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Management of medical and psychosocial consequences of a radiological or nuclear terrorist event

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Abstract. Medical, psychological, and social consequences of a terrorist event involving the release of ionizing radiation will differ significantly from attacks with "classical" explosives. Victims of a detonation of a "dirty bomb" or a nuclear device can actually or allegedly absorb various doses of radiation and should be viewed as radiologically contaminated patients. Hence, both first responders and medical personnel should behave and act accordingly. General rules, guidelines, and procedures are described that should be implemented at all levels of medical management from the on-site emergency care until admittance to and treatment of the victims at a specialist hospital ward. The causes, manifestations and management of psychosocial sequelae of radiological terrorist incidents are also discussed.

Key words: radiological/nuclear event • medical and psychosocial consequences • management

Introduction

Apparently, most national emergency response plans have been focused on accidents at nuclear reactor sites or other nuclear installations. Recently, however, possible threats by disaffected groups have shifted the focus to malevolent use of ionizing radiation aimed at creating disruption and panic in the society. Such malevolent acts have lately been categorized as the CBRN (chemical, biological, radiological, nuclear) terrorism which, according to some experts [6], "is a low-probability, high-consequence threat" that may be "serious and often underestimated, but not apocalyptic" [2]. Indeed, as judged by the outcomes of such radiological emergencies as the Chernobyl disaster in 1986 [8], or the radiation accidents in Goiânia (Brasil) in 1987 [1, 25] and in San Salvador (El Salvador) in 1989 [17], as well as based on the computer simulations thereof, radiological/nuclear terrorism may represent a difficult challenge for the authorities, responders, and the general public, but also the one which, when adequate planning and preparedness had been prearranged, can be effectively handled.

According to the current view, the most probable radiological/nuclear terrorist scenarios ("radioterror") include spreading of radioactive material in the environment (air, water, plants, soil, food products etc.) performed either by a direct dispersal of the material (e.g., from a mobile system such as airplane, truck, train or otherwise) or by detonation at a populated location of

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the so-called "dirty bomb" (composed of a conventional explosive such as trinitrotoluene – TNT, intermingled with one or more radioisotopes); both these methods fall under the category of the radiological dispersal device (RDD) [20–22, 24]. Possible sources of radioactive isotopes include theft from industrial, medical or scientific facilities or an attack on transport of radioactive material. In scenarios based on the dispersal of radioisotopes most likely only a small area (one or few city blocks in an urban milieu) will be affected and most exposures will be low-level (both from external irradiation and/or contamination with radioactive material). Another possibility, called the radiological exposure device (RED) [22] refers to a hidden radioactive source (typically emitting X or gamma rays) that will irradiate people externally.

More spectacular, but less plausible scenario involves detonation by terrorists of a stolen or self-made (improvised nuclear device – IND) atomic bomb. Indeed, most of these devices and material for their production are properly stored and protected from theft, but there are "nuclear" countries or regions where the security measures are much more lax. Although, in all probability, an atom bomb which the terrorists can take hold of will be a low-yield device, when detonated, it will certainly wreak havoc on the people and area at a considerable distance from the epicenter. In addition to ionizing radiation (both initial and residual which, in fact, will contribute to no more than 15% of all the issuing injuries) other effects such as the air blast ("shock wave") and thermal radiation will predominate and lead to about 85% of injuries in the victims. Consequently, most casualties of such a detonation will present with combined injuries including wounds, fractures, and burns compromised by absorption of various doses of ionizing radiation [7, 15, 20, 24].

Any attack involving the release of radiation will create significant uncertainty, fear, and terror among the affected (or purportedly affected) population. Indeed, such outcomes may predominate and overwhelm the available medical and social resources in the aftermath of an attack with a dirty bomb and a low-yield nuclear device [21, 24]. Terrorists, by definition, strive to provoke severe psychosocial and economic disruptions in the society, and radiation – an invisible, odorless, and poorly understood agent – is viewed as the extremely insidious and appalling threat. Hence, there are important differences between setting off a conventional explosive and use of a radiological or nuclear device by a terrorist (Table 1) which will determine the necessary medical and otherwise measures to treat the victims and cope with the consequences.

Phases of the management of an attack

Prior to or concomitantly with the introduction of a medical response the general objectives of the conse-

Table 1. Differences between a conventional and a radiological/nuclear terrorist attack

Conventional explosion	Radiological/nuclear attack
Victims only at the site of attack (the attack is bounded in time and space)	Possible victims also further away from the site of attack (the attack is unbounded)
The debris and the environment is not hazardous and the cleanup is localized	Not only the immediate site of the attack but also more remote areas may be radiologically contaminated and hazardous and cleanup will require appropriate monitoring equipment and trained personnel
Will require routine forensic investigation	Forensic investigation complicated by the need to wear protective equipment and by the contamination of evidence
No medical outcomes in witnesses without direct injuries	Postponed medical complications possible in victims with no visible injuries
No specific safety measures and treatment procedures necessary during first response and medical management along the evacuation chain	Specific safety measures and treatment procedures required during first response and medical management along the evacuation chain and final care provided by well trained and experienced personnel
The trauma and injuries experienced by the victims are familiar: wounds, burns, broken bones etc.	Injuries may be "hidden" and develop later in life
No stress associated with the prospect of late health effects	Specific stress associated with presumed or actual prospect of the development of late health effects resulting in neurological and psychological disturbances
No need for relocation (evacuation) of people and/or restrictions in water and food supplies	Relocation (evacuation) of people and/or restrictions in water and food supplies may be necessary
No stigmatization of the victims	Victims with the "stigma" of radiation exposure
Psychosocial consequences not likely to predominate	Psychosocial outcomes likely to dominate and overwhelm the available medical resources
Routine planning and preparedness for an emergency generally suffice to cope with the effects	Specific planning, preparedness, and training of the responders is necessary

quence management of a terrorist attack are to establish control of the primary site, limit further damage, protect the public and the environment, and, finally, restitute – as much as possible – the affected area. Historically, three time phases have been defined for the management of the nuclear reactor accidents, but these also apply to terrorist events [13, 20, 24]. In the *early rescue phase* which may last for hours to a few days after the attack the primary objectives are to minimize the extent of the contamination and irradiation of people and the environment. As in other types of emergencies, actions in this phase include: a) recognition of the type and range of the attack, b) shelter from the radiation source and/or evacuation of affected areas, c) estimation of the number and type of casualties, d) establishment of a controlled zone around the incident site, and e) primary management of injured persons. The *intermediate recovery phase* begins once the uncontrolled release of radiation and contamination has been terminated and the on-site rescue attempts completed. In this phase, the major concern is to protect people against secondary irradiation from deposited radioactive materials. Primary actions will consist in: a) careful field measurements and collection of samples in order to assess the extent and magnitude of radioactive material deposition, b) contaminated food and water interdiction, c) complete (final) decontamination of people, buildings, vehicles, and the environment, and d) when necessary, relocation of people from heavily contaminated areas. Depending on the circumstances, this phase may last from weeks to months. In the *late, long term phase* (also referred to as the *restoration* phase), restorative actions are taken to eliminate (or minimize) the need for previously imposed protective measures, so that normal activities may be resumed in the effected areas. Full recovery from the attack may take months to years, depending on the levels of the damages and radioactive contaminations. In this phase medical monitoring (screening) of the affected population will be carried out with aim to timely diagnose and treat the prospective late effects of radiation exposure such as cancer [15, 20].

Medical management of the casualties

As in any other emergency, medical aid to victims of a radiological/nuclear terrorist event should be instituted as soon as possible, i.e., already on the site of the attack which should be pre-recognized and secured by the police and fire fighters. For the safe and effective operation on a potentially irradiated/contaminated area, all first responders and medical rescuers must be properly equipped with masks, gloves, and clothing to guard against inhalation and ingestion of the radioactive material or its deposition on the skin (the safety of first responders is a priority); all members of the personnel should also wear individual radiation dosimeters (Table 2) [10, 13]. Generally, when no serious intake of and/or contamination with radioisotopes have occurred responding personnel operating for as long as 5 h in the area around the detonated dirty bomb are not likely to incur doses of radiation in excess of 0.2 Gy [7]. In cases when significant amount of radiation is expected prophylactic administration of the radioprotector amiphostine can be considered [23]. Optimally, the first contact medical team should be led by (or include) an individual with radiation protection training.

Each member of the responding medical personnel must be well aware that radioactive contamination (whether external or internal) is never immediately life-threatening and, therefore, radiological assessment or decontamination should never take precedence over significant medical conditions. In case of multiple casualties the on-scene *triage* should be performed in order to identify and stabilize victims with life-threatening injuries which always take precedence over measures to address the effects of radiation exposure and/or contamination; after stabilization, such victims should be immediately transported to a medical facility [3, 7–9, 14–16, 26]. All other victims with the preserved life functions should be removed from the irradiated and/or (potentially) contaminated area and should be sorted and treated according to standard medical triage guidelines with the exception that those who are

Table 2. Sequence of measures taken during the management of victims of a radiological/nuclear emergency

1. Ensure that all *first responders are properly guarded* against radioactive contamination and excess irradiation (protective clothing, face masks, double gloves, boots, individual dosimeters, work in shifts, etc.).
2. Assess and *treat life-threatening injuries* immediately (airways, bleeding, burns, fractures, etc.).
3. *Move victims away* from the radiation hazard area (stay within the controlled zone if contamination is suspected), *remove* victims' *clothing.*
4. Take *blood samples* and a.s.a.p. order complete and differential blood counts.
5. *Swab nostrils, oral cavity, and wounds* to detect any internal contamination.
6. If possible, *decontaminate* the victims by thoroughly washing body surfaces or with showers; if it is not possible *wrap* victims *up in blankets or sheets* and transfer to decontamination places/facilities.
7. *Collect* and label *urine and faeces* of victims suspected of internal contamination.
8. In cases of risk of inhalation of radioactive iodine (after a nuclear accident) seek advice from the radiation protection authority for *use of stable iodine* tablets or Lugol's solution.
9. Start *pharmacological treatment of prodromal syndromes* of radiation sickness (such as nausea, vomiting, diarrhea, weakness, headache, fever, hypotension) and *psychotherapy* (verbal and pharmacological).
10. *Transfer irradiated/contaminated victims* to a specialist medical facility.
11. *Survey and decontaminate members of the medical team.*

(presumably) contaminated should be separated so that they can receive a preliminary decontamination (more than 90% of contamination can be removed by removal of the clothing) before or during transport, if necessary, to a hospital [20]. The symptoms of individuals who have received large radiation doses will typically include nausea, vomiting, fatigability, diarrhea, and skin erythema. When such symptoms (especially – vomiting [9]) appear within 4 h after exposure to radiation, the absorbed dose is likely to be very high (but still treatable). Even though some or all of the above symptoms may reflect an exposure to many toxic materials and are also common in victims experiencing only great psychological stress (which may certainly result from participation in a radiological/nuclear event), patients with such conditions should be treated as potentially severely irradiated and as quickly as possible referred to a specialist medical facility. Irrespectively of the cause of the ailments, these and other victims and witnesses of a radio-terrorist attack should receive verbal advice and, if necessary, pharmacological treatment from a trained psychologist/psychiatrist who should complement the first contact medical team [20]; such psychotherapy should by continued during transportation to a medical facility, throughout the treatment period and often after the discharge from hospital.

In a mass casualty scenario, in order to avoid overwhelming of the existing medical facilities, "evacuation centers" [23] should be set up as close as possible to the site of the attack with primary objectives to receive and provide shelter to victims and the so-called "worried well" [22] who do not need immediate medical attention or who will not need any specific treatment at all. Such centers should be equipped with vehicles adopted to transportation of victims contaminated with radioactive material as well as with radiometers and decontamination facilities. Among the personnel of such centers radiation protection officers, psychologists/psychiatrists and other specialists should be included to provide the necessary expertise so that the 'victims' would be timely and properly treated and did not needlessly report to other medical facilities.

In anticipation of a possible threat each large city should designate at least one specialized medical facility ("referral hospital") equipped and prepared to receive and treat patients injured by radiation [11, 26]. In such a facility, a separate emergency room should be set up which, upon notification of the incident, should immediately initiate its radiological response plan [2, 14]. Personnel of the emergency room should be well trained in handling contaminated and injured patients and should be used to wear and work in protective gear complete with personal dosimeters. In order to contain the possible contamination to the decontamination--treatment area the ambulance crew and patients are ideally met and monitored outside the emergency room, access thereto should be roped off and safeguarded (by security and radiation safety personnel) and the boundary between the "dirty" zone and the "clean" zone should be clearly established. The driveways and hallways leading to as well as the floor in the "dirty" zone should be covered with non-skid plastic sheeting and everyone (and all equipment) leaving this zone should be checked for contamination by a radiation safety officer. All contaminated waste is collected in plastic bags and stays in the dirty zone for later cleanup. Patients who require an immediate life-saving surgery must be wrapped in blankets or sheets and universal precautions must be taken before transferring them to an operation room.

The sequence of treatment measures performed in the pre-organized emergency room is similar to those carried out on the site of the incident except that all the procedures can now be more thorough and complete. In the medically stable, contaminated patients special attention must be paid to decontamination of burns, wounds, orifices, and skin (preferably performed in a devoted separate room and radiologically monitored afterwards [23]), to collection and labelling of blood samples, swabs, and excreta, to treatment of prodromal symptoms and, last but not least, to psychological reassurance and comfort (which is all too often forgotten during the emergency management of such patients). When internal contamination is suspected application of emetics, laxatives, antacids, diuretics and/or gastric lavage can be helpful; if known radioisotopes have been deposited in the patient's body administration of the appropriate blocking, diluting, mobilizing or chelating agents (such as potassium iodide, Prussian blue, pentetic acid – DTPA, ethylenediaminetetraacetic acid – EDTA, sodium bicarbonate etc.; alas, most of these agents require experienced consultations, treatment, and management) as well as whole-body gamma counting may be recommended [14, 20].

Irradiated and/or contaminated patients who require specialized hospital treatment (especially those with combined injuries) should be "safely" transferred to an appropriate clinical ward; best suited for that purpose are oncology and haematology units, but clinics specializing in the therapy of burns and fractures may also fit the bill. When medium-to-high doses of radiation have been absorbed (a useful rule of thumb: if the number of blood lymphocytes have decreased by half and are less than 1×10^3 per μL within 24–48 h and no other medical conditions that could be the cause thereof are apparent, the patient is at least moderately injured by radiation) all surgical treatment (other than life-saving) should be performed before or after the time window between the 25th and 35th days post exposure, when the risk of sepsis is the highest due to immunosuppression [23]. In order to more thoroughly estimate the absorbed dose biologic dosimetry is performed using cultures of blood lymphocytes obtained from the patient.

In all patients with a moderate to severe radiation injury (before and after the development of the symptoms of radiation sickness) prevention and management of infection is the mainstay of therapy (with emphasis on low-microbial content food and water, air filtration, reverse isolation etc). In most of these patients pharmacological treatment of early (prodromal) symptoms of the radiation sickness must be continued and intensified, accompanied by psychotherapy. In patients with the anticipated and already manifested haematopoietic and gastro-intestinal syndromes, in addition to fighting infections with antibiotics, specific clinical support must include transfusion of fresh, irradiated platelets and other blood products, stimulation of bone marrow restitution (with use of haematopoietic growth factors), selective gut decontamination (with antibiotics

that suppress aerobes, but preserve anaerobes) and boosting of the recovery of intestinal mucosa. In internally contaminated patients the particular incorporated radionuclide(s) should be recognized and specific treatment protocols tailored to that radionuclide must be introduced (or continued) to facilitate its excretion and/or reduce incorporation in the body [14, 20] (detailed procedures to dilute, purge and/or stimulate urinary and/or faecal elimination of radionuclides are discussed in Refs. [11, 19].

In the wake of a radiological or nuclear emergency, it is necessary to arrange for identification, tracking, and long-term follow-up of all, actually and potentially, irradiated or contaminated victims as well as all patients who have recovered from acute radiation syndromes in order to detect possible delayed health effects. Primarily, these effects will include radiogenic cancer and consequences of prenatal exposures [11], but other outcomes (e.g., cardiovascular disorders in individuals who sustained moderate doses of radiation) could also be tracked down. The long-term medical follow-up must consist in regular medical examinations including routine laboratory tests as well as the available screening and diagnostic tests for neoplasia (especially for leukemia and carcinomas of thyroid, breast, lung, ovary, colon, and urinary organs).

Psychosocial effects

Today, no direct data exist upon which to base the psychological and social impact of a malicious act involving radioactive material. However, the existing experience of non-radiological/nuclear terrorism suggests that the psychosocial effects of a radiation emergency can be very significant and far outnumber any direct effects.

A radiological incident can certainly produce profound psychosocial impacts at the individual, familial, communal, and even national levels. Indeed, for perpetrators of a terrorist attack a major goal is to purposely evoke fear, anxiety, and uncertainty not only in the directly affected individuals, but primarily among the general population [7, 13, 18, 20]. Compared to other types of terrorist events, the psychosocial sequelae (both immediate and delayed) of an attack that intentionally involves exposure of people to ionizing radiation will be amplified and will certainly pose one of the most difficult issues to cope with during the rescue, recovery, and restoration phases of the management of the incident [16, 20–22]. This is due to the fact that people regard situations involving exposure to ionizing radiation "a good deal more threatening than both natural hazards of even the most dangerous kind and mechanical mishaps of considerable power" [5]. Indeed, hazards are regarded as having higher risk if they are unfamiliar, uncontrollable, poorly understood, involuntary, irreversible, affect children and may affect future generations, and are associated with potentially unethical activities [4, 18]. Compounded by views and opinions presented in mass media, these factors perceived as typical for unintentional exposure to ionizing radiation, have created and sustain the aura of "radiophobia" among the general public (Table 3) – a state of mind which certainly enables terrorists reach their goals (and makes the media "their best friends") [16, 20, 22].

Hence, a radiological or nuclear terrorist attack will have a powerful capacity to produce a range of both acute and chronic psychological effects manifested not only in victims and their families, but also in those who were not directly affected, termed "the worried well" (who may present with multiple idiopathic physical symptoms). In fact, the latter category of "victims" will most likely predominate and may easily overwhelm the capacity of the existing health and human services system. Among those at the highest risk of developing psychiatric disorders are: a) people directly exposed and those participating in rescue and recovery operations; b) pregnant women; c) mothers of young children and children; d) those who suffered resource losses and disruption of their family and social support; and e) people with a current or a prior history of psychiatric illness [7, 11, 13, 20].

Psychosocial consequences of any significant act of terror can be emotional, physical, cognitive or interpersonal in nature, ranging from fatigue, insomnia or impaired concentration to emotional numbing or social withdrawal [20]. When deliberate radiation releases are concerned, significant distress will be common and manifest as sadness, anger, fear, insomnia, impaired ability to concentrate, and disbelief; these may lead to substance abuse, social withdrawal, and/or aggressive behaviour. Notably, many patients who were not irradiated at all may present with psychosomatic symptoms that mimic those of prodromal phase of the acute radiation disease (e.g., nausea, vomiting, rashes) or show other psychological, behavioural, and cardiovascular-neuroendocrine effects [20]. Generally, affected individuals presenting psychological effects can be divided into three groups: a) those who are distressed; b) those who manifest behavioural changes; and c) those who develop psychiatric illness [13]. As indicated by the findings of the 2006 Chernobyl Forum, stress symptoms, increased levels of depression, anxiety (including post-traumatic stress syndromes), and medically unexplained

Table 3. Views and opinions causing the "specific stress" and "radiophobia"

- A nuclear bomb is the "ultimate weapon".
- Nuclear threats are the riskiest and the most dreaded.
- Ionizing radiation is a mysterious, invisible, and dreaded hazard which poses an unbounded ("open-ended") threat.
- Exposure to ionizing radiation causes hidden and irreversible damage or death.
- People irradiated or contaminated with radionuclides are dangerous to others and are thus socially "stigmatized".
- Calculated, intentional exposure of people to ionizing radiation by terrorists is an unusually repugnant and repulsive act of aggression.

physical symptoms occurred more often in populations exposed to radiation in the wake of the Chernobyl disaster than in the control, unexposed groups (similar symptoms were also recorded in the survivors of the atomic bombings of Hiroshima and Nagasaki as well as in residents near the Three Mile Island nuclear power plant accident in 1979 [12]. In most cases, distress and psychological and behavioural symptoms caused by such events are subclinical and diminish over time, but in some of the affected they will persist and result in the post-traumatic stress disorder (PTSD), generalized anxiety disorder, and phobic and/or panic disorder [13, 20]. However, less complex symptoms of depression, distrust, bereavement, family conflict, alcohol and drug abuse, demoralization, and/or various forms of somatization will be much more common than the full-fledged PTSD or other maladaptive syndromes. At the community level, the contamination and radiation exposure-related stigma as well as conflict related to the cleanup may significantly hinder the social reassurance and recovery efforts. Over time, contaminated communities may manifest reduced cohesiveness, low morale, and decreased social service due to distress and economic losses [13]. At the broadest level, a radiological/nuclear incident has the potential to produce widespread fear, a heightened sense of vulnerability, loss of public trust, and an overall loss of public confidence in societal institutions and the government [20]. It is vital, therefore, that psychosocial considerations be a high-priority component of the consequence management efforts.

Management of the psychosocial impacts of a radiological/nuclear terrorist act is a difficult and complex task. Knowledge of radiation and its effects can definitely serve to reduce the fear, anxiety and other psychological effects of participation in/witnessing of a radiation emergency. Thus, clear and simple advice based on internationally endorsed guidance should be given to the public. Apparently, members of the public seek guidance and information from physicians and other health care professionals. Unfortunately, medical education does not generally provide these professionals with sufficient information to enable them to knowledgeably answer questions about ionizing radiation, health effects of radiation exposure (especially, of exposures to low doses of radiation), or protective actions needed in case of a radiation emergency [20]. Appropriate medical and emergency information should, therefore, be made available to them so that they can inform the concerned public before, during, and after an emergency. Physicians should make an effort to learn more about the diagnosis and treatment of radiation injury, even though such injuries are rare [11]. Emergency preparedness for a radiological/nuclear terrorism should also include an ongoing education programme for the general population, medical staff, public officials, teachers, ministers, psychologists and others who have the respect of the community and are in positions of trust [11]. Of utmost importance in this regard is the appropriate education and training of all first responders (police, fire fighters, paramedics, emergency room, decontamination and hospital staff, etc.) and cleanup workers.

Psychological and social support programmes (encompassing preplanned, grounded on reliable knowledge, information and adequate social assistance) are necessary for an affected population, especially those who have been evacuated and relocated. This will prevent the development of additional stress conditions, restore people's self-confidence, increase their ability to change their own future, and restore confidence in the activities of the authorities [19]. Information about real threats and risks, education about ways to handle distress and restore normal reactions, early attention to symptoms and time-contingent follow-up (planned rather than as-needed visits without ignoring the "unfounded complaints") will increase public confidence, alleviate stress and anxiety, speed recovery and prevent long-term problems [16].

As noted earlier, information and psychological aid to victims should be provided as early as at the site of the event (each team of the medical first responders should include a psychologist or a psychiatrist) and then followed on along the chain of treatment until the patients regain self-confidence and can safely go about their own business. Ideally, separate allotted facilities of the psychological, psychiatric, and social welfare profile should be prepared and ready to receive, accommodate, and tend to the possibly numerous victims flowing-in, the majority of who will be composed of the non-irradiated "worried well" individuals.

One of the most troubling and persisting impacts of incidents involving radiation is the problem of social stigma: affected individuals and whole communities may be seen by others as "tainted" and dangerous and thus as those who are to be avoided. Because such a stigma can be powerful and hamper recovery efforts, it is important that officials have in place a plan (informed by current social and science research) for dealing with it. This, as will always be the case with management of psychosocial problems, should be a multidimensional approach and include educational programmes, media campaigns, high-profile visits by public figures, community forums, and other measures [20].

In conclusion, as psychosocial effects are likely to be a critically important outcome of any radiological terrorist event and may constitute the most challenging aspect of the consequence management, consideration of psychosocial factors should be an integral part of preparedness efforts including planning, education, information, training, research, and response operations. This *preventive* rather than restorative approach implies the need to have plans, infrastructure, resources, and educated and trained personnel already in place (in other words, the psychological and social components cannot be afterthought). Moreover, since some of the psychosocial impacts of a radiological/nuclear incident have the potential to be long-lived, it will be vital to focus additional attention on post-emergency response issues and organize long-term medical and psychosocial follow-up into a fully integrated whole. In this regard, further research on ways and measures of ameliorating acute and chronic psychological and social impacts as well as re-evaluation of the existing approaches should definitely be conducted. Unfortunately, most current response planning and training is focused on the emergency rescue phase of the medical response and no or little attention is paid to principles and practice of the mental health management in the wake of

disasters and terrorist acts [20]. This is largely due to the fact that at present there is no standard protocol or comprehensive manual available to deal with these issues. Indeed, brochures, fact sheets, and literature about self-management of the medically unexplained symptoms do not practically exist. These could and should be provided by the results of research on socio--behavioural aspects of radiological incidents devoted, among other things, to such issues as immediate and protracted psychosocial interventions after the incident, people's reactions to decontamination and to physical contact with the exposed/contaminated individuals and the environment, better identification of groups with a high risk of developing psychological disorders as well as research on the post-radiation stigma and radiophobia and on ways of preventing and/or ameliorating these symptoms [20].

References

1. Alves RN (1990) Contamination control in the Cs-137 accident in Goiania. In: Ricks RC, Fry SA (eds) The medical basis for radiation accident preparedness 2. Elsevier, New York, pp 271–281
2. American College of Radiology (2002) Disaster preparedness for radiology professionals – response to radiological terrorism. A primer for radiologists, radiation oncologists and medical physicists. ACR, USA
3. Commander's Guidebook (2002) MTF preparedness and response to radiological and nuclear terrorism. Bureau of Medicine and Surgery, Chemical, Biological, Radiological, Nuclear and High-Yield Explosives Program Cell MED-02 and the Integrated Product Team (CBRNE IPT), USA
4. Covello VT, McCallum DB, Pavlova MT (eds) (1989) Effective risk communication: the role and responsibility of government and non-governmental organizations. Plenum Press, New York
5. Erikson KA (1994) New species of trouble: the human experience of modern disasters. W W Norton and Co., New York
6. Falkenrath RA (1998) Confronting nuclear, biological and chemical terrorism. Survival 40:43–65
7. Flynn D, Goans RE (2006) Nuclear terrorism: triage and medical management of radiation and combined-injury casualties. Surg Clin N Am 86:601–636
8. Gale RP (1987) Immediate medical consequences of nuclear accidents. Lessons from Chernobyl. JAMA 258:625–628
9. Goans RE, Wasalenko JK (2005) Medical management of radiological casualties. Health Phys 89:505–512
10. IAEA (2002) Preparedness and response for a nuclear or radiological emergency. Safety standard series no. GS-R--2. Jointly sponsored by FAO, IAEA, ALO, OECD/NEA, PAHO, UN-OCHA, and WHO. International Atomic Energy Agency, Vienna
11. IAEA (2005) Generic procedures for medical response during a nuclear or radiological emergency, emergency preparedness and response EPR-Medical 2005, Co--sponsored by IAEA and WHO. International Atomic Energy Agency, Vienna
12. IAEA (2006) Chernobyl's legacy: health, environmental and socio-economic impacts and recommendations to the governments of Belarus, the Russian Federation and Ukraine. The Chernobyl forum: 2003–2005, 2nd revised version. International Atomic Energy Agency, Vienna
13. ICRP (2005) Publication 96. Protecting people against radiation exposure in the event of a radiological attack. In: Valentin J (ed) Ann ICRP 35 (1). International Commission on Radiological Protection, Elsevier Ltd, Oxford
14. Janiak MK (2005) Prophylaxis and treatment of health disorders in victims of radiological incidents In: Janiak M, Wójcik A (eds) Medicine of the radiation-associated threats and injuries. Wydawnictwa Lekarskie PZWL, Warsaw, pp 155–167 (in Polish)
15. Janiak MK, Jaworowski Z (2005) Threats from nuclear and radiological weapons In: Janiak M, Wójcik A (eds) Medicine of the radiation-associated threats and injuries. Wydawnictwa Lekarskie PZWL, Warsaw, pp 137–154 (in Polish)
16. Koenig KL, Goans RE, Hatchet RJ *et al*. (2005) Medical treatment of radiological casualties: current concepts. Ann Emerg Med 45:643–652
17. Littlefield LG, Joiner EE, Coyler SP *et al*. (1991) The 1989 San Salvador Co-60 radiation accident: cytogenetic dosimetry and follow-up evaluations in three accident victims. Radiat Protect Dosim 35:115–123
18. Mettler FA Jr, Upton AC (2008) Perception of radiation and psychological effects. In: Mettler FA Jr, Upton AC (eds) Medical effects of ionizing radiation, 3rd ed. Saunders Elsevier, Philadelphia, pp 459–472
19. NCRP (1980) Management of persons accidentally contaminated with radionuclides. Recommendations of the NCRP. Report no 65. National Council on Radiation Protection and Measurements, Bethesda, Maryland
20. NCRP (2001) Management of terrorist events involving radioactive material. Recommendations of the NCRP. Report no 138. National Council on Radiation Protection and Measurements, Bethesda, Maryland
21. Ring JP (2004) Radiation risks and dirty bombs. Health Phys 86;S1:S42–S47
22. Rojas-Palma C, Liland A, Jerstad AN *et al*. (eds) (2009) TMT handbook, triage, monitoring and treatment of people exposed to ionising radiation following a malevolent act. C Lobo Media AS, Norway
23. Turai I, Veress K, Gunalp B, Soulchkevitch G (2004) Medical response to radiation incidents and radionuclear threats. Brit Med J 328:568–572
24. US EPA (1992) Manual of protective action guides and protective actions for nuclear incidents. EPA 400-R-92--001. United States Environmental Protection Agency, Washington
25. Valverde NJ, Cordeiro JM, Oliviera AR, Brandao-Mello CE (1990) The acute radiation syndrome in the Cs-137 Brazilian accident In: Ricks RC, Fry SA (eds) The medical basis for radiation accident preparedness 2. Elsevier, New York, pp 89–109
26. Yehezkelli Y, Dushnitsky T, Hourvitz A (2002) Radiation terrorism – the medical challenge. IMAJ 4:530–534