radioactive. Yellow indicates that survivors have injuries that are moderately life-threatening, and Red indicates that the survivors have severely life-threatening injuries. Survivors are transported to a nearby hospital.

With civilian safety in mind, Emergency Response Guidelines (Federal Emergency Management Agency [FEMA], 2012) state that priorities for rescue, life-saving, first aid, and fire control are of higher priority than the priority for radiological assessment. Based upon literature review and professional training during an internship in 2012 with the Greene County Ohio

Combined Health District (GCCHD), the PI challenges the prevalent view that CRC responders should treat non-life threatening injuries before radiological screening and decontamination. Previous paradigms established by the CDC practice first aid treatment foremost for initial actions in response to radiological incidents (Caspary, 2012). However, in a CRC that is deemed to be a sanctuary for individuals who are uninjured and potentially exposed to radiation, it is important to screen for radiological exposure and decontaminate exposed survivors first and then provide first aid. For this group of survivors, radiation exposure is the greater danger, both to themselves and others with whom they will be in contact at the next aid station.

In return, this "screen first" method should provide assurance to the population that they are protected from unseen radiological contamination at the reception center. Community receptionists can quickly screen survivors with portable radiation detectors before transportation to a nearby hospital (if needed). Therefore, medical personnel coming in contact with the contaminated life-threatened patients can better protect themselves and others from cross-contamination.

Research Question

The question addressed in this project was as follows: *Is a public health professional's preferred routing of a post-radiological disaster displaced population arriving at a Community Reception Center (CRC) in seek of aid influenced by providing different flowcharts in a scenario?* This was answered by providing two randomly assigned groups of public health professionals on of the two flowcharts and comparing survey answers between the two groups. One of the provided flowcharts placed radiological screening and decontamination before first aid triage (novel protocol), while the other presented first aid and medical transportation before radiological screening and decontamination (the CDC standard protocol). This research question was driven by public health agencies' responsibility to assess and monitor people potentially tainted with radioactive material or exposed to radiation during a hazardous disaster with widespread contamination. The research hypothesis was that flowcharts would influence participants' triaging answers despite their training in the CDC standard protocol (triage before screening and decontamination). The first assumption in the scenario was that acute injuries are rare; the second assumption was that contamination is widespread but of relatively low level (5 to 10 µRoentgen Equivalent in Man [REM] per hour); the third assumption was that concern and panic would need to be minimized to prevent longer-term mental health effects; and the fourth assumption was that preservation of in-service personnel is the paramount concern.

Literature Review

Medical Consequences of Radiological Events

Radiological incidents may be the result of an intentional act such as terrorism, an accident, or general mismanagement. They can also be linked to different industrial products including federal and commercial nuclear weapons or technologically enhanced radioactive material (US Department of Health and Human Services [DHHS], 2005). Early in the event during the acute stages of the disaster, life threatening conditions must be addressed with a focus on limiting extremes of radiological exposure. Later in the event, recognition of wider zones of contamination may be recognized after radioactivity fallout has dropped, with evacuations ordered from the affected areas (Institute of Medicine, 2009).

The magnitude of a radiological incident not only affects a survivor's mentality but also his or her transportation to safety and care. Disruption of transportation routes due to the influx of emergency response and government orders to shut down streets leads to the inability for rescue personnel to reach the incident site and begin set up. The influenced population trying to self-evacuate will also impede effective transport of victims to medical care (IOM, 2009). Following a large casualty disaster it is usually necessary to distribute survivors to definitive care locations across a broader province, as the local emergency rooms quickly become occupied. Incidents concerning radiation will require an even larger distribution of victims to find available shelter and secure the needed specialty services for radiological-related injuries and screenings (Adams & Boscarino, 2011). With appropriate planning and resources the community reception center and co-located general shelter could fulfill the immediate needs of survivors while awaiting connection to needed services. The premise of this CE is how to best include radiation exposure screening and triage.

The presence of a person exposed to radiation influences triage, transport, and treatment strategies due to the impact of potential continued contamination of emergency responders from that survivor. Medical injury from radiation exposure can be described by three broad categories: Acute Radiation Syndrome (ARS), chronic effects of radiation, and radiation-induced cancer (Caspary, 2012). These three categories of radiation exposure are pertinent to this culminating experience project because the decontamination and internal radiation dose assessment teams within reception centers screen for all radiation levels across a broad spectrum.

Rotz, Khan, Lillibridge, Ostroff, and Hughes (2002) explain that ARS is due to complete or partial body exposure to a radiation dose above 1 Gray (Gy). A single Gy unit is equivalent to 1 Roentgen Equivalent in Man (REM), which is a large dose considering one REM carries a 0.055% chance of developing cancer. This dosage will likely create mild clinical effects such as vomiting and nausea; doses greater than 2 Gy will require urgent treatment for possible organ toxicity (Rotz, Khan, Lillibridge, Ostroff, & Hughes, 2002). ARS includes, by increasing dose: harmful effects to the central nervous system, gastrointestinal syndrome, cutaneous syndrome, and hematopoietic syndrome. The severity of these syndromes will increase with more radiation exposure. On average humans only experience 0.0015 REM for every medical or dental x-ray scan (DHHS, 2005). Therefore, the minimum radiation dosage required to qualify for ARS is equivalent to receiving over 60 x-ray scans at one time. ARS can result in death within approximately ten minutes if the radiation dosage is 5,000 REM or higher, which was the case in the 1986 Chernobyl nuclear plant accident (IOM, 2009).

Unlike acute radiation effects, long-term effects of radiation include organ dysfunctions that surface months to years after initial exposure and tissue fibrosis (Rotz et al., 2002). The lung is the major organ at-risk and a dose greater than eight (8) Gy to cause tissue fibrosis. Other organs/tissues require substantially higher doses than 8 Gy to cause chronic effects: doses greater than 12 Gy are usually lethal (Rotz et al., 2002). Untreated chronic radiation exposure and a single large dose greater than 5,000 REM can cause cancer. Radiation-induced cancer usually occurs years, and sometimes even decades, following initial exposure before diagnosis. Although the likelihood of developing cancer is dependent on the dose of radiation exposure, the severity of the cancer is not related to dose (IOM, 2009).

There is debate involved on whether the risk of cancer increases linearly with increasing dose at the low end of the dose range (less than 10 cGy), and whether exposure to these small doses are even pre-markers to cancer is questionable (Rotz et al., 2002). Nonetheless, the linear relationship is used for radiological protection purposes. Guidelines have been established for occupational and industrial purposes suggesting that annual radiation exposure not exceed 5 REM per year (Rotz et al., 2002). Guidelines state that exposures from any source, except for medical treatment, safety shall be optimized in order that the number of people exposed all be kept as low as reasonably achievable, with the restriction that the doses to individuals delivered by the source be restricted to dose constraints and the magnitude of individual doses must be warranted by medical treatments (Rotz et al., 2002). Also Rotz and colleagues (2002) mention that all abrasions and cuts be covered so that no radioactive material may enter the wound.

CRCs and Emergency Shelters

The order in which to conduct first contact in the reception area to persons requiring assistance after a radiological emergency requires attention because Community Reception Centers (CRC) are a fairly new paradigm (FEMA, 2012). Correct triaging of the displaced population arriving at the center is central to proper emergency care. Once survivors are correctly triaged, they can remain in the CRC's adjunct Emergency Mass Care Shelter or a nearby general shelter (FEMA, 2012).

The term Emergency Shelter means "any facility with overnight sleeping accommodations, the primary purpose of which is to provide temporary shelter for the homeless in general or for specific populations of the homeless" (US Department of Housing and Urban Development, 2012). Within this definition, some states differentiate a General Shelter from a Medical Needs Shelter with the major difference being that a General Population Shelter is utilized by able-bodied persons capable of self-care who are supported with food, sanitation, blankets, and trained staff. General Population Shelters must attempt to meet the current requirements for the Americans with Disabilities Act Services (FEMA, 2012).

The definition of shelter types is important to this discussion of radiological emergencies because if the process of reception is taken for granted, contamination may be spread and community's confidence in the public health system to respond may be impaired. This is especially true for this age of constant media scrutiny and immediate news dissemination. The loss of confidence could, in itself, cause further disengagement of persons seeking services, thereby worsening health outcomes. A well-designed process that effectively engages people seeking services will take into account the receptionists' role as the first points in service delivery and intake (IOM, 2009). This research considered previous CRC data alongside relevant literature to develop an effective response to radiological hazards.

CRC Training and Setup

A CRC is a local response strategy for conducting population monitoring and processing persons out of the hazardous zone to safer areas (CDC, 2012). They are normally located adjacent to the disaster site and a mass care shelter, although a mass care shelter can be located within the CRC. CRCs are public-health lead and coordinated by local and state officials (IOM, 2009). CRC infrastructure and staff exist prior to an emergency and operate in a pre-determined, but temporary, location during a biological or chemical disaster such as a nuclear accident or chemical spill (Caspary, 2012).

The CDC suggests annual trial practices with mock disasters be performed within CRCs (CDC, 2012). They are staffed with medical and administrative personnel, allied healthcare assistants, and volunteers responsible for emergency care delivery to "all hazards" survivors (Caspary, 2012). CRCs are designed to address the following emergency response objectives: initial sorting, contamination screening, first aid, decontamination, registration, and discharge of arriving radiological disaster survivors. These objectives are prioritized by flowcharts designed by the CDC or by an individual health department (CDC, 2012). In the past, minimal attention has been given to the role of public health emergency management of radiological emergencies until the proposed CRC concepts from CDC in 2005 (Caspary, 2012). Therefore, CRCs are a fairly new emergency response concept.

CRC facilities are established at or near emergency shelters typically run by the American Red Cross and supported by Medical Reserve Corps volunteers. Potential CRC sites require adequate showers and restrooms (Caspary, 2012). The chosen locations need to have well-defined exits and entries for crowd control. All-weather facilities such as convention centers or sports arenas with roofs are ideal. Agreements for such use must be instituted in advance with facility operators and owners (Culley & Effken, 2010).

A CRC may be a survivor's first point of emergency contact if he/she left the disaster site prior to Emergency Medical Service (EMS) personnel arrival or if they were in an area adjacent to the "ground zero" and are concerned about exposure (Pinney et al., 2003). There is therefore a need for CRC managers to consider the receptionist role as the first point in survivor service delivery and intake. Practicing the flowchart process within the CRC is imperative to improve the outcomes and engagement of people seeking emergency services (IOM, 2009). A community reception flowchart process developer can assist receptionists and volunteers by including all relevant radiation emergency first responders, developing a survivor intake system, and supporting them in their role as public health responders (Hodge & Costin, 2004).

Research has shown that community center receptionists profit from training related to communication skills and mental illness recognition and prevention (Brannen, Fannin, & McDonnell, 2013). Being able to recognize a survivor with a mental disability assists receptionists in assigning such survivors with special needs such as hygiene assistance for mentally challenged survivors during mass care sheltering. The research also shows that system review in terms of training the CRC flowchart and planning are beneficial to receptionists (Brannen, Fannin, & McDonnell, 2013). It is imperative that staff receive such training and knowledge prior to any hazard event. This is accomplished by 'situated learning', which is learning that takes place in the same context in which it is applied within mock disasters (Goldman & Kirtane, 2003). Thoroughly training CRC participants ensures proper execution of emergency responses to radiological and other biological disasters alike (Goldman & Kirtane, 2003).

CRCs in Radiological Events

CRCs are designed as points of dispensing for emergency supplies from the Strategic National Stockpile in case of radiological and biological threats (DHHS, 2005). Once survivors of such events are released from CRCs, each are given a set of discharge instructions explaining the follow-up protocol for the CDC, tribal, local, or state health departments for additional monitoring and medical evaluation (Caspary, 2012).

During the first days after a radiological disaster only limited federal help may arrive on-site depending on the scale of need for service (FEMA, 2012). State, local, and tribal responders will need to establish and conduct emergency operations until federal assistance arrives (Caspary, 2012). Local health departments in collaboration with the US National Response Team (NRT) take charge at the radiological hazard site (CDC, 2012). First responders include the local hazardous material response team, firefighters, police officers, and Emergency Medical Services (EMS).

Field Triage and Medical Sequelae

Chronic Care Triage (CCT) at the CRC can help determine if survivors requiring shelter should go to a medical shelter stocked with medical supplies or a general population shelter (Goldman & Kirtane, 2003). Pre-hospital treatment usually occurs at a field medical station or in an ambulance on its way to a hospital. Emergency support functions of a radiological event involving community mass care determines the following survivor care requirements: palliative care, delayed care, immediate care, or no treatment, and supports victim priority for transport to other care locations, such as mass care shelters and outpatient clinics (FEMA, 2012). Palliative care is medical care provided to relieve symptoms associated with illness such as stress and pain, while delayed care occurs when a survivor's symptoms are not unbearable (FEMA, 2012). Due to the potentially large number of civilians involved in radiological outbreaks, casualty collection points and on-scene treatments may be necessary to maximize the management of the number of survivors awaiting transport to CRCs and hospitals (DHHS, 2005). CRCs will be a focal point from where relocation to alternate homes, sheltering, and other services will occur.

Mass casualty radiological incidents require developing at least one Community Reception Center for decontamination and population monitoring is the process of immediate monitoring after an incident to control contamination and long-term monitoring to evaluate survivors' health statuses occurs in response to a hazardous emergency. Long-term monitoring follows for health effects from the event is conducted for a time decided by local, state, and/or federal agencies such as the CDC (Caspary, 2012).

Early radiological response teams working with local public safety are responsible for establishing a safety perimeter, evacuation zones, and the location of the CRC. Organizations such as the local public health department and hospitals work together to conduct population monitoring during biological hazards including radiological outbreaks (CDC, 2012). Survivors with life threatening conditions are immediately transported out of the CRC to the nearest emergency medical center (Caspary, 2012).

Other emergency response plans may be in place for public health incidents instead of, or in addition to a CRC. Many local emergency plans include a concept akin to the Modular Medical Emergency System (MEMS) which does not include general shelters and Alternative

Care Centers (ACS) which do include emergency sheltering (FEMA, 2012). These response systems provide surge capacity for different care centers to provide assistance including limited medical care for public health emergencies (Rotz et al., 2002). Some of these facilities are known as Neighborhood Emergency Help Centers (NEHC) and are established at well-known locations such as high schools or community pavilions (Culley & Effken, 2010). These facilities may be familiar by common use for weather-related emergencies.

Population monitoring starts immediately after a radiation incident is reported and continues until all those potentially affected have been evaluated for medical treatment needs, radioactive contamination and internal radioactive materials within the body, decontamination, radiation dose, health risks and long-term health effects from exposure (Pinney et al., 2003). The current CDC protocol places population monitoring at the medical centers. In the amended process suggested here population monitoring would start in the CRC. This would reduce the number of potentially exposed persons lost to follow-up if they leave the CRC on their own and relieve the influx of citizens without acute injuries to local hospital emergency rooms. A CRC staffed with receptionists and volunteers with adequate resources, including physicians and nurses, results in a more prepared county and health department (Brannen, Fannin, & McDonnell, 2013).

State and local radiation exposure guidelines agree about that population monitoring as a critical function to prevent further contamination and civilian casualties during environmental disasters (DHHS, 2005). The guidance places responsibility on the state and local agencies to launch and assess population monitoring plans because the community may be troubled about potential radiological contamination after a radiation disaster (DHHS, 2005).

Monitoring mass-casualty populations does not only concern victims, but also includes emergency responders. It is common for radioactive and other hazardous particles and fibers to become airborne when affected individuals remove contaminated clothing (Brannen et al., 2011). The first responders engaged in screening of survivors are asked to wear protective gear that incorporates respiratory protection as designated by disaster site safety officers (Rubonis & Bickman, 1991). At the radiological disaster site and within community reception centers, it is highly recommended that all responders wear filtering face-piece respirators, also known as N-95 respirators, to prevent inhalation of particles carried by survivors (Caspary, 2012). The CDC suggests filter/N-95 respirators be equipped with exhalation valves to improve communications (CDC, 2012).

Although current research recognizes time as a crucial variable to any radiation dose, CDC-formatted reception centers triage for first aid and urgent medical evacuation before radiation screening. CDC's reception center guidelines state that medical care evaluations and hospital transport, if necessary, be applied to each radiological survivor prior to radiation screening (CDC, 2012). This implies that survivors that are need for urgent care will leave the reception center not knowing whether or not they are contaminated while the main point to CRCs is to determine which survivors are radioactive. This traditional "first-aid-and-medical-transport-first" method is flawed because majority of community reception center arrivals do not require urgent medical need or transport to a nearby hospital, but many may have low levels of radioactive decontamination requiring spot field decontamination (Brannen, Fannin, & McDonnell, 2013). Therefore, this protocol only increases radiation doses and cross-contamination between survivors. In a terrorism situation this feasibly may exacerbate the goals of terrorists to create fear and distrust of the responding authorities.

During mass-casualty disasters, emergency medical service providers give the initial triage, transport, and treatment (Brown et al., 2009). However, in larger events, survivors are more likely to use non-emergency medical services or self-transport to the nearest hospital or CRC, so that survivors may request care beyond immediate threats to life. This type of care is known as Chronic Care Triage (CCT) and is an additional function CRC. CCT is conducted via standard mental and physical health evaluations administered by healthcare providers within the reception center (Adams & Boscarino, 2011). These evaluations consist of surveys that ask questions about a survivor's emotional state and physical symptoms of stress such as shortness of breath (Adams & Boscarino, 2011).

Radiological-related injuries are not always visible and some, such as psychosocial issues, may require extensive chronic care. Psychosocial injuries are common after radiation exposure and affect hundreds to thousands who may seek help and information about their exposure level and potential health risks (Hamer, Endrighi, Venuraju, Lahiri, & Steptoe, 2012). Mental health triage addresses these psychological issues so that those affected do not self-refer to a nearby hospital and overtax emergency resources (Hamer et al., 2012). These concerned victims will seek radiological screening because they want to be assured that their health will not deteriorate. If gone untreated, psychosocial symptoms can manifest into nausea and vomiting as a result of anxiety (Hamer et al., 2012). Once the victim is triaged into a mental health assessment, health professionals counsel to reassure safety and provide radiation exposure fact sheets (Rubonis & Bickman, 1991). Mental health triage can be incorporated as part of the community mass care operations conducted at a community reception center (Brannen, McDonnell, Price, Alsept, & Caudill, 2013).

The range of the acute medical consequences of a radiological exposure include both permanent and temporary blindness, continued exposure to high doses of radiation, burn and blast injuries, and trauma from structural collapse (Feldman et al., 2005). Injuries including a combination of physical and radiological harm have a larger fatality rate than the summation of individual traumas. It is important to note that traumatic injuries from a nuclear explosion can take place in the absence of radiological exposure, and likewise, radiological exposure can happen without other injuries (Feldman et al., 2005).

For routine radiological screenings, a standard head-to-toe radiation survey method is practiced and includes documentation of all survey findings (Hodge & Costin, 2004). However this is not the recommended survey methodology for mass casualty incidents because delay may increase the radiation dose while people are waiting. As recommended by FEMA, if a large number of people require surveys, performing a screening of only the face, head, hands, and shoulders (spot survey) is acceptable because these areas are more likely to be contaminated (Hodge & Costin, 2004). A head to toe survey should be done after spot screening and within 24 hours of initial exposure (CDC, 2012).

A hand-held radiation survey meter such as a Geiger-Mueller (GM) probe (Canberra Industries, Inc. Meriden, CT, USA) is adequate for either spot or detailed surveys because they are ubiquitous, versatile, and portable. GM probes detect alpha contamination, which consist of particles ejected by the nuclei of unstable atoms. Beta/gamma radiations, which in higher dose can be fatal, are detected with portal (walk-through) monitors that require radiologically experienced operators and are limited in number (Culley & Effken, 2010). “Dirty Bombs” are radiological dispersal devices that are used by terrorists to set off an explosion with a small amount of radiation (Gale & Lax, 2013, pg. 173). “Dirty Bombs” contain gamma radiation, and it suggested that CRCs be equipped with walk through monitors to detect the gamma particles (Gale & Lax, 2013, pg. 174).

Gross Field Decontamination (GFD), a decontaminate wash that occurs at the disaster site, rarely occurs due to the potential that another dirty bomb or biological hazard may happen immediately after the initial radiological disaster (Caspary, 2012). However, GFD can eliminate the radiation particles found on externally contaminated survivors and significantly reduces the amount of radiological material carried to the transportation vehicles and the downstream healthcare community. In general, disposing of exterior clothing and washing with mild soap and water removes most of the external radiological contamination (Caspary, 2012). If someone has been contaminated with radiation that person must remove his or her clothing and wash their skin with large amounts of soap and water (FEMA, 2012). The wash neutralizes all radioactive material, and therefore it is safe to allow the wash to flow down any drain after use. Contaminated clothing should be placed in a plastic bag (FEMA, 2012): local or state health departments or other authorized emergency personnel collect the contaminated clothing and incinerate the garments (Gale & Lax, 2013).

It is anticipated that spot decontamination would be the most prevalent process at the decontamination center designed as a part of the overall complex of operations near the CRC (e.g. medical needs shelter or hospital). After spot decontamination the survivor is again screened and triaged to the next CRC sub-station. However, according to current CDC protocol, if they again screen positive, the survivor must receive a nude self-wash/shower administered by him or herself at the CRC (CDC, 2012). If the survivor is still positive after the shower, then that survivor must be assessed for internal contamination dosage by a radiological specialist/ physician. If chelation is required due to internal contamination, it would be initially facilitated by the decontamination staff and followed by appropriate medical transport and services at the hospital (Brannen, Fannin, & McDonnell, 2013).

Methods

This secondary analysis used anonymous data collected by Greene County Combined Health District (GCCHD). Permission to use the anonymous data was granted by GCCHD Health Commissioner Mark McDonnell (Appendix 1), and IRB exemption was also granted (Appendix 2). In compliance with federal regulations, this research met the requirements for the policy of exemption of institutional board review. The GCCHD study design was a simple random assignment of raters to complete a single blind survey (either Survey A or Survey B).

These raters consisted of public health workers who were not involved in the design of the surveys, vignettes (clinical scenario survey questions), or flowcharts. There were two surveys, each consisting of the same scenarios, with different flow charts (Figures 1 and 2). These scenarios each consisted of a unique radiological incident survivor said to present to the Community Reception Center (CRC) seeking assistance. Every scenario presented had a single correct answer based upon an answer key developed using research assistant and GCCHD epidemiologist Donald Brannen's extensive experience in chronic care triage. The survivor either goes to special needs, radiation screening, registration, wash/decontamination, first aid, or transport. The status quo has persons going to medical triage then straight to first aid and then to transport regardless of contamination.

Every subject response ($n = 1$) was scored based upon how close their responses were to the PI and RA's answer key to the subject question. The six possible answer choices to each survey question (n) were as follows: A. Special Needs, B. Radiation Screening, C. Registration, D. Decontamination, E. First Aid, and F. Transport. There is only one best possible answer choice to each question/subject, however the PI and RA decided to rank each possible response in order from most correct to least correct catering specifically to each question. For example, the PI and RA may have decided the best possible answer choice for question #7 was B. Radiation Screening, and the second best was A. Special Needs, third best was E. First Aid, fourth best was D. Decontamination, fifth best was F. Transport, and the least and sixth best possible answer was C. Registration.

This made it possible to see how close each subject response was to the answer key. If the subject response scored exactly as the answer key's first ranked answer choice, then that subject was considered absolutely correct. If the subject response was not exactly as the answer key's response, then that subject was not absolutely correct. If the subject response scored one of the top 3 best answer choice for the given clinical scenario question/vignette, then that subject was considered mostly correct. If the subject did not choose one of the top three ranked answer choices for the given vignette, then that subject was not mostly correct.

The raters (n=66) did not know that the two surveys contained a different flowchart/ algorithm. Survey B's flowchart ("Novel") incorporated radiation screening prior to first aid and transport, while Survey A's flowchart ("Standard Operating Procedures/SOP") incorporated the traditional method of placing radiation screening after first aid and transport. Half of the raters were randomized survey A/SOP (n=33), while the other half was randomized to receive survey B/ Novel (n=33). Both surveys consist of the same 20 vignettes/questions. If each asked public health employee responds to a survey, we will have 1,320 surveyed radiological clinical vignettes completed. The process of which flowchart is more effective is what we are testing.

One assumption was that many of the persons evacuating to a public health run CRC will be mostly healthy (acutely injured will already have been evacuated or self-selected to seek treatment at care centers) and that about 10% will have functional needs (which in a wide dispersal radiological event includes those with positive radiation screening). Other assumptions were that acute injuries are rare; contamination is widespread but with relatively low levels (≤15 μ REM); concern and panic need to be minimized to prevent longer-term mental health effects; and that preservation of in-service personnel is crucial. The primary assumption is widespread but low radiation contamination has occurred and persons arriving at a CRC have minimal injuries. These flowcharts are not meant for first responders at the disaster site but for staff at a community reception center.

Every scenario has one "best possible" answer that has been established by RA, Donald Brannen and PI, Ameer Matariyeh and the percent correct of a fair choice of selecting the right triage was 16% without other prior knowledge. The percentage of correct triage selections was determined and compared between the two survey groups. The standard error and 95% confidence intervals were calculated for both groups of participants. The number of responses from Survey A were compared to responses from Survey B using a One-Way Analysis of Variance (ANOVA) to ensure that randomization was successful by comparing the means of correctly triaged clinical scenario questions. An analysis of covariance was conducted after exploratory analysis to determine if there was a significant difference in the percent of correct answers between the two surveys. Risk-based estimates are used to assess the probability of an unfortunate outcome happening. In this case, risk-based estimates were taken to determine the chances of cross-contamination between survivors and the general public if a rater incorrectly answers a scenario question.

Results

Table 1 displays the raw results for participant responses recommending treatment before decontamination and the potential to transmit radioactive particles to others, which is termed as "Radioactive Cross-Contamination", within the medical treatment zone of the Community Reception Center (CRC). Eight survey participants completed the survey with the "Treatment Before Decontamination, Survey A" flowchart (TDA) and answered/triaged a total of 20 survivor questions/subjects (n) each resulting in 160 responses (n=160). The subjects were not real persons and did not receive any form of physical treatment. Of the 160 subjects, 125 were triaged to areas within the CRC where they could not spread radiation to non-contaminated subjects, (cross-contamination).

Table 1

A Comparison Between the Subjects that Received Treatment before Decontamination and a Potential for Transmitting Further Radioactive Contamination

	Radioactive Cross-Contamination		Total
Flowchart A (SOP)	35	125	160
Flowchart B (Novel)	30	110	140
Total	65	235	300

Therefore, 78% triaged in the way I proposed which is focuses on screening before treating survivors. Specifically, these are subjects that are either arriving to the CRC that are not carriers of radiation or they are infected with radiation but are triaged to other contaminated areas of the CRC such as Radiation Dose Assessment station. Therefore, they cannot potentially contaminate the survivors who screened negative for radiation. However, 35 radiation positive subjects did potentially cross-contaminate by being triaged to areas where radiation levels are supposed to be non-existent, such as the first aid station. This resulted as a 22% chance cross-contamination when participants triaged survivors using Survey A.

In comparison, seven survey participants completed the "Decontamination before Treatment, Survey B" survey and answered/triaged a total of 20 subjects resulting in 140 responses (n=140). Of the 140 subjects 110 did not potentially cross-contaminate other survivors, but 30 subjects were triaged to stations where they can cross-contaminate others. As a result, there is a 21% chance of cross-contamination when subjects were triaged using survey B. Although it may not be a significant difference, there is a 1% less chance of cross-contamination when subjects are guided using Survey B's rather than Survey A's flowchart.

Table 2 contains the Chi Square test type with the correlating P-values. The research hypothesis states that addressing mandatory radiation decontamination before mandatory medical treatment yields a greater percent of correctly triaged survivors, (survivors triaged the same as epidemiologist Donald Brannen had selected), within the CRC than addressing medical treatment before mandatory decontamination. The null hypothesis states that addressing mandatory radiation decontamination before mandatory medical treatment does not yield a greater percent of correctly triaged survivors within the CRC than addressing medical treatment before mandatory decontamination. In this case, the P-value was 0.5194. This result is not statistically significant at the 0.05 level. Therefore, these data claim that addressing mandatory radiation decontamination before mandatory medical treatment yields a greater percent of correctly triaged survivors, (correct answers to the survey questions), within the CRC than addressing medical treatment before mandatory decontamination.

Table 2

A Chi Square Analysis with Corresponding P-Values of Percent Correctly Triaged with Flowchart A and Flowchart B

Chi Square and Exact Measures of Association		
Test	p-value (1-tail)	p-value (2-tail)
Fisher Exact	0.5194	>0.9999

Table 3 takes risk estimates into consideration. The "exposed" are the scenario questions answered using the novel flowchart in Survey B created by the PI, and the unexposed are the scenario questions answered using the standard operating procedure flowchart in Survey A that placed medical treatment before decontamination. The table reveals that there is a 21.88% risk of incorrectly triaging the survivor using Survey B with a Confidence Interval (C.I.) of 16.14% and 28.93% in the upper and lower limits, respectively. Since the C.I. is larger than 10% the treatment, which in this case is the flowchart found in Survey B, it is not very useful according to Taylor Series Calculations (Khamis, 2011). There is no p-value associated with risk-based estimates. The unexposed subjects that used the flowchart in Survey A have a lower risk of being incorrectly triaged. Survey A's risk is 21.43 % (C.I. 15.4% - 28.98%), which shows that this flowchart is also not very useful in correct survivor placement. The overall risk is 21.67%.

Table 3

Potential Cross-Contamination Resulting from Incorrectly Triaged Survivors

Risk-Based Estimates and 95% Confidence Intervals			
Point Estimates		Confidence Limits	
Type	Value	Lower, Upper	Type
Risk of Incorrectly Triaged (Flowchart B)/ Novel	21.88%	16.14, 28.93	Taylor series
Risk of Incorrectly Triaged (Flowchart A) /SOP	21.43%	15.4, 28.98	Taylor series
Overall Risk	21.67%	17.37, 26.68	Taylor series
Risk Ratio	1.021	0.663, 1.572[1]	Taylor series
Risk Difference	0.4464%	-8.893, 9.786°	Taylor series
Etiologic fraction in Pop. (EFP)	1.099%	-21.89, 24.09	
Etiologic fraction in Exposed (EFE)	2.041%	-50.84, 36.38	

The risk ratio of 1.021 indicates that risk in the exposed group is slightly greater than that of the non-exposed group with a risk difference of 0.4464%. This is attributable to the one difference in the two surveys - the placement of medical treatment and transport within the CRC. The etiologic fraction in the population (EFP) is the attributable risk, defined as the difference in the rate of an illness or disease between the exposed and unexposed population (Friis & Sellers, 2009). Table 3 shows the EFP of 1.099%; therefore the population of radiation hazard survivors is at a reduced risk of being incorrectly triaged by just over 1% in response to a radiological disaster with the help of Survey A's (SOP) CRC flowchart. However, with the use of the flowchart in Survey B (Novel), the population is at a reduced risk of being incorrectly triaged by just over 2% during a radiation related emergency community reception response. This small percentage is not statistically significant; however, it makes a practical difference when designing a CRC.

Table 4 lists odds-based estimates with corresponding C.I.s. The Conditional Maximum Likelihood Estimate (CMLE) is an odds ratio that measures the association between an exposure and an outcome (Friis & Sellers, 2009). This represents the odds that the predicted outcome will take place given a certain exposure, compared to the odds of the outcome occurring without the presence of that exposure (Friis & Sellers, 2009). The research predicted outcome is that each subject is triaged correctly when using Survey B (Novel) flowchart. The CMLE value is 1.027, which translates to the exposure associating with the higher odds of the outcome. According to this value, there is a 2.7% increase in chance that the subjects will be correctly triaged when participants follow Survey B flowchart instead of Survey A (SOP) flowchart.

Table 4

Odds of Correct Triaging with Survey B Flowchart (Novel)

Odds-Based Estimates and Confidence Limits		
Point Estimates		Confidence Limits
Type	Value	Lower, Upper
CMLE Odds Ratio	1.027	0.5708, 1.854
Etiologic fraction in pop.	1.399%	-27.77, 30.57
Etiologic fraction in exposed	2.597%	-68.96, 43.85

The C.I. associated with this value was used to estimate the precision of the odds ratio. A small C.I. indicates a higher precision of the odd ratio, whereas a large C.I. indicates a low level of precision of the odds ratio (Friis & Sellers, 2009). The CMLE value has an associated C.I. of 0.5708 to 1.854. This range has a greater than 10% difference between the upper value of the interval and the lower value. Therefore, according to academically respected and universally acknowledged statistician Karl Pearson, the CMLE odds ratio has a low level of accuracy in predicting the chance of subjects being correctly triaged using the Survey B flowchart exposure. It is important to note that the C.I. does not report a measure's statistical significance. It is inappropriate to interpret the odds ratio with 95% C.I. that has a large interval range as indicating evidence for lack of correlation between the outcome and the exposure (Friis & Sellers, 2009).

Table 4 reports an etiologic fraction in population as 1.399% with a C.I. ranging from 27.77 to 30.57. This translates to a chance increase of 1.399% of the amount of people saved from the radiation exposure when subjects are triaged using the generic Survey A (SOP) flowchart. The large C.I. indicates a low level in precision. However, the etiologic fraction in exposed is 2.597% with a C.I. ranging from -68.96 to 43.85. This means that there is a 2.597% increase in chance of survivors being saved from radiation exposure as a result of being correctly triaged using the private researcher's flowchart found in Survey B (Novel). In theory, the population being exposed to Survey B flowchart will experience a 1.198% greater chance of being triaged correctly than the population that will be using Survey A flowchart.

Table 5 reports three variables associated with each survey group. The first variable asks each survey participant how comfortable they would feel participating in a real radiological event emergency response. Survey B/Novel subjects were exposed to the non-generic "Decontamination Before Treatment" flowchart created for the original Greene County study (variable group), and Survey A subjects were given the SOP "Treatment Before Decontamination" flowchart followed in past CRCs. Survey B had a total of seven survey participants who each answered 20 clinical scenario questions resulting in 140 responses (n = 140). Of the 140 subjects in Survey B's group only 40 subjects, or 25% of the subjects, were triaged by a comfortable survey participant, while 100 subjects, were triaged by a survey participant who does not feel comfortable being asked to participate in a radiological event. This translates to 2 out of the 7 participants of Survey B as comfortable to respond to a real radiological event.

Table 5

Post Hoc Check of Randomization in Future: Assign Test Groups Based on Comfort with Radiological Events

		Group			
		Radiation Screening and Chronic Care Triage DTB Survey B (Novel)		Radiation Screening and Chronic Care Triage TDA Survey A (SOP)	
		Count	Row N %	Count	Row N %
How comfortable would you feel if asked to participate in a real radiological event?	Not Comfortable	100	75%	40	25%
	Comfortable	40	25%	120	75%

Survey A/SOP had a total of 8 survey takers that responded to 20 clinical questions/ vignettes (n) resulting in 160 responses (n = 160). Of the 160 participants that followed the "Decontamination before Treatment" flowchart, 120 participants (75%) reported "comfortable" if participating in a real radiological event, whereas 40 participants (25%) reported they would not feel comfortable participating in a real radiological event. This suggests that the PI and RA's "Decontamination before Treatment" flowchart does not provide as much comfort to public health employees responding to a radiological event as a "Treatment before Decontamination" flowchart. The flowcharts have opposite effects, and it is possible that the randomization was affected by peoples' comfort coming into the study as opposed to the flowchart received.

Table 6 shows the scores of subjects correctly triaged. In terms of absolute correctness, Survey B/Novel, which contained the flowchart placing decontamination before medical treatment, had a total of 65 (n = 65) out of 140 subjects (46.4%) that were triaged to the best possible answer choice and therefore were “absolutely correct”. This survey group had a total of 75 subjects (n = 75) that were not triaged to the best possible answer choice and therefore were not “absolutely correct”. Survey A/SOP, which contained the flowchart placing medical treatment before decontamination, had a total of 64 (n = 64) out of 160 subjects (40%) triaged to the best possible answer choice and therefore were “absolutely correct”. This survey had a total of 96 subjects (n = 96) that were not triaged to the best possible answer choice and therefore were not absolutely correct. Survey A had a total of 40% of its subject responses triaged “absolutely correct”. When comparing the two surveys, Survey B/Novel has a 6.4% greater amount of subjects triaged “absolutely correct”.

Table 6

Subjects Correctly Triaged

		Group					
		Flowchart B (Novel)			Flowchart A (SOP)		
		Count	Row N %	Mean Absolute Correct	Count	Row N %	Mean Absolute Correct
Best Possible Answer	Incorrect	75	53.6%		96	60%	
	Correct	65	46.4%		64	40%	
Acceptable Answers	Answered 3 Least Correct Possible Choices	37	26.4%		46	28.8%	
	Answered 3 Most Correct Possible Choices (Includes Best Possible Answer)	103	73.6%		114	71.2%	
Triage Score				0.68			0.63

In terms of mostly correct, Survey B/Novel had 103 subjects (n = 103) that were triaged to one of the top three answer choices and 37 subjects (n = 37) that were not triaged to one of the top three answer choices. Survey B had 73.6% of its subject responses as mostly correct. Survey A had 114 subjects (n = 114) triaged as mostly correct and 46 subjects (n = 46) that were not triaged as mostly correct. Survey A had 71.2% of its subjects triaged as mostly correct. When comparing both surveys, Survey B had 2.4% more of its subjects triaged more as mostly correct than Survey A.

Figure 4 is a data plot measuring the comfort of the survey responder with the amount of survivors triaged "absolutely correct". The graph suggests that the survey participants who would not be comfortable responding to an actual radiological event after taking either survey correctly triage more scenarios than those who would feel comfortable. Within the "Uncomfortable Group", those who used Survey A's flowchart (SOP) of "Treatment before Decontamination" scored a higher amount of correctly triaged than those who used Survey B's flowchart of "Decontamination before Treatment". However, within the "Comfortable Group", those who triaged subjects using Survey B's flowchart scored a number of correctly triaged subjects than those who used Survey A's flowchart. Figure 5 showed that despite other variables, those who triaged using Survey B's flowchart of "Decontamination before Treatment" scored a higher mean of correctly triaged subjects than the subjects triaged using Survey A's "Treatment before Decontamination".

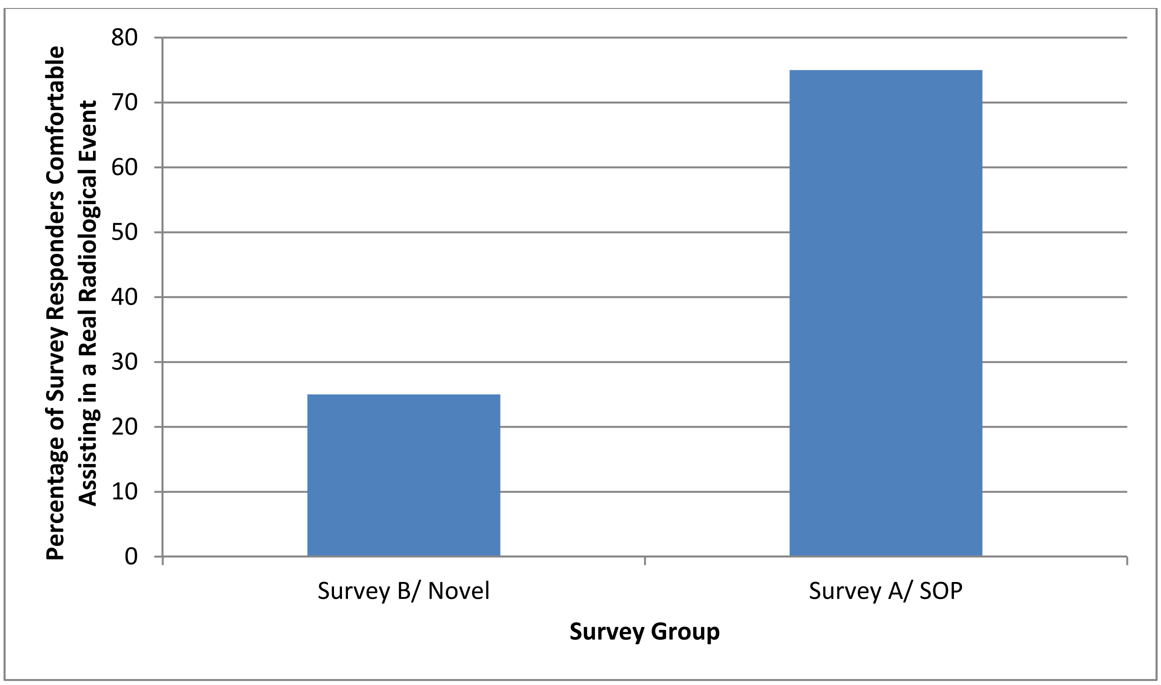

Figure 4. Comfort level of survey responders. "How comfortable would you feel if asked to participate in a real radiological event?"

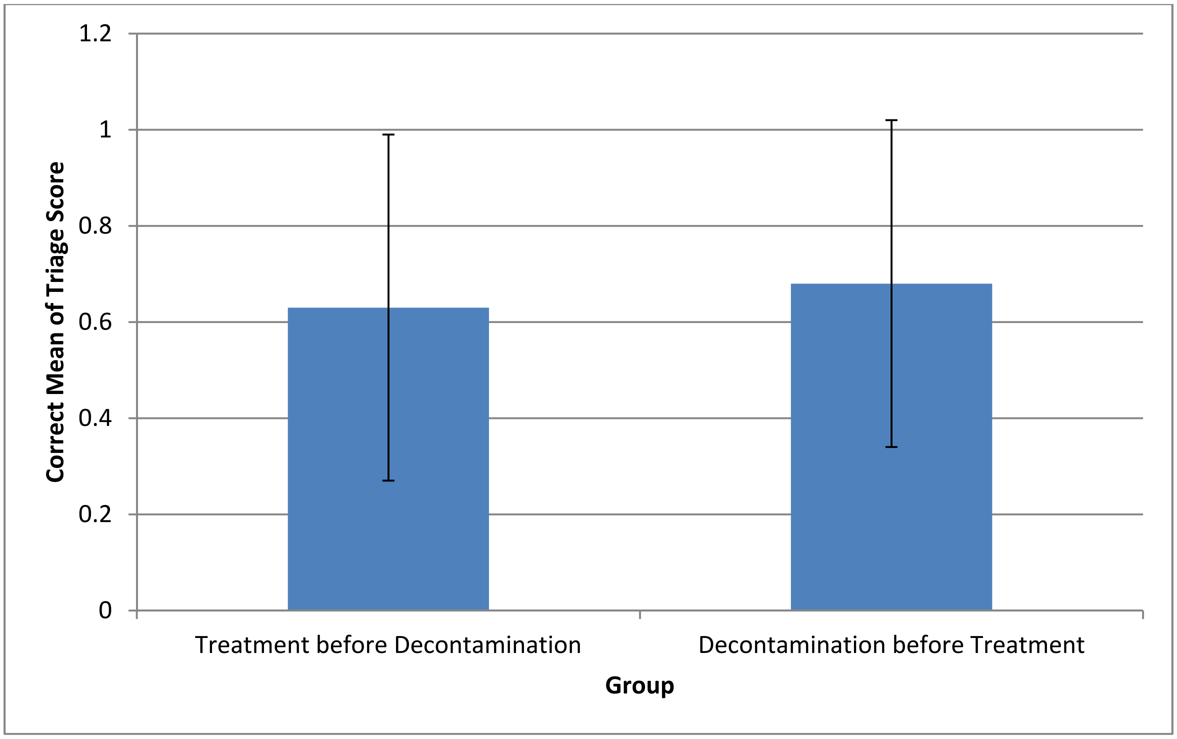

Figure 5. Survey group plotted against mean of correct triage score.

Discussion

The public health implications identified as a result of this study are the following: Fear of radiation is high and although the first priority in response to any type of disaster is to preserve life, precautions to prevent further contamination should be considered. Due to the general populations unfamiliarity with radiation, including public health professionals, clear communication and information before and during an emergency will help to reduce public fear and in return will yield more appropriate response decisions. Precautions such as practicing triage exercises within a Community Reception Center and establishing a venue prior to a radiological disaster in response of such an emergency should be established. Personal/ professional opinions seemed to outweigh the flowcharts' influence. Although the PI and RA created flowcharts did not have much of an influence, the survey responders displayed popular support for the idea of decontaminating survivors before first aid treatment.

Although this research was carefully planned, there were limitations. First, the data collections portion of the research was conducted over a one week trial due to last minute corrections of survey formatting. In the one week time span we only received 15 survey participants. Second, the demographic of the survey population consisted of only Greene County Combined Health District (GCCHD) employees. The survey lacked diversity in participants and would have had a greater diversity if the Dayton Metropolitan Medical Response System (MMRS) responded to our survey. We distributed the survey to Dayton MMRS, but received zero responses. Their emergency response and radiation experience would have been greatly appreciated.

Conclusion and Recommendations

Triage following a radiological accident is more complex than in other mass-casualty disasters. Field trauma triage systems used by initial responders at mass-casualty sites do not properly account for the chance of further contamination between survivors with radiological, chemical, biological, or nuclear material (Brannen et al., 2013). Thus, I recommend that CCT along with screening for contamination practiced in reception centers is utilized to screen survivors prior to admission to hospitals and mass care shelters, isolating those contaminated from survivors with no radiation dosage. If a survivor does not screen positive for radiation, then he or she can move onto another triage station until said survivor ends up in mass care shelter or home. The challenges of a radiological event including limited available outcome data and multiple injury types suggests that a consensus approach to establishing comprehensive triage systems including CCT, fast mental health triage, radiological screening and medical triage would be most valuable (Brannen, Fannin, & McDonnell, 2013).

Treatment of survivors and field management of a radiological incident also presents more challenges than other mass-casualty accidents given the possible geographic scope of the radiation-filled environment that may result. Therefore, a triage process practiced within a reception center in a safe zone is an adjunct to the public safety medical emergency triage conducted separately at or near the initial radiological release event site (Goldman & Kirtane, 2003). The paradigm of an expedited population-level triage process described by Brannen, Fannin, and McDonnell (2013) screens for lower level contamination quickly as opposed to those near the event expected to present with burn and trauma injuries, with a case mix of radiologically contaminated, radiation sicknesses, and multiple injuries requiring medical attention.

Fear of radiation is high and although the first priority in response to any type of disaster is to preserve life, precautions to prevent further contamination should be considered. Practicing triage exercises within a Community Reception Center and establishing a venue prior to a radiological disaster in response of such an emergency should be established. Although the PI and RA created flowcharts did not have much of an influence, the survey responders displayed popular support for the idea of decontaminating survivors before first aid treatment. I suggest that mental health triage is imperative for radiological event CRCs and must include radiation exposure fact sheets and referral guidelines. When coupled with radiological screening, this will give the public a sense of safety.

References

Adams, R. E., & Boscarino, J. A. (2011). Per event panic attack and depression after the World Trade Center disaster: A structural equation model analysis. *International Journal of Emergency Mental Health, 13*(2), 69-79.

Brannen, D., Fannin, A., & McDonnell, M. (2013). Evaluation of algorithms for chronic care triage prior to community mass care. [Abstract] and poster presentation presented at the Public Health Preparedness Summit, Atlanta, 2013. Retrieved online May 1, 2013, from http://naccho.sclivelearningcenter.com/index.aspx?PID=6192&SID=170124

Brannen, D. E., McDonnell, M. A., Price, A., Alsept, C., & Caudill, K. (2013). Randomized evaluation of two mental health triage tools in medical cleared disaster survivors by MRC volunteers and public health workers. *Disaster Medicine and Public Health Preparedness, 7*(1), 20-28.

Brannen, D. E., Schmitt, A., & McDonnell, M. (2011). Critical issues faced by MRC in a special needs shelter. *Domestic Preparedness Journal*, *7*(5), 17-21.

Brown, L. M., Bruce, M. L., Hyer, K., Mills, W. L., Vongxaiburana, E., & Polivka-West,L. A. (2009). Pilot study evaluating the feasibility of psychological first aid for nursing home residents. *Clinical Gerontology*, *32*(3), 293-308. doi:10.1080/07317110902895317

Caspary, K. (2012). *Radiation emergency preparedness tools: Virtual community reception center*. Retrieved December 15, 2012, from http://www2c.cdc.gov/podcasts/media/pdf/Radiation_VirtCommunRecepCtrl.pdf

Centers for Disease Control and Prevention. (2012). Radiation. Retrieved from http://emergency.cdc.gov/radiation/

Culley, J. M., & Effken, J. A. (2010). Development and validation of a mass casualty conceptual model. *Journal of Nursing Scholarship*, *42*(1), 66-75.

Federal Emergency Management Agency [FEMA]. (2012). *CFDA 97.067 Homeland security grant program.* Retrieved December 20, 2012, from https://www.rkb.us/grantdetail.cfm?grant_id=627

Feldman, J. M., Siddique, M. I., Morales, E., Kaminski, B., Lu, S. E., & Lehrer, P. M. (2005). Psychiatric disorders and asthma outcomes among high-risk inner-city patients. *Psychosomatic Medicine, 67*(6), 989-996.

Friis, R., & Sellers, T. A. (2009). Epidemiology for public health practice (1st ed.). Burlington, MA: Jones & Bartlett.

Gale, R. P., & Lax, E. (2013). Radiation: What it is, what you need to know (1st ed.). New York: Alfred A. Knopf/Random House, Inc.

Goldman, L., & Kirtane, A. J. (2003). Triage of patients with acute chest pain and possible cardiac ischemia: The elusive search for diagnostic perfection. *Annals of Internal Medicine, 139*(12), 987-995.

Hamer, M., Endrighi, R., Venuraju, S. M., Lahiri, A., & Steptoe, A. (2012). Cortisol responses to mental stress and the progression of coronary artery calcification in healthy men and women. *PLoS One, 7*(2), e31356.

Hodge, J. G., & Costin, L. O. (2004). Public health practice versus research: A report for public health practitioners including cases and guidance for making decisions. Atlanta, Georgia: Council for State and Territorial Epidemiologists.

Institute of Medicine [IOM]. (2009). Guidance for Establishing Crisis Standards of Care for Use in Disaster Situations. Letter Report, Board on Health Sciences Policy, September 24, 2009. Retrieved from http://www.iom.edu/Reports/2009/DisasterCareStandards.aspx

Pinney, S. M., Freyberg, R. W., Levine, G. E., Brannen, D. E., Mark, L. S., Nasuta, J. M., … & Wones, R. (2003). Health effects in community residents near a uranium plant at Fernald, Ohio, USA. *International Journal of Occupational Medicine and Environmental Health, 16*(2), 139-153.

Rotz, L. D., Khan, A. S., Lillibridge, S. R., Ostroff, S. M., & Hughes, J. M. (2002). Public health assessment of potential biological terrorism agents*. Emerging Infectious Diseases, 8(*2), 225-230. Retrieved from http://wwwnc.cdc.gov/eid/article/8/2/01-0164_article.htm

Rubonis, A. V., & Bickman, L. (1991) Psychological impairment in the wake of disaster: The disaster-psychopathology relationship. *Psychological Bulletin, 109*(3), 384-399.

US Department of Health and Human Services [DHHS]. (2004). Mental health response to mass violence and terrorism: A field guide. DHSS Pub. No.SMA3959. Rockville, Maryland: Center for Mental Health Services, Substance Abuse and Mental Health Services Administration. Retrieved from http://store.samhsa.gov/shin/content/SMA04-3959/SMA04-3959.pdf

US Department of Housing and Urban Development. (2012). United States housing. Retrieved 12/15, 2012, from http://www.gpo.gov/fdsys/pkg/CFR-2003-title24-vol1/pdf/CFR-2003-title24-vol1-sec91-5.pdf

Appendix A – List of Tier 1 Core Public Health Competencies Met in CE

Domain #1: Analytic/Assessment
Use variables that measure public health conditions
Use methods and instruments for collecting valid and reliable quantitative and qualitative data
Identify sources of public health data and information
Recognize the integrity and comparability of data
Identify gaps in data sources
Adhere to ethical principles in the collection, maintenance, use, and dissemination of data and information
Collect quantitative and qualitative community data (e.g., risks and benefits to the community, health and resource needs)
Use information technology to collect, store, and retrieve data
Describe how data are used to address scientific, political, ethical, and social public health issues
Domain #2: Policy Development and Program Planning
Participate in program planning processes
Domain #3: Communication
Communicate in writing and orally, in person, and through electronic means, with linguistic and cultural proficiency
Solicit community-based input from individuals and organizations
Participate in the development of demographic, statistical, programmatic and scientific presentations
Domain #4: Cultural Competency
Recognize the role of cultural, social, and behavioral factors in the accessibility, availability, acceptability and delivery of public health services
Domain #5: Community Dimensions of Practice
Collaborate with community partners to promote the health of the population
Maintain partnerships with key stakeholders
Use group processes to advance community involvement
Gather input from the community to inform the development of public health policy and programs
Domain #6:Public Health Sciences
Describe the scientific evidence related to a public health issue, concern, or, intervention
Retrieve scientific evidence from a variety of text and electronic sources
Discuss the limitations of research findings (e.g., limitations of data sources, importance of observations and interrelationships)
Describe the laws, regulations, policies and procedures for the ethical conduct of research (e.g., patient confidentiality, human subject processes)
Domain #7: Financial Planning and Management
Describe the organizational structures, functions, and authorities of local, state, and federal public health agencies
Adhere to the organization's policies and procedures
Participate in the development of a programmatic budget
Apply basic human relations skills to internal collaborations, motivation of colleagues, and resolution of conflicts
Domain #8: Leadership and Systems Thinking
Incorporate ethical standards of practice as the basis of all interactions with organizations, communities, and individuals
Describe how public health operates within a larger system
Participate with stakeholders in identifying key public health values and a shared public health vision as guiding principles for community action
Participate in the measuring, reporting and continuous improvement of organizational performance
Describe the impact of changes in the public health system, and larger social, political, economic environment on organizational practices