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EMERGENCY PREPAREDNESS AND RESPONSE

Generic Procedures for Medical Response During a Nuclear or Radiological Emergency

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GENERIC PROCEDURES FOR MEDICAL RESPONSE DURING A NUCLEAR OR RADIOLOGICAL EMERGENCY

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FOREWORD

The aim of this publication is to serve as a practical resource for planning the medical response to a nuclear or radiological emergency. It fulfils in part functions assigned to the IAEA under Article 5.a(ii) of the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (Assistance Convention), namely, to collect and disseminate to States Parties and Member States information concerning methodologies, techniques and available results of research relating to such emergencies.

The 2003 IAEA General Conference, in Resolution GC(47)/RES/7, encouraged Member States to "adopt IAEA standards, procedures and systems developed as part of international co-operation" and to "contribute to the international efforts to develop a consistent, coherent and sustainable joint programme for improved and more efficient international response to nuclear and radiological emergencies". In 2004, the IAEA General Conference, in Resolution GC(48)/RES/10, encouraged Member States to "implement the Safety Requirements for Preparedness and Response to a Nuclear or Radiological Emergency".

In 2005, the IAEA published a manual entitled Generic Procedures for Medical Response During a Nuclear or Radiological Emergency (EPR-Medical 2005), co-sponsored by the World Health Organization (WHO), in order to help contribute to a coherent international response to nuclear and radiological emergencies.

In November 2015, the IAEA's Board of Governors approved IAEA Safety Standards Series No. GSR Part 7, Preparedness and Response for a Nuclear or Radiological Emergency, jointly sponsored by thirteen international organizations, including the World Health Organization (WHO). GSR Part 7 establishes the requirements for an adequate level of preparedness and response for a nuclear or radiological emergency in any State. Paragraph 5.63 of GSR Part 7 states:

> "Arrangements shall be made for medical personnel, both general practitioners and emergency medical staff, to be made aware of the clinical symptoms of radiation exposure, and of the appropriate notification procedures and other emergency response actions to be taken if a nuclear or radiological emergency arises or is suspected."

The current publication supersedes EPR-Medical 2005. Its content has been updated in line with the relevant IAEA Safety Standards published since 2005, particularly GSR Part 7. Other pertinent publications have also been taken into account, as have the changes and developments based on lessons learned from the Fukushima Daiichi nuclear power plant accident (March 2011) and other radiological emergencies.

The IAEA wishes to acknowledge the contribution of the International Federation of Red Cross and Red Crescent Societies (IFRC), the Pan American Health Organization (PAHO) and WHO, for co-sponsoring this publication and to the American Society for Radiation Oncology (ASTRO), the European Association of Nuclear Medicine (EANM), the Latin American Association of Societies of Biology and Nuclear Medicine (ALASBIMN) and the Society of Nuclear Medicine and Molecular Imaging (SNMMI). The IAEA officers responsible for this publication were H. Tatsuzaki, M. Fukahori and E. Herrera Reyes of the Incident and Emergency Centre.

EDITORIAL NOTE

CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

Nuclear or radiological emergencies, in general terms, may involve workers in facilities and hospitals; other personnel; emergency workers; medical patients; and members of the public. The accidents at the Chornobyl (1986) and Fukushima Daiichi (2011) nuclear power plants serve as dramatic examples that these emergencies can result in widespread public exposure and generate considerable public concern.

Over the past few decades, members of the public have received high doses from lost or stolen sources that were used either in industrial radiography or medical therapy. Examples include cases in Brazil, Estonia, Georgia, Mexico, Peru, the Russian Federation and Thailand. High doses involving workers have occurred, for instance, in Belarus, Bolivia, Chile, El Salvador, Islamic Republic of Iran, Israel, Peru and Türkiye. Radiological emergencies in Costa Rica, Panama and Poland, among others, have shown that medical patients, for different reasons, might receive significant overexposures (e.g. errors in calibration, equipment failure or miscalculation in administered activity levels of radionuclides).[1]

1.2. OBJECTIVE

The aim of this manual is to provide practical guidance for medical preparedness and response to nuclear or radiological emergencies. It describes the tasks and actions of different members of an emergency medical response organization and the various teams within the national, regional or local medical infrastructure.

The medical response to a nuclear or radiological emergency needs to be understood as part of a multidisciplinary approach. Therefore, this publication is intended as a tool for different organizations and professionals that could be involved in the medical response to nuclear or radiological emergencies, including (but not limited to) first responders, healthcare providers, health authorities, policy makers for emergency management and national competent authorities. Radiation protection services and their personnel, general emergency management personnel and other professionals may also find useful information in this publication.

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[1] See, for example, the following IAEA publications: The Radiological Accident in Goiânia, IAEA, Vienna (1988); The Radiological Accident in San Salvador, IAEA, Vienna (1990); An Electron Accelerator Accident in Hanoi, Viet Nam, IAEA, Vienna (1996); The Radiological Accident in the Reprocessing Plant at Tomsk, IAEA, Vienna (1998); Accidental Overexposure of Radiotherapy Patients in San José, Costa Rica, IAEA, Vienna (1998); The Radiological Accident in Istanbul, IAEA, Vienna (2000); The Radiological Accident in Lilo, IAEA, Vienna (2000); The Radiological Accident in Yanango, IAEA, Vienna (2000); The Criticality Accident in Sarov, IAEA, Vienna (2001); Investigation of an Accidental Exposure of Radiotherapy Patients in Panama, IAEA, Vienna (2001); The Radiological Accident in Samut Prakarn, IAEA, Vienna (2002); The Radiological Accident in Gilan, IAEA, Vienna (2002); The Radiological Accident in Cochabamba, IAEA, Vienna (2004); Accidental Overexposure of Radiotherapy Patients in Białystok, Vienna, IAEA (2004); The Radiological Accident in Nueva Aldea, IAEA, Vienna (2009); The Radiological Accident in Lia, Georgia, IAEA, Vienna (2014); The Radiological Accident in Chilca, IAEA, Vienna (2018).

1.3. SCOPE

This manual applies to medical preparedness and response to nuclear or radiological emergencies regardless the type or magnitude of an event.

The main parts of this publication contain information and guidance on medical preparedness and response. In addition, selected public health issues are addressed, such as the medical follow-up of persons involved in nuclear or radiological emergencies. This manual focuses on the medical *management* aspects of the response. It does not provide detailed descriptions related to the medical *treatment* of individuals involved in nuclear or radiological emergencies.

1.4. STRUCTURE

Following this introductory chapter, the second part of this publication, the Overview, provides relevant information on definitions and the particular roles of the participants in the response to nuclear or radiological emergencies.

The third part is organized in individual sections, based on an assumed medical response structure to a nuclear or radiological emergency. It starts with the initiation of the formal emergency medical response at the pre-hospital level and concludes with guidance on the provision of mental health support to those involved in the response. Each section contains generic implementing procedures, and each of them is organized in the order that actions will mostly likely be performed.

Section A provides procedures for the first steps of emergency personnel on the scene of the emergency (pre-hospital level), which include radiological surveys of casualties and monitoring of possible external contamination (for the purpose of this publication, in several cases the term ‘casualties’ will be related with the pre-hospital response and ‘patients’ to the hospital response, in any case both terms will be used indistinctly). Section B covers the steps to be taken at the hospital level consisting of assessment of patients and treatment such as decontamination and decorporation. Arrangements for long term medical follow-up after the nuclear or radiological emergency are dealt with in Section C, while Section D provides guidance on the procedure for dose assessment. Section E gives general advice on mental health support arrangements at the preparedness stage, and Section F addresses procedures for dealing with psychological and mental health consequences of the emergency.

This publication also contains worksheets and appendices to provide additional information supporting the medical response to nuclear or radiological emergencies. Given the multidisciplinary approach of this manual, some of the specific procedures discussed in this publication are not necessarily performed by medical professionals but are to be carried out by other healthcare providers.

2. OVERVIEW

2.1. DEFINITION OF A NUCLEAR OR RADIOLOGICAL EMERGENCY

IAEA Safety Standards Series No. GSR Part 7, Preparedness and Response for a Nuclear or Radiological Emergency [1] defines the relevant terms as follows:

Emergency

A non-routine situation or event that necessitates prompt action, primarily to mitigate a hazard or adverse consequences for human life, health, property or the environment.

- This includes nuclear and radiological emergencies and conventional emergencies such as fires, release of hazardous chemicals, storms or earthquakes.
- This includes situations for which prompt action is warranted to mitigate the effects of a perceived hazard.

Nuclear or radiological emergency

An emergency in which there is, or is perceived to be, a hazard due to:

(a) The energy resulting from a nuclear chain reaction or from the decay of the products of a chain reaction;

(b) Radiation exposure.

2.2. GOALS OF EMERGENCY RESPONSE

In a nuclear or radiological emergency, the goals of emergency response are [1]:

1. Regain control of the situation and mitigate consequences;
2. Save lives;
3. Avoid or minimize severe deterministic effects;
4. Render first aid, provide critical medical treatment and manage the treatment of radiation injuries;
5. Reduce the risk of stochastic effects;
6. Keep the public informed and maintain public trust;
7. Mitigate, to the extent practicable, non-radiological consequences;
8. Protect, to the extent practicable, property and the environment;
9. Prepare, to the extent practicable, for the resumption of normal social and economic activity.

Most of the goals are directly related to human health. Medical terminology is used in some of these goals. Therefore, every medical and technical specialist participating in the emergency response has to know and understand the meaning of the terms and the relation between radiation medicine, emergency medicine, physics and radiation protection.

2.3. GOALS OF EMERGENCY MEDICAL RESPONSE

The goals of the medical response to a nuclear or radiological emergency need to be in line with the goals of overall emergency response. A main principle is that life-saving actions are priority in triage terms and that the medical condition takes always precedent over the radiological aspects.

2.4. RATIONALE

2.4.1. Preparedness for emergency medical response

To be effectively implemented, emergency medical response needs to be planned and organized to include a consideration of the potential consequences of different types of nuclear or radiological emergencies. As part of general emergency preparedness and response, medical response needs to take the same approach to planning as stipulated in the international requirements for preparedness for and response to a nuclear or radiological emergency for all response organizations in Refs [1, 2].

It is essential that national authorities have made the necessary arrangements for providing an adequate preparedness and response to nuclear or radiological emergencies [1] (see Appendices I, II and III for additional information).

2.4.2. Types of nuclear or radiological emergencies

Reactor emergencies

These emergencies might occur when irradiated fuel elements have been breached due to loss of coolant. In the event of insufficient venting or failure of containment, high doses might be received by onsite workers or members of the public in the vicinity of the reactor as a result of loss of integrity of the fuel elements and/or release of other radioactive materials. Widespread environmental contamination could occur and lead to external exposure of the public from radionuclides in air or deposited on the ground or to internal exposure from inhalation and ingestion of released radionuclides. Reactor emergencies have resulted in widespread non-radiological consequences, including long lasting psychological and mental effects in humans.

Criticality emergencies

These emergencies can occur when nuclear materials are inadvertently allowed to undergo fission in the absence of criticality controls. Prompt, high level exposure is generally associated with this type of emergency, and persons in close proximity might receive very high doses. Workers more than about 10 metres from the assembly receive lower doses (depending on circumstances, such as the presence of physical barriers or shielding). Members of the general public might also receive a low level exposure due to neutron radiation, if they live close to the facility.

Emergencies involving a lost or stolen dangerous source

A lost or stolen source is a special case of emergency involving radioactive material. The risk to the public will depend on the activity of the radioactive source, whether the source was unshielded, the distance from the source, the decay mode of the radioactivity and duration of exposure. It needs to be assumed that the source may have been handled by persons who do not know its nature and hazard, potentially resulting in a rupture of the source and in radiological contamination. Such emergencies can cause high doses to the whole body or localized body areas and, if the source has been breached, internal or external contamination. Serious injury or death might be a consequence of these emergencies.

Emergencies resulting from use or misuse of dangerous industrial sources

These emergencies occur when proper source security or occupational safety procedures are not followed. Failure to use exposure control might lead to inadvertent overexposure to workers in the immediate work area. Touching an unshielded source may result in serious injury. Whole body exposure to high doses may cause illness or death. Emergencies at the industrial irradiation facilities most often result in whole body exposure at high doses. Emergencies with involvement of mobile industrial radiography sources most probably lead to local radiation exposure.

Accidental medical overexposure

Accidental medical overexposure might occur because of miscalculation of the activity of a therapy source or output, misuse of a treatment planning system, improper function of an X ray device or accelerator, or when higher activities than intended are inadvertently administered during diagnosis or therapy in nuclear medicine. When a patient receives a lower dose than that prescribed by the physician, it can lead to a serious medical problem. However, such a situation is not considered a nuclear or radiological emergency and is, therefore, not considered in this manual.

Transport emergencies with involvement of radioactive material

Many thousands of transport operations involving radiation and radioactive material occur daily. Transport can include road, rail, air or sea modes. The spectrum of items transported varies greatly and includes nuclear industry products, radiography sources for industrial purposes, gauges and radioactive materials for medical use. The main problem in planning for transport emergencies is the fact that they can occur anywhere and might potentially affect the members of the public. However, compared to all other emergency categories, radioactive transport emergencies are extremely rare. Moreover, transport packages are designed to withstand different types of emergency situations (e.g. involving fire, pressure and mechanical shock). Accidents involving the shipment of radioactive materials are unlikely to result in significant exposures when the materials are packaged and transported in accordance with legislated guidelines.

Emergencies involving malicious use of radioactive material

Emergencies involving malicious use of radioactive material can be divided into three categories or scenarios. These scenarios include the placement of unshielded sealed sources in areas occupied by people; the use of a radiological dispersal device; or the detonation of a nuclear weapon that can be crude or quite sophisticated. Each scenario presents different aspects that need to be considered in the emergency medical response. See Appendix VI for details.

Emergencies involving radioactive contamination of air, food products and water

Contamination of air, food products and water could result from accidents (e.g. a reactor emergency with release of radioactive material, damage to a lost or stolen dangerous source) or intentional actions (malicious acts involving radioactive material). As a result of a reactor emergency, the contamination of food products or drinking water supply could lead to the exposure of a large number of people. In particular, exposure of children to radioactive iodine may lead to an increased risk of thyroid cancer. To prevent this possibility, iodine thyroid blocking needs to be introduced as an urgent protective action [1, 3]. Widespread public health action to restrict the consumption of contaminated food and drinking water might be necessary (which is an urgent protective action that falls outside of the scope of this manual). The contamination of food products, especially in excess of national and international trading standards for commodities, could have massive health and economic consequences.[2]

2.4.3. Considerations related to the medical response to nuclear or radiological emergencies

The response to nuclear or radiological emergencies could be influenced by a number of factors, such as:

- health conditions of the overexposed persons;
- presence of contamination with radioactive material;
- number of persons affected;
- location of the emergency;
- weather conditions;
- availability of the response resources.

In a nuclear or radiological emergency, individuals might have been affected in one or more ways: external exposure (localized, partial or whole body), internal exposure (organs and/or whole body), skin contamination with radioactive material, as well as wounds, trauma, burns and mental health issues.

2.4.4. Potential consequences to individuals involved in nuclear or radiological emergencies

Depending on the circumstances of the nuclear or radiological emergency, individuals need to be assessed considering all these factors for radiation exposure/contamination with radioactive material, with priority given to life-saving actions. Medical staff need to have sufficient knowledge, appropriate procedures, proper equipment, and suitable supplies to perform medical examinations and analyses after patient arrival at the hospital to perform medical triage of affected individuals. The potential consequences associated with nuclear or radiological emergencies are as follows:

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[2] On this matter, see, for example: JOINT FAO/WHO FOOD STANDARDS PROGRAMME, CODEX ALIMENTARIUS COMMISSION, Codex Standard for Natural Mineral Waters, CODEX STAN 101-1981, http://www.fao.org/input/download/standards/223/CXS_108e.pdf (accessed 3 November 2023); JOINT FAO/WHO FOOD STANDARDS PROGRAMME, CODEX ALIMENTARIUS COMMISSION, General Standard for Bottled/Packaged Drinking Waters (Other than Natural Mineral Waters), CODEX STAN 227-2001, http://www.fao.org/input/download/standards/369/CXS_227e.pdf (accessed 3 November 2023); WORLD HEALTH ORGANIZATION, Management of Radioactivity in Drinking-Water, WHO, Geneva (2018), http://www.who.int/iris/handle/10665/272995 (accessed 3 November 2023).

External exposure

External exposure occurs when an individual is exposed to radiation from a source outside the body. External exposure could involve the whole body, partial body or a localized body area.

The most common early signs and symptoms of acute radiation exposure to a large body volume in high doses are nausea and vomiting. Nausea and vomiting resulting from radiation exposure typically ensue within hours after exposure [2, 4, 5].

One of the consequences of the exposure is described as acute radiation syndrome (ARS). ARS is a deterministic effect of radiation exposure to the whole body or to a significant volume of the body (partial body irradiation) above a dose threshold of about 1 Gy[3]. This deterministic effect induces a set of clinical and biological manifestations because of the organs and tissues being affected [2, 4].

Another consequence, from a localized radiation exposure, is the local radiation injury (LRI)[4]. This may develop depending on the absorbed doses delivered to the skin and deeper tissues, affecting the skin as well as subcutaneous and other underlying tissues [2]. Several radiological accidents have occurred which involved workers or members of the public manipulating sealed, unshielded, highly radioactive sources intended for industrial use. LRI is one of the most common health consequences of these actions [6, 7]

LRI usually has a latency period from days to weeks. In some cases, the clinical manifestations of LRI have been misinterpreted by medical professionals as resulting from other causes or diseases; biological, chemical or thermal reactions (see Appendix VI). This situation has delayed the timely diagnosis and early medical management of affected patients [2, 8, 9].

Some emergencies are not discovered for days or weeks after the radiation exposure has occurred. This is especially true when the loss of a dangerous radioactive source is unknown or unreported [8]. Thus, it is important that medical staff are able to detect the clinical manifestations and link them to a potential overexposure to ionizing radiation [9].

Persons who might potentially have been exposed to radiation, but who do not require immediate medical treatment (stable medical condition), may require early dose assessment to provide useful information for the diagnosis and clinical management, if necessary.

Radiological or radioactive contamination

Contamination most commonly occurs due to unsealed sources of radioactivity, such as radioactive powders, liquids, or gases as a result of an accident, malevolent act or natural disaster. Workers, response personnel or members of the public might become externally or internally contaminated following a release of unsealed radioactive material.

- External contamination: Occurs when radioactive material is deposited on the surface of the skin, hair or clothing. Depending on the isotopes, external contamination could lead

[3] The SI unit for absorbed dose is joule per kilogram (J/kg), termed the gray (Gy).

[4] In some countries, the term 'cutaneous radiation syndrome' is used instead of LRI to express the manifestations of local radiation exposure.

to radiation doses to the skin that may have threshold effects such as erythema and blistering and non-threshold effects such as malignancy [2, 10].

Acute medical concerns, such as life-saving procedures, are to be prioritized over contamination concerns. Decontamination is helpful to prevent or reduce further exposure, reduce the risk of the intake of radioactive material into the body, and reduce the spread of contamination.

- Internal contamination: Occurs when radioactive material is taken into the body through inhalation, ingestion, contaminated wounds and in rare cases absorption through the skin. In rare cases, internal contamination could result in severe, even lethal, consequences [2, 10].

Externally or internally contaminated individuals need to be monitored to assess the degree of contamination. It is possible, but very unlikely, that contamination alone might be sufficient to have an acute effect on the individual. In cases involving internal contamination, in particular, longer exposures are more common, which may cause higher total exposures; therefore risks of non-threshold (stochastic) effects, such as malignancy, need to be especially considered[10]. Emergency responders utilizing proper contamination control techniques and proper personal protective equipment face little risk of becoming contaminated during the response to an event involving radioactive contamination [2].

Combined injury

Combined injury is defined as conventional injury plus radiation, for example, trauma combined with contamination with radioactive material of a wound suffered in the event.

Since radiation does not cause immediate life-threatening risks, any serious injury will take priority over concerns about irradiation or contamination [5].

Treatment of such casualties has to be specific to the nature and grade of the combined injury. In almost all scenarios involving serious medical injury, radiation-related concerns are ranked below concerns regarding life-threatening medical injuries [2]. Combined injuries may worsen the medical prognosis of radiation exposure. It is not a matter of a simple additional risk but the danger of a synergistic effect [5].

Victims of traumatic events involving radiation exposure need to be taken to a trauma center when serious conventional injuries have occurred. Trauma centers need to be advised of inbound patients that may be contaminated or exposed to radiation to allow the center to prepare for screening for contamination and decontamination, if needed. If possible, non-exposed/contaminated patients are best treated in a hospital area different from the one where contaminated victims are being evaluated or treated, to avoid unnecessary exposures and spread of contamination.

Mental health and psychological consequences

Mental health and psychosocial (MHP) effects of any emergency situation can be widespread and long lasting, constituting some of the most significant and challenging consequences of a nuclear or radiological emergency. Consideration of MHP support arrangements needs to be an integral part of nuclear or radiological emergency response planning and requires special training for response personnel (see Appendix IV).

MHP effects in the affected populations and responders are among the most important non-radiological public health consequences caused by an emergency and/or by such response actions as sheltering and evacuation. Guidelines for mitigating MHP consequences are available in Ref. [11], including short term and long term actions that need to be implemented.

Uninjured and unexposed persons requiring psychological support

Persons involved or affected by nuclear or radiological emergencies might experience varying degrees of psychological stress and anxiety. Such stress symptoms may manifest at any time following the event, and the severity of stress can be further exacerbated in case of a terrorist attack or a malicious act involving radioactive material. Adequate mental health and psychological support needs to be provided in a timely manner to the affected individuals by trained, experienced professionals. A potential challenge to the medical response may result from asymptomatic 'worried-well' people who overwhelm medical facilities concerned about risk to their health and seeking medical advice.

Even when there is no potential risk, there will be worried-well persons who might need to be reassured and provided with information and psychological support, after which they may return to their normal activities (or to a suitable shelter or evacuation facility if movement restrictions do not permit an immediate return to normality).

Registration

The registration of all affected persons from the immediate vicinity of an emergency may be necessary to facilitate a formal basis for longer term reassurance or follow-up and to avoid falsified liability claims after the emergency.

Paragraph 5.67 of GSR Part 7 [1] states:

> "Arrangements shall be made to identify individuals with possible contamination and individuals who have possibly been sufficiently exposed for radiation induced health effects to result, and to provide them with appropriate medical attention, including longer term medical follow-up".

Before deciding on the termination of the emergency, it is necessary to establish a registry of those individuals who have been identified, by the time the emergency is to be terminated, as requiring longer term medical follow-up, based on criteria established [12].

2.4.5. Biological effects of ionizing radiation

Deterministic effects

Health effects resulting from extensive cell killing at high radiation doses are called deterministic effects, threshold effects or non-stochastic effects. Above a threshold level of dose, these effects are predetermined to occur. Therefore, they do not appear clinically at low radiation doses. Deterministic effects are also referred to as *tissue reactions*.

Generally, a threshold level of dose exists, which varies with person and circumstance. Above this threshold level, the severity of the health effect is greater for a higher dose. The term *tissue reactions* describes a group of health effects that comprise deterministic effects and some health effects (such as cataracts and fibrosis) that are not determined solely at the time of irradiation but can evolve after radiation exposure [13].

If the number of damaged or killed cells is large enough, it may result in organ dysfunction and even death. These health effects are characterized by a relatively high threshold that has to be exceeded over a short period before the effect occurs. The severity of the effect increases with increasing dose after the threshold has been exceeded [14].

Deterministic effects of acute exposure to ionizing radiation have a dose threshold that is typically several grays. These effects are specific to particular tissues, and the severity of harm is dependent on the dose and the dose rate (once the threshold is surpassed, the higher the dose, the more acute the onset and severe the effect). Examples of deterministic effects include ARS, LRI, radiation-induced hypothyroidism, infertility and effects in the embryo and foetus such as abortion and teratogenesis [2].

Stochastic effects

A *stochastic effect* (non-threshold effects or non-deterministic effects) is a radiation related health effect whose probability of occurrence depends on the radiation dose and whose severity (if it occurs) is independent of the dose. In radiation protection the so-called linear non-threshold (LNT) model is used, which assumes that one can linearly extrapolate from moderate/high doses to low and very low doses without a threshold [13].

Unrepaired DNA mutations occurring naturally or from radiation damage may produce modified but viable stem cells. If the modified cell is a somatic cell, it can be the initiator of a long and complex process that may lead to cancer. Alternatively, if the cell is a germ cell, the mutation could be transmitted to the progeny of the exposed person. These effects, both somatic and hereditary, deriving from a cell modification are called ‘stochastic’ because their expression is of a random nature. There has been no clear evidence for radiation-induced germ cell mutations in humans that led to birth defects, chromosome aberrations or Mendelian disorders [15]. Hereditary effects from radiation exposure have not been demonstrated in human populations. For example, hereditary effects have not been found in the descendants of survivors of the atomic bombing attacks of Hiroshima and Nagasaki [13, 16].

Although the exact cause of most cancers remains unknown or poorly understood, exposure to agents such as tobacco smoke, asbestos and ionizing radiation, is known to play a role in inducing certain types of cancer. The development of cancer is a complex, multistage process that usually takes many years. Radiation appears to act principally at the initiation stage, by introducing certain mutations in the DNA of normal cells in tissues [16, 17]. These mutations allow a cell to enter a pathway of abnormal growth that can sometimes lead to the development of a malignancy.

Epidemiological studies of survivors of Hiroshima and Nagasaki are the main sources for the association of irradiation and cancer development. An increase in papillary thyroid cancer was also observed in children and teenagers exposed to radioiodine after the accident at the Chornobyl nuclear power plant in 1986 [18–20].

2.5. GENERAL CONCEPT OF MEDICAL RESPONSE

The response to a nuclear or radiological emergency and the medical care for affected individuals depend largely on factors associated with the emergencies. The general principles of medical attention and care of injured persons will apply at the scene of the emergency as at the hospital, but the details and extent of medical care will differ [2, 5].

As described before, the affected individuals in a nuclear or radiological emergency might have been externally or internally exposed to radiation, and potential health consequences include deterministic and stochastic effects. The exposure pathways and some of the severe deterministic effects that may require particular therapeutic approaches are summarized in Fig. 1.

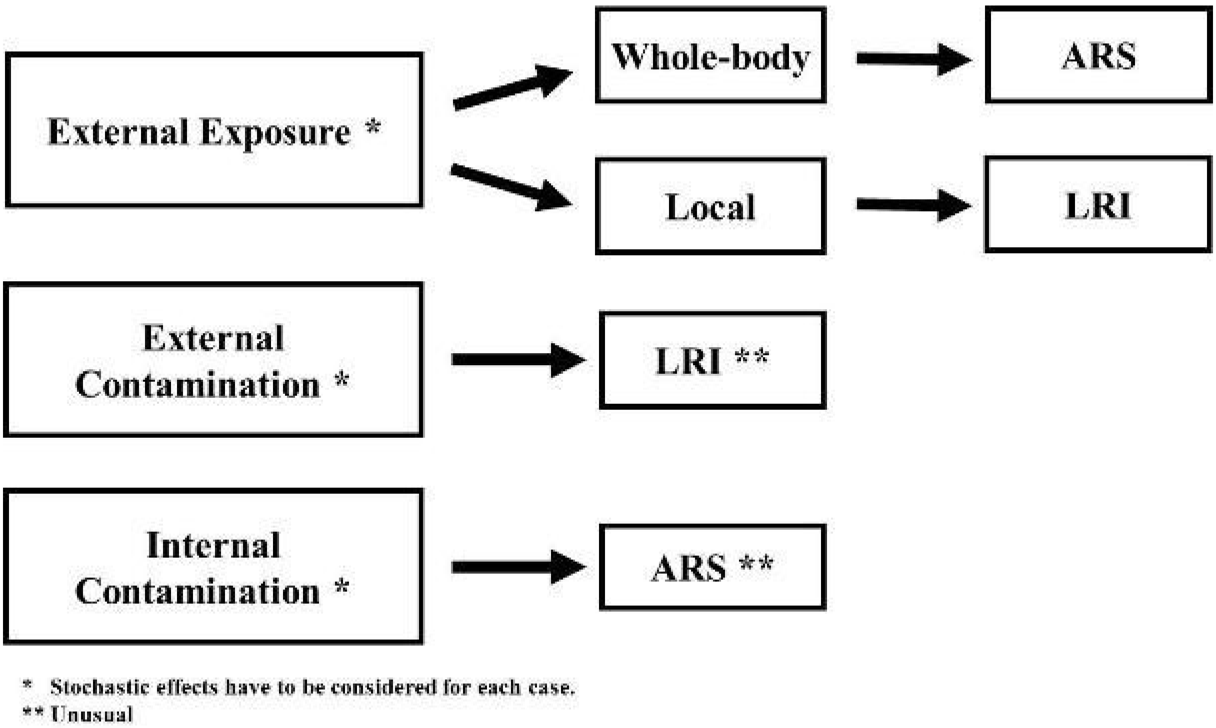


FIG. 1. Possible exposure pathways and short-term consequences, ARS - acute radiation syndrome, LRI - local radiation injury.

2.5.1. Triage of individuals

Triage is the use of simple procedures for rapidly sorting people into groups based on their degree of physical injury and actual potential effects on health, and allocation of care to these people to expedite treatment and maximize the effective use of resources [5].

The first step of triage in nuclear or radiological emergencies will be based on the severity of medical conditions, using conventional triage systems, not on radiation exposure or contamination criteria. Emergency attention will always be given to life-threatening conditions [2].

Primary triage is the assessment of vital signs and symptoms, common to any emergency situation. In addition, patients with injuries that require immediate surgery need to be identified. In extended triage, radiation induced effects are identified first. This assessment will have implications on further evaluation and treatment [21].

The triage for children will not differ from the one for adults in its objective, with priority of life-threatening conditions over the radiation exposure. Further information on medical triage for children can be found in Ref. [22].

The second step consists of identifying individuals that may have been exposed to radiation or contaminated with radioactive material [2].

The severity of radiation injuries depends on the dose received, the dose rate, the radiosensitivity of affected tissues and organs and the dose distribution. For the same dose and dose-rate, a partial body exposure has fewer health consequences than a whole body exposure [2].

As a reference, an absorbed radiation dose of about 3.5 Gy homogeneously distributed to the whole body is expected to result in the death of 50 per cent of the exposed population group within two months, if no medical treatment is provided (LD50/60 means, 50% in 60 days) [2].

Radiation exposure may be combined with trauma, thermal, chemical or other injuries [4, 5]. The decision on hospitalization, in cases of whole body exposures or local exposures, depends on the presence of early clinical signs, such as vomiting or erythema. However, hospitalization needs to be considered depending on the medical condition of the patient and the estimated dose. In patients suspected to have received substantial radiation exposure, hospitalization allows closer monitoring for the potential signs/symptoms of radiation exposure during the first 48 hours after exposure [2, 4].

2.5.2. General approach for persons potentially exposed in a nuclear or radiological emergency

A multidisciplinary approach is necessary to respond to nuclear or radiological emergencies. The team will need to include a radiological assessor and a medical physicist or health physicist who perform actions such as radiation monitoring and radiological assessment. Nuclear medicine technologists are familiar with survey meters and can also be helpful. An exposed patient poses no hazard to medical care providers; however, the potential for contamination still needs to be considered [2].

With proper training, actions concurrently performed by different experts and multidisciplinary professional teams will not interfere with the medical management of patients involved in a nuclear or radiological emergency. The following is a summary of the steps to be considered for the management of individuals affected in nuclear or radiological emergencies [2, 21, 23]:

1. Apply universal precautions.
2. Follow universal biosafety precautions for handling the patient and patient fluids. Patients with only external exposure pose no radiation exposure risk to others. Those that are contaminated can usually be cared for safely using gown and glove universal precautions. If the presence of radioactive materials is suspected, perform dose rate monitoring. Life-saving interventions are a priority. Potentially or immediately life-threating injuries

always have to be treated as a priority. If the patient is in stable condition, proceed with the following:

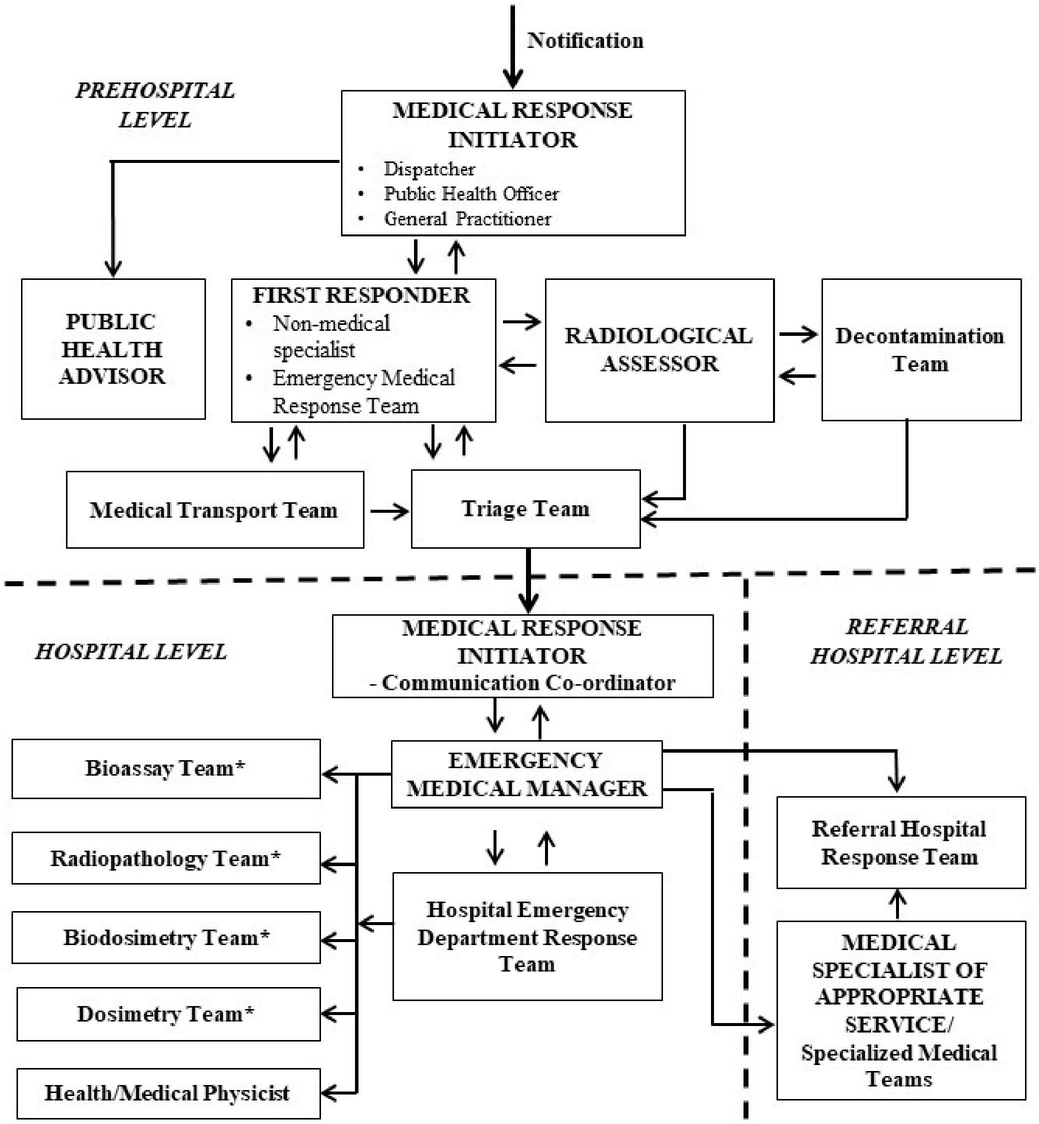
- Perform an external contamination survey of the patient.
  - If radiological contamination of skin/clothes is suspected, a radiological survey needs to be performed. The radiological assessor(s) will assist with this task. If the general condition of the patient is stable, the contamination survey can be performed concurrently with the history and physical examination.
- Register the medical history.
  - A detailed history is needed, including as much information about the radiation exposure as possible. Information about the start and length of exposure time, the source of the exposure, distance from the source and onset of any clinical manifestations (e.g. nausea and vomiting). It is also helpful to ask the victims about their familiarity with radiation, since accidental exposures can involve radiation workers. Keep in mind that most victims will have little knowledge about radiation and radiobiology, so any information obtained from the victim needs to be verified with other sources.
- Perform a physical examination.
  - Identify any erythema, oedema, blister or any lesion with no apparent cause. Depending on the local absorbed doses, signs and symptoms may be delayed for hours to days (weeks) after the exposure. Take serial colour photographs of lesions for evolution comparison.
- Consider hospitalization.
  - If radiation exposure is suspected, an in-patient hospital evaluation may be necessary.
- Notify the national competent authority.
  - This might not be the responsibility of the treating physician; however, steps are needed to ensure that proper notifications are made. Nuclear authorities can be an excellent resource for information about identifying the specifics of the radiation exposure, such as the isotopes involved, the doses received, as well as options for decontamination and medical treatment. Depending on the emergency, in some cases, international notification will be necessary [24, 25].
- Perform dose assessment.
  - Consider multiple dose assessment methods to support the medical management of exposed patients (clinical, biological, cytogenetic and dose calculations, for example). It is expected that the dose assessment will be performed by professionals dedicated to internal, external and biological dosimetry [26, 27]. The dose received by individual victims may be difficult to determine. However, with a careful history, contamination survey, and survey of the site of the incident as well as clinical findings such as physical examination and blood counts, reasonable dose estimates may be developed.
- Transfer the patient to a specialized centre.
  - Once stable, consider transfer of the patient to a medical facility that has expertise in the management of victims of acute radiation exposure, if needed.

- Request international assistance (if necessary).
  - National authorities may request international assistance from the IAEA whenever deemed necessary under the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency [28].
- Consider psychosocial support.
- Arrange for medical follow-up including exposure data.

2.6. MEDICAL PREPARDNESS AND RESPONSE TO A NUCLEAR OR RADIOLOGICAL EMERGENCY

Arrangements between the organizational systems, the institutions involved and the roles assumed by professionals responding to nuclear or radiological emergencies are different from country to country. A general structure of a medical response organization in a nuclear or radiological emergency is presented in Fig. 2. Each of the positions (functions) presented in the figure is discussed according to their respective levels. For further details on a hospital plan for nuclear or radiological emergencies, see Appendix II.

International cooperation may contribute to supporting the response to nuclear or radiological emergencies to an affected Member State following an official request. The provision of assistance in different areas, including the medical aspects of the response, may be coordinated through official channels [1, 24, 25, 28–33].



(*) Bioassay, radiopathology, biodosimetry, dosimetry and health/medical physicists may not generally available at most of the treatment facilities. Nevertheless, arrangements have to be coordinated with other organizations in the country to make these services available. International assistance can be coordinated by the IAEA to provide some of these activities.

FIG. 2. Medical response organization in nuclear or radiological emergency.

2.6.1. Pre-hospital level

Medical Response Initiator

A medical response initiator is the person who initiates the formal emergency response (medical or general) after notification of a real or suspected nuclear or radiological emergency.

The role of the medical response initiator could be assumed by the dispatcher or communication coordinator, who initiates the emergency medical response at the pre-hospital and hospital levels accordingly.

In the case of public health response initiation, this will be done by a public health officer at the local or national level.

If the event is recognized as a nuclear or radiological emergency, a general practitioner or any other medical specialist following examination of a casualty, this physician will have the responsibility to act as the medical response initiator and initiate a general emergency response by notifying the appropriate entity or personnel.

The medical response initiator is responsible for obtaining the basic information characterizing the emergency and initiating the appropriate level of response. At the pre-hospital level, the emergency medical responder is to be notified and alerted. At the hospital level, the emergency medical manager is to be notified. In the case of a public health response initiation, emergency response personnel and decision makers are to be alerted in accordance with the existing system of emergency response. Where there is a need for general response initiation, the medical response initiator will notify the head of the organization of the initiator's place of employment [2].

First Responder(s)

The first responder is the first person or team to arrive at the scene of an emergency with an official role to play in the emergency response [34].

For example, at a facility where radioactive sources, radioactive material or radiation generators are used, the first responder might be the radiation protection officer. For an emergency in a public place, the first responder(s) would likely be one of the emergency services (i.e. police, fire service or emergency medical responders). First responders are responsible for dealing with the initial aspects of the emergency at the scene. They are also responsible for providing first aid to injured persons, using standard methods of medical first aid (if qualified) until the emergency medical response team arrives.

Emergency Medical Response Team

The emergency medical response team is the specialized medical team arriving at the scene of the emergency upon notification. It is responsible for providing first aid and qualified pre-hospital assistance to victims. Members of the team will have knowledge of emergency medicine; however, knowledge of biological effects of ionizing radiation and the recognition and treatment of health consequences of these effects may be limited. They will also be trained in resuscitation and in radiation protection. In some countries, the role of emergency medical responders may be performed by qualified paramedical personnel [34].

Triage Team

The triage team performs triage at the scene of an emergency, determining the initial management of victim. For a limited number of casualties, triage is usually performed by the emergency medical response team, in conjunction with specialists that are communicating from off-site locations.

Radiological Assessor

The radiological assessor will normally be the senior member of the team(s) of radiological professionals (qualified experts) sent to the scene of an emergency to assess the radiological hazards, provide radiation protection information for the first responder, emergency medical response team and other responders on scene [34].

The radiological assessor may be a single individual or part of a team whose tasks include, among other things, the conduct of surveys, contamination control and arranging decontamination operations (if necessary to be performed on scene) among injured persons.

Decontamination Team

The decontamination team monitors personal and equipment contamination at the scene of an emergency. This team will assist emergency medical response personnel with monitoring of everyone at the scene of the exposure and preventing the spread of contamination. Decontamination procedures that interfere with necessary medical care are not to be performed at the scene. The team acting on scene might not include specialists qualified for special decontamination of wounds, eyes, ears and body orifices. If not available at the scene, this may be performed at a health care facility for acutely injured victims, or at decontamination centers for victims without medical injury. Swabs of nasal or oral cavities may provide important information about potential internal contamination. This information needs to be recorded and become a permanent part of the victim's medical record.

The decontamination team on scene usually has tasks and responsibilities in addition to those associated with monitoring and decontamination. This team is part of the generic response organization and particularly the generic environmental/source monitoring organization. In addition to familiarity with the proper use of personal protective equipment, team members need to be skilled in the use of radiation monitors to assess contamination and dose rates in order to prevent the spread of contamination and to monitor the efficiency of decontamination procedures [10, 27, 34].

The decontamination team acts in cooperation with the radiological assessor.

Public Health Advisor

The public health advisor is an official of the public health service at the local or national level. The role of the public health advisor in a nuclear or radiological emergency is to notify the public of threats and initiate the appropriate response for protection of the public. Initiation of stable iodine prophylaxis (if applicable) and establishment of long term medical follow-up needs are high priority tasks of the public health advisor.

Medical Transport Team

The medical transport team is responsible for transporting the casualties from the scene of the emergency to the emergency department of the hospital. The members of the team need to know how to deal with injured persons during transportation. They need to be trained in contamination control procedures.

2.6.2. Hospital level

The individuals or teams described in this subsection are meant to serve as example of the infrastructure that may be developed for the management of victims of unintended radiation exposure and are intended for planning considerations only, as local assets and equipment availability need to be taken into consideration. Regardless of their specific titles, each of these functions needs to be incorporated into nuclear or radiological emergency response planning.

Medical Response Initiator

At the hospital level, a designated medical response initiator triggers the emergency medical response.

Emergency Medical Manager

The emergency medical manager is a specialist (e.g. a nurse administrator) working in the hospital. The emergency medical manager is responsible for managing the actions of the hospital nuclear or radiological emergency response team, the medical specialist of the appropriate service, the health/medical physicist, and the radiation protection team or support group. They may assist in the triage of victims at the accident scene through communication with first responders.

The role of emergency medical manager could be assumed by the head of the hospital, team coordinator or (in the absence of team coordinator) the emergency physician from the hospital nuclear or radiological emergency response team.

Hospital Emergency Response Team

The hospital emergency response team consists of a group of specialists and support personnel from the hospital. The team is activated upon notification that casualties will arrive at the hospital. Ideally, the team will include a team coordinator, emergency physician, triage officer, nurse, radiological support personnel, technical recorder, public information officer, security personnel, laboratory technician and maintenance personnel. In some cases, the response team may have fewer members if all responsibilities are covered. Team functions may be carried out by healthcare personnel who are trained to perform the assigned tasks [2].

The hospital emergency response team is responsible for accepting the patient in the prepared reception area, assessing the patient's medical status, and providing necessary treatment while coordinating medical care with radiological care. The emergency physician will decide about referring the patient to the appropriate department within the hospital or relocating the patient directly to more specialized facility, if needed. The radiation protection team or support group will work jointly with the hospital emergency response team, and their activities will be coordinated by the emergency medical manager.

Each member of the team needs to be familiar with the hospital's emergency plan and be trained in scheduled drills.

Health/Medical Physicist

The health/medical physicist is the radiological specialist acting within the emergency medical response. This person needs to have the necessary knowledge and experience in dose assessment, radiological surveys, rapid screening for contamination and in decontamination of the patients.

The health/medical physicist works closely with the radiological assessment team and provides guidance on the collection of data for isotope identification and the selection of appropriate bioassay laboratories. This person is responsible for dose evaluation of the patient, considering the data provided by biodosimetry laboratories, bioassay laboratories, scenario reconstruction and physical dosimetry reports. [27].

The health/medical physicist is also responsible for providing data on dose assessment to the medical personnel to inform patient-care decisions.

Radiological Assessment Team

The radiological assessment team is responsible for ensuring the collection of samples for further radioanalysis, monitoring of personal and equipment contamination at the hospital level and assisting with the decontamination of patients, equipment and staff. Post-emergency facility monitoring will also be needed.

The pathology department may require assistance from the radiological assessment team when collecting necessary samples (such as biopsies) or performing autopsies of bodies contaminated with radioactive substances.

Specialized Laboratory Support

Bioassay is the analysis of biological samples for the presence of radioactive materials. The bioassay laboratory needs to have in-vitro and in-vivo internal contamination monitoring techniques and be able to provide interpretation of bioassay data, as well as provide biokinetic modelling from individual retention data and/or biokinetic models.

Cytogenetic dosimetry, such as dicentric chromosome aberration (DCA) analysis and physical dosimetry such as electron spin resonance (ESR) measurement may be useful for external dose assessment [2, 23, 26]. Since, generally, a bioassay laboratory will not be available at a regular hospital, identification of specialized laboratory support is needed, and a protocol for sample collection techniques will need to be established during emergency planning [12].

In occupational incidents, the individual may be wearing a personal dosimeter. The dosimeter can help assess the external dose.

2.6.3. Referral Hospital level

A referral hospital is intended to provide highly specialized treatment to exposed and/or contaminated people, as well as for people with combined injuries as a result of a nuclear or radiological emergency. If there is no such hospital in the country concerned, the national authorities may request the coordination of international assistance for diagnosis, assessment and treatment of affected individuals through the official channels established by the IAEA and other international organizations under the relevant international conventions [1, 24, 28, 29].

At the referral hospital, assistance will be provided by medical specialists with qualifications corresponding to the specialty of the service (e.g. traumatology, surgery, haematology, clinical toxicology). They are responsible for providing the necessary treatment and continued decontamination of the patient, considering possible external/internal contamination, external exposure and complications derived from these conditions. They need to be familiar with the procedures in the hospital plan dealing with patients involved in a nuclear or radiological emergency.

2.6.4. Drills and exercises

As illustrated in Fig. 3, There are four main components of an effective emergency response preparation programme: (1) develop procedures and plans; (2) train and educate; (3) drills and exercise (practice); and (4) identify areas for improvement.

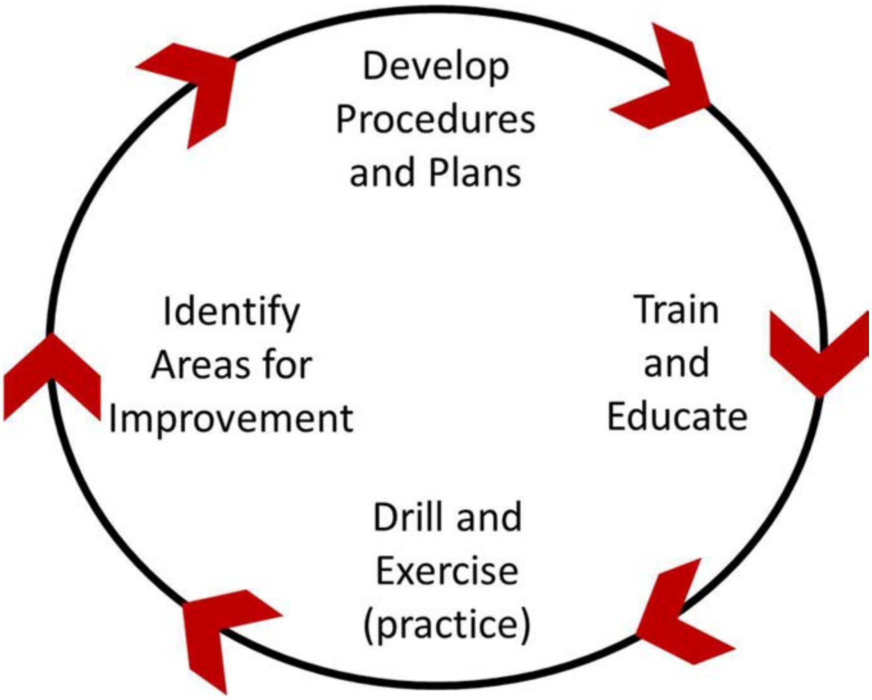


FIG. 3. Plans, procedures, training, drills and exercise (courtesy from Mr S. Sugarman, SummitET).

Proper plans and procedures are needed to address all the aspects of the response. Proper training ensures that the staff is familiar with their roles and their procedures. However, unless there is a real emergency, the only way to ensure that these plans and procedures, and the training supporting them, are adequate and effective and result in a high response capability is by carrying out a drill or an exercise.

Drills are more specific to a function or department, such as contaminated patient drills in the emergency department. Their purpose is to maintain proficiency. Exercises are more comprehensive.

Nuclear or radiological emergency response exercises are a powerful tool to verify and improve the quality of emergency response arrangements [2]. However, they represent a significant investment of effort, financial resources and people. Therefore, it is important that the maximum benefit be achieved from each exercise, which depends primarily on having clear objectives throughout the process. In practice, this means good preparation, professional conduct, and a fair and accurate evaluation.

Goals of an exercise

The purpose of an exercise is to test the overall plan and the general arrangements. Hence, the focus is on the performance of the entire organization, not on the ability of individuals. An exercise theoretically will not be construed as simply a learning experience for individuals but as a learning experience for the organization.

As stated in this section, a good exercise is one which allows many lessons to be learned. Therefore, an exercise will not be seen as an opportunity to demonstrate how good the response is.

An exercise can also be used to verify that new concepts or plans will work or to suggest adjustments that should be made before fully implementing a certain emergency response system. Exercises are also an excellent learning experience on how people react under stress, provided the exercise is conducted in a realistic and serious manner.

Note

The general procedures that are provided in this document are intended to give guidance and are not meant to dictate response. It is imperative that available assets, personnel, facilities and subject matter knowledge are taken into account during the planning stage, so that the intent of these procedures can be met. It is also essential to properly inform the public in the case of a nuclear or radiological emergency. Proper communication also needs to be incorporated into the implementation of the guidance procedures described.

PROCEDURES

SECTION A – RESPONSE PROCEDURES AT PRE-HOSPITAL LEVEL

PROCEDURE A1: INITIATION OF PRE-HOSPITAL RESPONSE

Performed by: Medical Response Initiator - Dispatcher	**PROCEDURE A1** **INITIATION OF PRE-HOSPITAL RESPONSE**	*Page 1 of 2*

Purpose

To provide guidance to initiate the formal emergency medical response at the pre-hospital/scene level upon notification of a nuclear or radiological emergency with casualties.

Discussion

This procedure is to be known and followed by medical response initiator — dispatchers of the emergency medical service.

Input

- Notification of a nuclear or radiological emergency.

Output

- Activated response of the emergency medical service.
- Emergency Registration Form (Worksheet A1).

Step 1

Obtain emergency description from the reporting person using Emergency Registration Form (Worksheet A1). Verify the authenticity of the notification.

Step 2

Advise the caller to take the following actions, if applicable:

- Wait for the emergency medical response team and the medical transport team.
- Provide first aid if qualified.

Decide about the number of emergency medical responders and medical transport teams needed.

Alert the emergency medical responder(s) and medical transport team(s). Inform team leaders if malicious acts involving radioactive material are known or suspected. The medical component of the response will be integrated with the global response, including security.

Inform the emergency medical responder(s) and medical transport team(s) about the emergency. Provide them with the information registered in Worksheet A1.

Step 3

Advise the emergency medical responder(s) and medical transport team(s) on necessary precautionary actions and/or protective equipment using available information on the emergency.

Step 4

Provide Worksheet A1 to public health officer (if applicable by nature and magnitude of the event).

PROCEDURE A2: ACTIONS ON SCENE UNTIL ARRIVAL OF THE EMERGENCY RESPONSE MEDICAL TEAM

Performed by: First Responder(s)	**PROCEDURE A2** **ACTIONS ON SCENE UNTIL ARRIVAL OF THE EMERGENCY MEDICAL RESPONSE TEAM**	*Page 1 of 2*

Purpose

To provide guidance to the first responder(s) on actions to be taken on scene until arrival of the emergency medical response team, when applicable.

Discussion

Until the arrival of the emergency medical response team on the scene, first responder(s) (facility responder, police, fire service or other personnel who have been trained in techniques of scene assessment and first aid) can provide emergency first aid for injured person(s). Radiation exposure or contamination with radioactive material does not typically cause immediate signs or symptoms. Therefore, if casualties are unconscious, disoriented, burned or otherwise in distress, look for causes other than radiation (see Appendix VI).

Note: It is important that all responders take precautions to ensure that the scene is safe for them to enter before taking any actions.

Input

- Emergency situation with casualties.

Output

- First aid performed at the scene.

Step 1

Note conventional hazards in the area (e.g. fire, smoke, steam, chemicals, electrical hazards), see Appendix VI. Search for casualties. If available, use radiation monitoring devices to assess radiation hazards.

CAUTION
Follow basic principles of radiation protection (see Appendix VII).

Step 2

Call for emergency medical response team and indicate situation and location (if it was not done previously).

Step 3

If the area is free of conventional hazards, check the conditions of the patient(s). If there is an immediate life-threatening hazard in the area, mitigate the hazard, and then move the victim to a safe area.

Step 4

Apply standard first aid and life-saving procedures.

Step 5

Do not move patients with severe injuries unless there is a life-threatening hazard (such as fire) in the area.

Step 6

Brief the emergency medical response team.

PROCEDURE A3: ON SCENE EMERGENCY MEDICAL RESPONSE

Performed by: Emergency Medical Response Team	**PROCEDURE A3** **ON SCENE EMERGENCY MEDICAL RESPONSE**	*Page 1 of 5*

Purpose

To provide guidance for the emergency medical response team on the scene of nuclear or radiological emergencies.

Discussion

First aid actions performed by first responder(s) may be in progress.

Upon arrival at the scene, the emergency medical response team will be briefed and will coordinate the medical evaluation and management of casualties, including their transport to hospital facilities.

Input

- Notification of an emergency with casualties.

Output

- Assessment, medical and radiological triage of casualties at the scene.
- Implementation of response actions.

Step 1

Get briefing from the general incident commander upon arrival (Emergency response commander is used in place of incident commander recently.). Consider areas established by first responders (see Fig. 4).

CAUTION

Follow basic principles of radiation protection (see Appendix VII).

NOTE

The first person or entity on the scene in a mass casualty nuclear or radiological emergency needs to notify the appropriate health authority/agency responsible for the strategic and tactical medical management of the nuclear or radiological emergency. The services need to be carefully coordinated with the general incident commander.

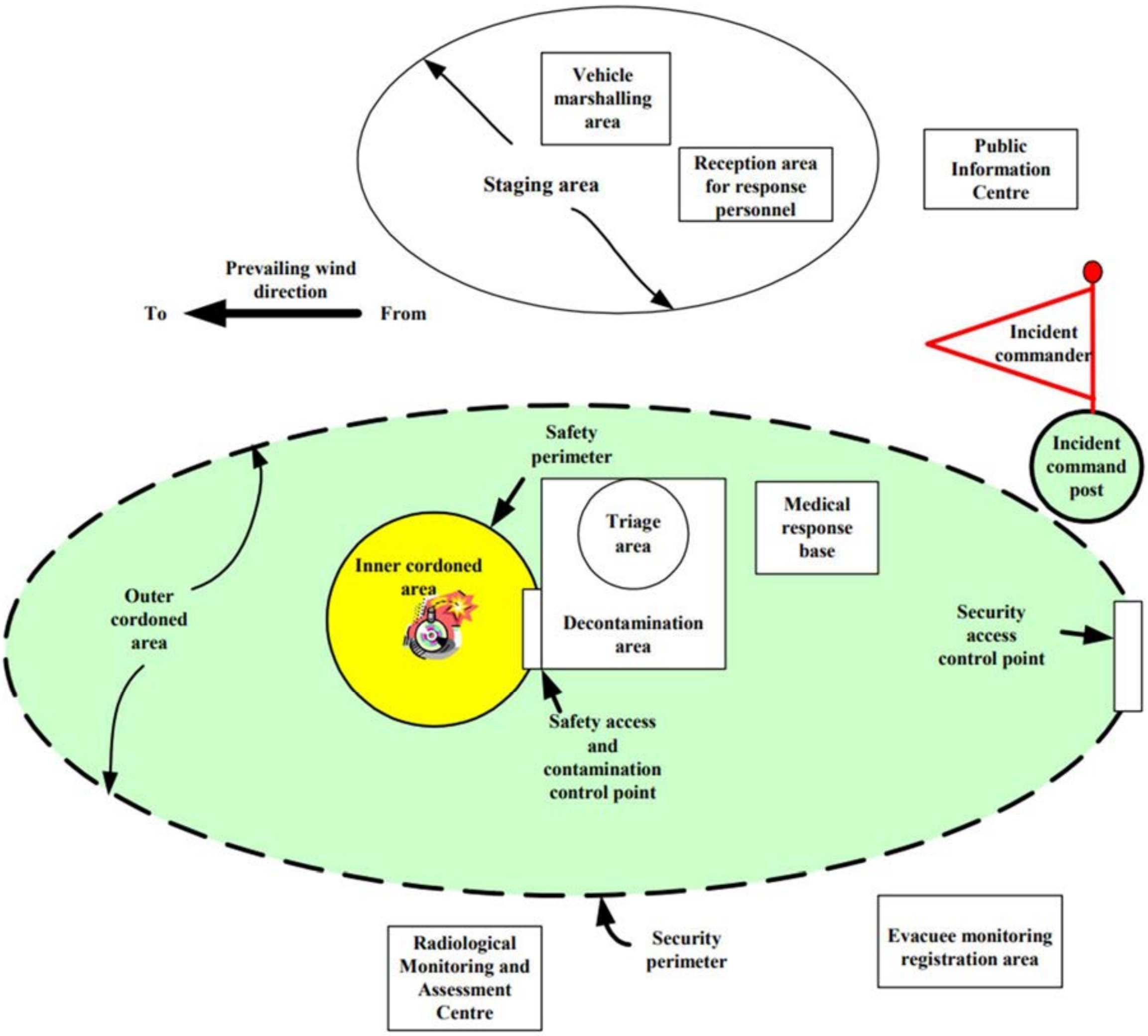


FIG. 4. Areas established by first responders [35].

(Recently, emergency response commander has been used in place of incident commander.)

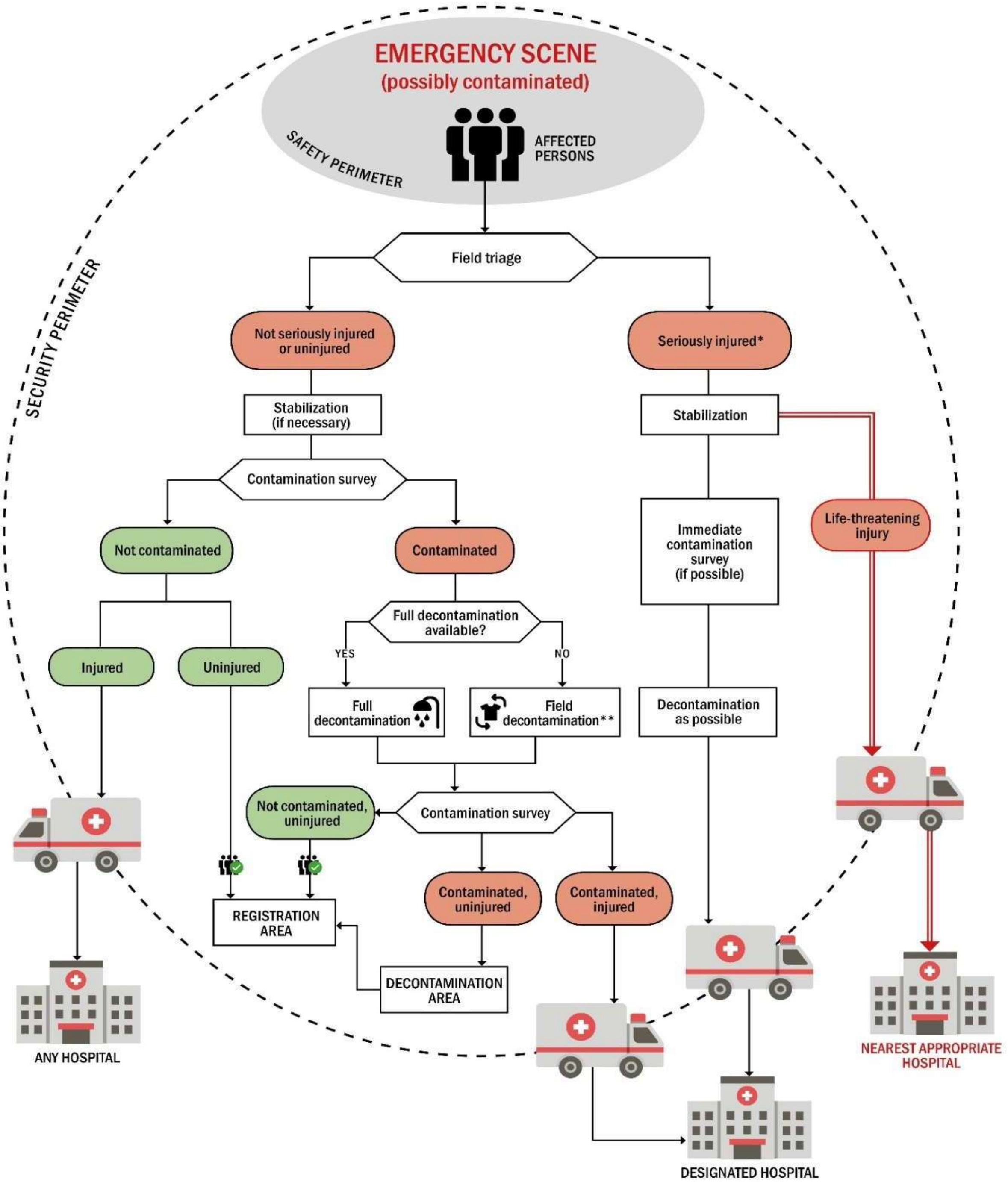
Step 2

Perform search and rescue for injured persons as soon as possible. Remove injured persons (either patients or casualties) from the hazard area into the triage area as soon as possible (see Fig. 5).

NOTE

The inner cordoned area within the safety perimeter will often represent a direct hazard to victims and responders if they remain there for long periods of time. It is therefore best to perform medical triage, radiological triage and stabilization procedures in a triage area outside the safety perimeter.

Use Fig. 4 as guidance for actions to be performed.



* Considered exposed if not proven otherwise

**If not available, release evacuees with instruction to control ingestion and to decontaminate when possible

Life-threatening/immediate care

Possibly contaminated

Not contaminated

FIG. 5. Field triage during nuclear or radiological emergency.

NOTE

The transfer of patients from the scene to the designated hospital needs to be arranged at the preparedness stage. Other hospitals might be needed depending on the magnitude of the emergency, location of the emergency, health status of the patients, local protocols, and other factors.

Step 3

Assess the status of the casualties using established medical triage systems to ensure that priority is given to the management of life-threatening injuries over radiological concerns.

Step 4

Assess and treat life-threatening injuries immediately. Transport casualties with such injuries to the appropriate hospital immediately, even if a contamination survey has not been carried out. Stabilize other victims.

Inform the receiving hospital about the nature of the conventional injuries and of any known or suspected exposure or contamination with radioactive materials.

NOTE

Keep the deceased casualties at the site until law enforcement officer(s) have acquired any available evidence and living casualties have been moved to the healthcare facility. A deceased person who has been externally exposed does not represent a radiological hazard to the responders. Special precautions may be needed in case of internal or external contamination of the deceased person(s). Procedures regarding management of deceased casualties depend on the character of the nuclear or radiological emergency, the number of injured and/or deceased victims and local protocols.

Step 5

Cover wounds with sterile dressings. Prepare injured persons for transport to the hospital.

Step 6

Work in close cooperation with, and follow the directions of, the radiological assessor for the radiological survey and other appropriate actions.

NOTE

It is possible to perform a radiological survey during stabilization of a casualties if monitoring procedures do not interfere with medical actions. Detailed description, criteria and guidance for the radiological survey and triage are presented in Procedure A5.

Step 7

Direct the contaminated non-critically injured patients to decontamination. Ensure medical status of the patients is monitored during this process.

Remove all clothing found or suspected to be contaminated unless medically contraindicated. In cold environmental conditions, ensure that warming blankets be provided for patients.

Isolate (bag and secure) contaminated clothing, shoes and personal belongings for further decontamination.

NOTE

Contaminated clothes may be a useful sample for further analysis. If a malicious act is suspected, retain all items for forensic investigation.

The radiological assessor will record the result of the surveyed casualties (Worksheet A3), and records will be maintained in accordance with the local registration.

Step 8

A personal and equipment contamination check will be performed by the radiological assessor as appropriate (See Appendix III).

NOTE

When the medical conditions of affected persons do not require urgent hospitalization, DO NOT leave the scene of an emergency without being checked for personal contamination. DO NOT take any equipment out of the scene area prior to being checked for contamination. If you have to leave the scene urgently, contamination control procedures need to be performed as soon as reasonably practicable.

Step 9

Submit any personal dosimeters to the responsible person or organization (according to arrangements for the keeping of dose records) for evaluation of personal doses.

PROCEDURE A4: TRANSPORT OF CASUALTIES TO HOSPITAL

Performed by: *Medical* *Transport Team*	**PROCEDURE A4** **TRANSPORT OF CASUALTIES TO HOSPITAL**	*Page 1 of 2*

Purpose

To provide guidance for the transfer of casualties from the emergency scene to the hospital.

Discussion

If possible, affected persons are to be transported by qualified medical or paramedical personnel who have not entered the controlled area on scene (in the security perimeter). Exposed casualties require no special handling, while contaminated persons are handled and transported using contamination control procedures. If there is any doubt, assume that all casualties are contaminated until proven otherwise. Continue medical assessment and treatment during transport when necessary.

Note: Ensure that ambulance services are willing and prepared to transport contaminated patients.

Input

- Casualties on site ready to be transported to the hospital emergency department.

Output

- Medical response actions during transportation of the casualties.
- Delivery of casualties to the hospital.

Step 1

Upon arrival on scene, wear personal dosimeters if available. Wear personal protective equipment as the situation requires. Consider preparing ambulance or transport vehicle to transfer contaminated patient and equipment.

Step 2

Place the ambulance in an area to allow patient loading that will not interfere with other actions or increase the probability of spreading contamination.

Step 3

Cover victim by folding a sheet or blanket over him/her and securing it in place, such that it does not interfere with medical actions.

Step 4

Transport the victim to the ambulance reception area of the hospital emergency department or alternative designated emergency hospital reception area for patients.

Step 5

Assess the victim's vital status during transport and intervene appropriately. Medical care takes priority over contamination concerns.

Step 6

Advise the receiving hospital of any change in the victim's medical status. Ask for any special instructions the hospital may have.

Step 7

Use contamination control during transport. Change gloves as necessary.

Step 8

Transfer the patient in accordance with hospital instructions.

Step 9

Do not return to regular service until you, the vehicle and equipment have been monitored and decontaminated (if necessary), unless urgently needed elsewhere.

Step 10

Submit personal dosimeters to the responsible person or organization (according to arrangements for keeping of dose records) for evaluation of personal doses.

NOTE

DO NOT eat, drink, smoke or apply make-up at the emergency scene, in the ambulance vehicle or at the hospital until surveyed and released by the appropriate service of the hospital.

PROCEDURE A5: RADIOLOGICAL SURVEY OF CASUALTIES

Performed by: Radiological Assessment Team or Health/Medical Physicist	**PROCEDURE A5**	*Page 1 of 5*
	RADIOLOGICAL SURVEY OF CASUALTIES	

Purpose

To monitor casualties for skin and clothing contamination.

Discussion

Monitoring of the external contamination of casualties needs to start as soon as possible, without interfering with medical care. The results of monitoring will allow the prevention of the spread of contamination and the performance/prioritization of decontamination procedures. The initial radiological survey therefore needs to start on the scene of the emergency and be continued in the hospital. External contamination is assessed by direct monitoring of skin and clothing. Pay attention to contamination of the face, as it may indicate internal contamination.

Note: Internal contamination is evaluated by in vivo or in vitro bioassay or by other sampling techniques.

Precautions

For persons who might be contaminated and require urgent medical attention and subsequent urgent transportation, priority needs to be given to their medical condition and its treatment. The use of standard universal precautions provides protection against radioactive contamination. Ensure that radiation dose rates are at acceptable levels.

Input

- Transferred casualties.

Output

- Results of radiological survey of the casualties on scene (Worksheet A3).

Step 1

Perform quality control checks of monitoring instrumentation [2] (this step is to be performed prior to the patient arrival). Verify background levels.

Step 2

Turn contamination monitor on and place probe in a lightweight plastic bag or cover to prevent it from being contaminated. Do not cover the probe window when alpha emitters are suspected.

Step 3

Determine and record the background radiation level periodically at the location where the monitoring is to take place (Worksheet A3 or B1).

Step 4

Place the probe about 1 cm from the person's body, being careful not to touch the person.

Monitor the entire body following a sequential order, as shown in Fig. 6. Pay particular attention to the feet, seat, elbows, hands and face. Move the probe slowly (about 5 cm per second).

CAUTION

Precautions have to be made to prevent internal contamination with radioactive materials during the radiological survey process (see Appendix VII for basic principles of radiation protection in an emergency).

NOTE

Do not allow contamination monitoring to interfere with medical actions to stabilize patients' conditions or with the transport of casualties with life-threatening injuries. Any radiological survey at the scene of the emergency needs to be done in co-operation with medical personnel.

Monitoring of affected persons

Step 5

After getting request from medical personnel, perform contamination monitoring of the casualties.

On the basis of the results of the survey, perform radiological triage according to the following guidance:

- Consider areas that show more than 2–3 times the normal background level as contaminated and decontaminate accordingly.
- Alpha background is considered to be zero. If alpha emitters are present at any level, consider the patient to be contaminated.

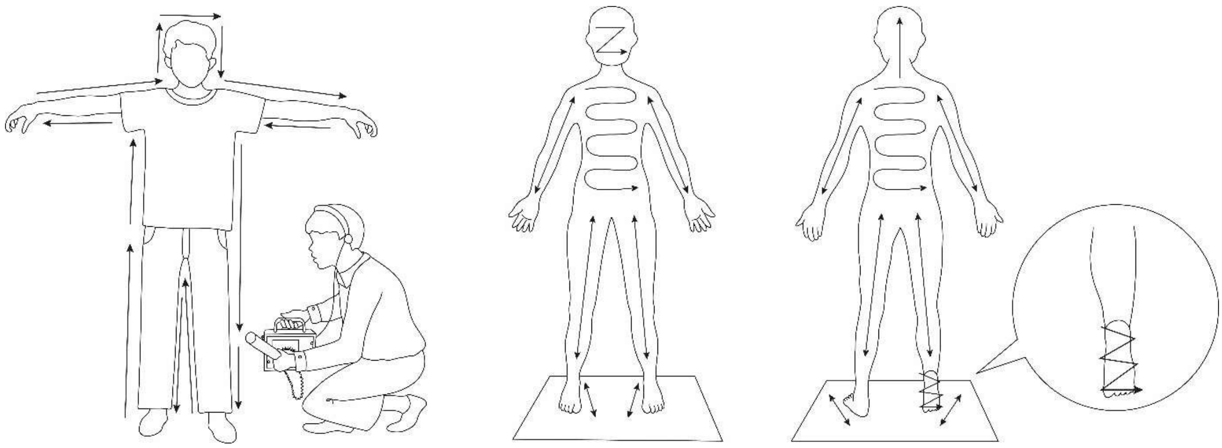


FIG. 6. Frisking technique.

NOTE

If the radioactive material is in liquid form, it could penetrate clothing, thereby increasing the possibility of contamination being on some of these latter parts of the body.

Typical contamination measurements are reported in activity.

Surveying to detect external contamination of clothing with radionuclides that emit alpha particles can be unreliable due to folds, shielding and the inability to keep the probe at the correct distance over uneven surfaces.

Remove contaminated clothing and place it in labelled plastic bags. Re-survey the person.

DO NOT monitor at the scene of the emergency if this might jeopardize medical assistance in life-threatening conditions.

Monitoring of wounds

NOTE

It is difficult to locate radioactive material within a wound without specialized monitoring equipment and techniques.

Specialized wound probes (scintillation or semiconductor detectors) provide a good sensitivity to assess the gross activity at the wound site but are not commonly available.

Information about contamination of the wound may give an idea how to interpret the bioassay measurements. Methods of in vitro or in vivo bioassay are to be used to verify dose assessment.

Step 6

Survey the uncovered wound. If the wound is dressed, request assistance from the medical personnel to remove the dressing.

NOTE

Alpha particles can be shielded in wounds. Intact skin immediately adjacent to the wound site may provide information about contamination level in the wounds.

Monitoring of facial body orifices

Step 7

Monitor the areas near the nose to assess the potential for internal contamination.

Step 8

Collect nasal and oral swabs using moist, clean cotton-tipped applicators, within about 60 minutes of the intake because of the rapid clearance from the nose [2, 10]. Negative oral swabs have very little meaning, since the mouth clears quickly. Positive oral swabs may indicate an elevated intake of radioactive material.

NOTE

If only one nostril is contaminated, it could be due to a deviated septum, but cross-contamination from a contaminated finger is also a possible cause.

Nasal swabs can be used to estimate the magnitude of the internal dose. However, variations in conditions, collection efficiency and the constitution of individuals can result in deviations from what is predicted. Bioassay needs to be used for a definitive internal dose determination.

If alpha emitters are involved, a very low activity on the swab may indicate a significant intake.

After monitoring

Step 9

Where surface contamination derived limits are not specified by the national competent authority, compare results of monitoring with default values suggested in Table 1. Take appropriate actions within your expertise. Perform decontamination following Procedure B5.

Step 10

Record results on Worksheet A3 or B1. Also make a record of the measured area (active surface of the detector).

Step 11

As possible, monitor all personal belongings, including watches, handbags and money. Bag and label any contaminated items for decontamination. Contaminated personal clothing may be removed, bagged and labelled, and substitute garments provided (usually by public welfare agencies).

Levels of radioactive material on the skin that exceed Operational Intervention Level (OIL)4 may indicate that the person has inadvertently ingested or inhaled enough radioactive material to result in doses warranting a medical follow-up.

TABLE 1. RECOMMENDED ACTION FOR OPERATIONAL INTERVENTION LEVELS (OILs) REGARDING SKIN CONTAMINATION (OIL 4) (adapted from [36])

OIL Value	Response action (as appropriate) if the OIL is exceeded
Gamma (γ) 1 μSv/h at 10 cm from the skin	Provide for skin decontamination[a] and reduce inadvertent ingestion[b].
1000 counts/s direct beta (β) skin contamination measurement[c]	Register and provide for a medical examination.
50 counts/s direct alpha (α) skin contamination measurement[c]	For a detailed description and information in this regard see the Appendix VIII.

[a] If immediate decontamination is not practicable, advise evacuees to change their clothing and to shower as soon as possible.
[b] Advise evacuees not to drink, eat or smoke and to keep their hands away from their mouths until their hands have been washed.
[c] This is performed using good contamination monitoring practice.

SECTION B – PROCEDURES AT THE HOSPITAL

PROCEDURE B1: INITIATION OF HOSPITAL RESPONSE

Performed by: Emergency Medical Manager	**PROCEDURE B1** **INITIATION OF HOSPITAL RESPONSE**	*Page 1 of 2*

Purpose

To provide steps with basic actions by the emergency medical manager to be performed at the hospital level in a nuclear or radiological emergency.

Discussion

The emergency medical manager assesses the situation immediately based on information from the medical response initiator of the hospital. If the hospital was not notified in advance by the medical transport team, and casualties have already arrived, the emergency medical manager assesses the situation accordingly. This manager needs to manage the participation of the hospital specialists, the implementation of the decision to transfer casualties to the referral hospital and provide the information for the official channels inside the country. The emergency medical manager needs to have constantly updated information about changes in patient conditions and progress of the response in the hospital.

Input

- Information about victims' arrival at the hospital (information included in Worksheet A2 is suggested to provide this information). The information could be provided by first responders, the medical response initiator, the radiological assessor, radiation safety officer or any authorized emergency contact.

Output

- Activation of the staff and the hospital for a nuclear or radiological emergency previously established—hospital emergency response team (see Appendix II).

Step 1

Activation of the hospital nuclear or radiological emergency plan.

NOTE

In the event of a nuclear or radiological emergency involving a large number of contaminated casualties, adapt a reception area for radiological triage and decontamination of non-emergency patients. These aspects need to be considered in the hospital nuclear or radiological emergency plan.

Step 2

Issue an order for the necessary preparation of ambulance reception and treatment areas.

Step 3

Make sure that all necessary personal protection actions are implemented in accordance with the hospital plan for a nuclear or radiological emergency.

Step 4

Ensure that the hospital public information officer has been notified and has started to fulfil the responsibilities for rapid media response that were given to the officer's position. Medical staff may be asked to provide inputs for the message provided by the public information officer.

Step 5

Ensure that systems of communication are established with the national health authority/agency responsible for the strategic and tactical medical management of the emergency in accordance with the national regulations.

NOTE

It is essential that this step is undertaken early in mass casualty nuclear or radiological emergencies when the services to many sites need to be carefully coordinated to ensure an adequate response to the event and the continued provision of effective healthcare services to the population not immediately affected by the emergency.

PROCEDURE B2: RECEPTION OF CASUALTIES AT THE HOSPITAL

Performed by: Hospital Emergency Response Team	**PROCEDURE B2** **RECEPTION OF CASUALTIES AT THE HOSPITAL**	*Page 1 of 1*

Purpose

To provide steps to initiate a formal emergency medical response at the hospital level upon notification of arrival of casualties as a result of a nuclear or radiological emergency.

Discussion

According to the emergency response plan, hospitals need to be notified about the arrival of victims. When receiving the casualties, a planned course of action needs be followed.

Input

- Activation of the hospital nuclear or radiological emergency plan and reception of casualties.

Output

- Hospital response.

Step 1

After receiving the notification of victims, the following information is to be considered (Worksheet A2 is suggested for this step):

- Number of casualties and their medical status (type of injuries).
- First aid, if provided.
- Radiological status of victims (exposed versus contaminated), if they have been monitored/surveyed for contamination. Identity of contaminant, if known.
- Estimated time of arrival.

Step 2

Check that hospital arrangements are in place to receive contaminated patients.

Advise ambulance personnel of any special entrance to the emergency department for nuclear or radiological emergency casualties.

Step 3

Consider that, in some nuclear or radiological emergencies, the number of worried-well persons seeking medical attention could create an extra burden on the facility. Coordination with other medical facilities may be necessary.

PROCEDURE B3: ASSESSMENT OF CASUALTIES IN AMBULANCE RECEPTION AREA

Performed by: Hospital Emergency Response Team	**PROCEDURE B3**	*Page 1 of 2*
	ASSESSMENT OF CASUALTIES IN AMBULANCE RECEPTION AREA/TRIAGE	

Purpose

To provide guidance on the sequence of steps to be performed in the ambulance reception area upon arrival of casualties.

Discussion

Once the casualties arrive at the planned reception area, the emergency physician or triage officer (qualified members of the hospital emergency response team) determines the general medical condition of the casualties and the severity of any combined injury.

The medical transport team or emergency medical response team then provides a briefing on the medical condition and the information provided at the scene on the casualties' radiological status.

Input

- Reception of casualties and data on casualties (suggested Worksheet A2).
- Results of radiological survey of casualties on the scene (suggested Worksheet A3).

Output

- Triage for medical management.
- Results of radiological survey of casualties (suggested Worksheet B1).

Step 1

Meet the casualties at the ambulance reception area or at a triage area established near the treatment area.

Follow the basic principles of contamination control and radiation protection (See Appendix VII).

Step 2

Instruct the medical transport team to stay with their vehicle until they, their vehicle and their equipment have been surveyed and released by an appropriate service of the hospital.

Step 3

Perform triage of casualties. During triage, consideration needs to be directed first to medical, then to radiological problems.

NOTE

Triage needs to occur at each stage due to changes in the casualties' status. The purpose of triage at the hospital is to sort the injured by priority and determine the best use of available resources (e.g. personnel, equipment, medication, hospital beds).

Urgent clinical interventions always have priority over radiological concerns, and immediate attention is directed to life-threatening problems. Radiation injuries rarely cause unconsciousness or immediate visible signs of injury and is not immediately life threatening; if these manifestations are present, other causes than radiation exposure have to be considered.

Act in accordance with the results of triage:

Condition of casualty	Action to be performed
Life-threatening	Stabilize, postpone radiological survey if it interferes with stabilization. Treat according to the health condition.
Stable	Proceed with steps 4 to 6 described below

Step 4

If the casualties' clothing was not removed before arrival at the hospital (at the emergency scene), remove the clothing as promptly as possible, unless medically contraindicated, taking care to avoid spread of contamination.

NOTE

Clothing and any accompanying sheets and blankets are to be placed in plastic bags, sealed, labelled, and properly stored for radiological analysis and/or evidence preservation (if applicable).

Step 5

Once the clothes have been removed, and if the patients' condition allows, ask the radiological assessor to perform a radiological survey of the patient(s) to determine if they are contaminated and to estimate levels of contamination on specific body areas.

Step 6

Use the following procedures to assess and treat casualties on the basis of survey results:

Patient	Procedure
Contaminated	B4a
Non-contaminated	B4b

PROCEDURE B4: CONTAMINATION CONTROL IN HOSPITAL

Performed by: Hospital Emergency Response Team	**PROCEDURE B4**	*Page 1 of 4*
	CONTAMINATION CONTROL IN THE HOSPITAL	

Purpose

To provide guidance on establishing arrangements for contamination control in the hospital.

Discussion

When the hospital nuclear or radiological emergency response team is notified that victims are arriving, it is essential that emergency medical supplies and equipment are readily available (see Fig. 7).

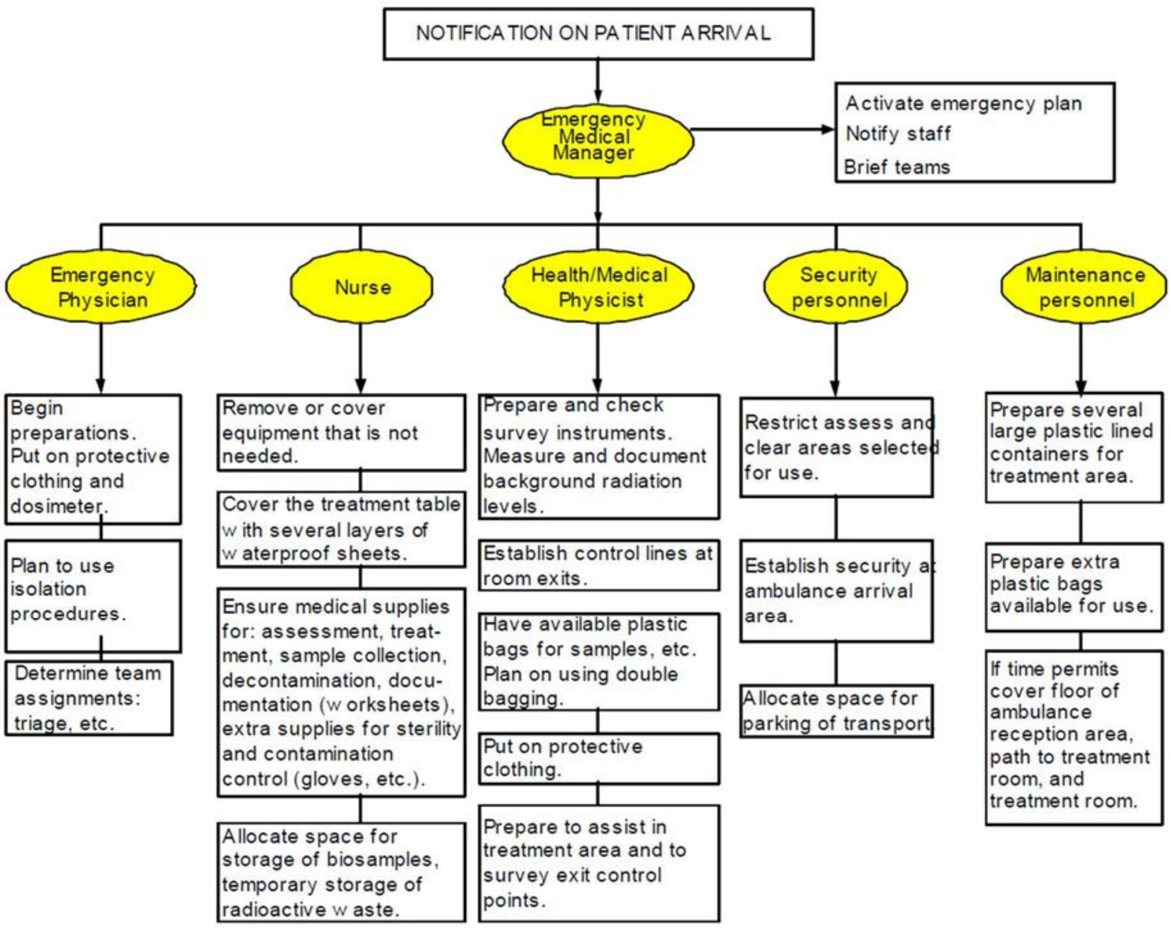


FIG. 7. Preparation for contamination control by Hospital Emergency Department Response Team [37].

An ambulance reception area is to be established and clearly designated according to the hospital plan for medical response to nuclear or radiological emergencies (examples of arranging the reception area are provided in Fig. 8).

Each hospital has to consider its individual situation and respective facility design. The figure below represents a sample set-up for hospital reception areas for emergencies resulting in a small number of casualties. A set-up for mass casualties also needs to be considered [5, 37]. (See Appendix II).

The example in Fig. 8 needs to be adapted to the local conditions.

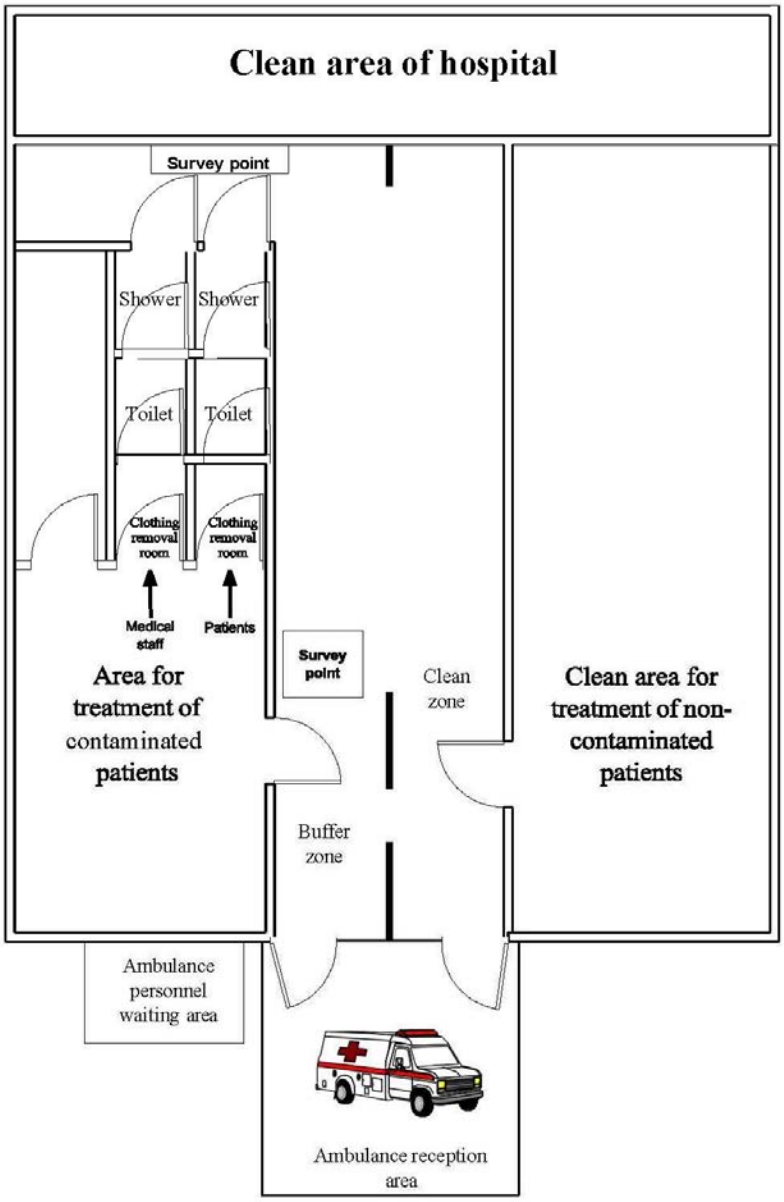


FIG. 8. Example of a scheme for preparation of the hospital reception area. (Reproduced from [37])

NOTE

In mass casualty nuclear or radiological emergencies, implement provisions to assess the concerns of members of the public (worried-well) about possible contamination. Be prepared to perform radiological triage of a large number of people at a location away from the hospital treatment area.

Individuals who are only externally contaminated but not injured are best decontaminated at a facility other than the hospital to conserve hospital resources for the injured.

Input

- Notification about the arrival of victims.

Output

- Hospital prepared for admission of contaminated victims.
- Data on background radiation levels (Worksheet B1).

Prepare ambulance reception area

Step 1

Select an ambulance reception area close to the entrance of the treatment area.

Step 2

If time permits, make a path large enough to accommodate the stretcher and attending personnel, from the ambulance entrance to the hospital entrance (use appropriate covering material for this purpose). Tape the floor covering securely to the floor. Rope off and mark the route to prevent unauthorized entry.

NOTE

Plastic sheets can be slippery (especially if wet). Secure the floor covering to prevent slippage and tripping hazards. Do not delay urgent or emergent medical care. Covering floor of reception area and treatment room can be more hazard than help. Slippery or uneven surfaces can serve as a hazard to responders and even serve to spread contamination. Most floors can be cleaned if contaminated.

The medical transport team and equipment need to be surveyed after the delivery of patients to the hospital, unless urgently needed elsewhere.

Prepare hospital treatment area

Step 3

Take precautions to restrict access to the treatment area. Clear the area of visitors and relocate non-acute patients if possible. Remove or cover equipment that will not be needed during emergency care of the victims.

Step 4

If time permits, cover the floor of the treatment area in the same way as described in Step 2. Tape the floor covering securely to the floor. Prepare warning labels and signs for temporary control areas.

Step 5

Check survey instruments and prepare them for use. Document background radiation levels. Make provisions to monitor persons and equipment leaving the area. Prepare enough instruments and supplies (e.g. outer gloves, dressings) to change them when they become contaminated.

Step 6

Cover the treatment table with several layers of waterproof, disposable sheeting. Make sure that, during the process of decontamination, contaminated water will not accumulate under the patient (direct the runoff to a collection basin).

NOTE

A damp washrag can be used to minimize spread of contamination. It is better for any contamination to stay on absorbable material than to run off of waterproof sheets in some cases.

Step 7

Prepare several large plastic lined waste containers. Make sure plastic bags of varying sizes are available. Post signs and attach labels in accordance with local regulations.

Step 8

Use waterproof materials to limit the spread of contaminated liquids, for example, use waterproof dressings for wounds, direct runoff into appropriate collection containers.

NOTE

While it may be desirable that the room, or rooms, have either a ventilation system that is separate from the rest of the hospital or a means of preventing the unfiltered exhaust air of the nuclear or radiological emergency area from mixing with the air that is distributed to the rest of the hospital, there is very little likelihood that contaminants will become suspended in air and enter the ventilation system. This is achieved via proper patient handling techniques; hence, no special precautions are advised.

In case of discovery of radioactive contamination after admission of the patient:

Step 9

Secure the entire area where the victim and the attending staff have been located. Establish control lines; do not allow anyone or anything to leave the area until cleared by the health/medical physicist, unless medically necessary.

Step 10

Perform all medical and other actions as necessitated by the patient’s status (as described in Procedures B4a and B4b).

Step 11

Assess the patient's radiological status using Procedure A5. Perform decorporation using Procedures B4a and B4b.

PROCEDURE B4a: ASSESSMENT AND TREATMENT OF CONTAMINATED CASUALTIES

Performed by: Hospital Emergency Response Team	**PROCEDURE B4a** **ASSESSMENT AND TREATMENT OF CONTAMINATED PATIENTS**	*Page 1 of 4*

Purpose

To provide guidance for assessment and treatment of contaminated casualties in the treatment area, the specialized medical service and the referral hospital.

Discussion

It highly unlikely that a patient contaminated with radioactive material could represent a significant hazard to the attending team in terms of external exposure emitted from the patient. Monitoring of radiation levels can be undertaken to confirm no hazard for the medical staff.

A patient contaminated with radioactive material can transfer this contamination to premises, equipment and other persons. Contamination control procedures to avoid spread of contamination need to be in place.

Input

- Results of radiological surveys of the casualty in the ambulance reception area.
- Medical Information.

Output

- Samples for conventional medical and radiological analysis.
- Results of radiological survey of casualties in the treatment area.

Step 1

Reassess the medical condition of the patient.

NOTE

A patient with contaminated wounds needs to be evaluated by appropriate bioassay methods.

Step 2

Follow the basic principles of radiation protection (see Appendix VII).

Step 3

Ask the radiological assessor to perform a radiological survey. This can be repeated throughout patient treatment as long as it does not interfere with patient care.

Step 4

Place clothing and any accompanying sheets and blankets. in a plastic bag. Label the bags with warning signs and information on the identification of the patient. Store the bags in a secure place at a distance from the immediate work area. Patient clothing may be a good sample for isotope identification.

Step 5

Change or monitor gloves routinely and/or after handling clothing or other potentially contaminated items.

Step 6

Obtain a complete and detailed medical and occupational history. Examine the patient.

Step 7

Assess the possibility and potential magnitude of internal contamination via nasal swabs, facial surveys, wound monitoring or other indicated methods. If internal contamination is suspected, initiate the collection of samples for analysis. Consider the need for decorporation treatment if necessary (see Procedure B6 for details).

Step 8

Take necessary laboratory samples using the guidance in Table 2.

NOTE

All samples taken from individuals involved in a known or suspected malicious act involving radioactive material need to be retained as evidence for examination.

Step 9

Identify the appropriate medical service within the hospital or referral hospital for continuing medical management of the patients. Many hospitals do not have the necessary equipment to perform bioassay, so arrangements may be needed with outside organizations.

TABLE 2. IMPORTANT LABORATORY SAMPLES TO BE TAKEN IN TREATMENT AREA FOR SUBSEQUENT ANALYSIS

Samples Needed	Purpose	Description
When a whole body exposure or a radiation injury is suspected:		
Immediate CBC and differential (follow with absolute lymphocyte count every 6 h for 48 h when history indicates possibility of high dose whole body irradiation)	To assess the exposure dose range; initial counts establish a baseline, subsequent counts reflect the degree of injury	Choose a non-contaminated area for venipuncture; cover puncture site after collection.
Routine analysis of urine	To indicate if kidneys are functioning normally and establish a baseline of urinary constituents	Avoid contaminating specimen during collection; if necessary, give the patient plastic gloves to wear for collection of specimens; label the container accordingly.
Serum amylase	To assess the exposure dose range; the upper neck region and indirectly of the whole body dose	
Serial colour photographs (local injuries)	To document and track changes associated with local radiation injury	Try to be consistent with the photographs regarding light and background, so comparisons can be easily made.
When external contamination is suspected (may lead to internal contamination):		
Swabs from nostrils and mouth	To assess possibility of internal contamination	Use separate swabs to wipe the inner aspect of each nostril and mouth.
Wound dressing, swabs from wounds	To identify contaminants and to help inform medical decisions (may be an indicator of contamination levels in wounds)	Save dressings in a plastic bag. Use swabs to sample each wound. For wounds with visible debris, use tweezers or forceps to transfer samples to a proper container if radiation doses are at a level of concern.
When internal contamination is suspected:		
Urine	To identify contaminants: Body excreta may contain radionuclides if internal contamination has occurred. Excretion pathway is determined by radionuclide's chemistry. Radioactive materials remaining in the body may also be measured.	Collect initial spot samples for quick assessment, followed by continuing 24-hour urine sampling.
Faeces		Collection of faeces according to the protocol in place.
In vivo counting	To identify contaminants: It may assess internal contamination by gamma emitters and indirectly by beta emitters	In vivo monitoring is often used to assess internal doses, especially for gamma emitters.

PROCEDURE B4b: ASSESSMENT OF EXTERNAL EXPOSURE AND TREATMENT PLANNING

Performed by: Hospital Emergency Response Team	**PROCEDURE B4b** **ASSESSMENT OF EXTERNAL EXPOSURE AND TREATMENT PLANNING**	*Page 1 of 4*

Purpose

To provide guidance for assessment and treatment of externally exposed patients.

Discussion

If the patient has been exposed only to external sources of radiation, there is no additional risk to medical personnel and others around (patients, relatives). There is no need, therefore, to follow radiological contamination control procedures.

NOTE

External irradiation due to criticality accidents may result in activation of materials, making them radioactive. Past experience has shown that this has not created a significant hazard to medical personnel using proper patient handling and contamination control techniques.

Input

- Scene information and patient(s) presentation.

Output

- Assessment, evaluation and treatment of the patient.

NOTE

The aim of this document is not to describe potential treatment modalities. Treatment of irradiated patients may require specialized procedures. A large number of patients may stress the system and affect allocation of resources and require additional assistance. International assistance maybe requested through the official channels.

Step 1

Reassess the patient's medical status.

Step 2

If necessary, ask the radiological assessor to perform a radiological survey to confirm the non-contaminated status of each patient.

Step 3

Ensure patients are medically stable. Obtain a complete history to determine the possibility of exposure to radiation from external sources. Following stabilization of non-exposed patients, discharge or assign these patients to care by medical specialists of appropriate services or transfer them to referral hospitals as necessary. Observe for radiation induced signs or symptoms described in Steps 4, 5 and 6.

Step 4

Observe patients with nausea and vomiting in the emergency department for about six hours. Manage patients in accordance with guidance given in Tables 3 and 4.

NOTE

A small percentage of patients who have been exposed to acute whole body (or large body volume) doses of penetrating, photon (gamma or X ray) radiation over 1.0 Gy may experience radiation induced nausea or vomiting. The occurrence and severity of vomiting increases as the radiation dose increases. Therefore, early vomiting may be a sign of a significant radiation dose. As opposed to psychosomatic vomiting, radiation induced vomiting tends to be persistent and is resistant to routine anti-emetics.

To facilitate the understanding and the overlapping of clinical manifestations, ARS has been classically subdivided into three groups depending on the absorbed dose and primarily involved organs (haematopoietic, gastrointestinal and neurovascular types). Nevertheless, it needs to be understood that the overlapping of these clinical manifestations reflects the expression of an inflammatory body response, affecting all the organs and tissues, which in severe cases may lead to a multi-organ failure.

TABLE 3. GENERAL DOSE RANGE ESTIMATION FOR WHOLE BODY EXPOSURES IN MASS CASUALTY EVENTS BASED ON TIME TO VOMITING [2].

Time of vomiting after exposure	Dose range estimation (Gy)	Estimated incidence of vomiting in exposed individuals (%)	Severity of ARS
No vomiting	<1	–	–
≥2 h	1–2	10–50	Mild
1–2 h	2–4	70–90	Moderate
<1 h	4–6	100	Severe
<30 min	6–8	100	Very severe
<10 min	>8	100	Lethal

TABLE 4. DETERMINATION OF TREATMENT PLAN BASED ON PATIENT'S SYMPTOMS [37]

Symptoms	Treatment strategies
No nausea, vomiting or diarrhoea; Lymphocyte count above 1000 mm^{-3} at 48 hours; Probably no life-threatening injury	Observe periodically for any change in clinical status.
Nausea, mild vomiting; conjunctival redness and erythema; Lymphocyte count between 700 and 1000 mm^{-3} at 48 hours	Probable injury with mild grade of severity; plan for therapy.

Symptoms	Treatment strategies
Pronounced nausea and vomiting; possible diarrhoea, conjunctival redness and erythema; Lymphocyte count between 400 and 700 mm^{-3} at 48 hours	Probably life-threatening injury; plan for maximum therapy in specialized hospital.
Prompt severe vomiting and bloody diarrhoea; erythema and hypotension; Lymphocyte count between 100 and 400 mm^{-3} at 48 hours	High probability of lethal outcome; provide with maximum therapy in specialized hospital.
Loss of consciousness; Prompt severe vomiting and bloody diarrhoea; erythema and hypotension; Lymphocyte count below 100 mm^{-3} at 48 hours	Low probability of survival; provide with supportive therapy.

This table is applicable to whole body irradiation.

Step 5

Determine the possibility of LRI; if suspected, photographs of the affected areas will be ideally obtained daily if signs of radiation injury become evident. Photographs need to be included in the medical history records of the patient.

NOTE

Radiation injury of skin produces lesions clinically similar to electrical burns, or might be initially confused with thermal burns, but they progress differently. Clinical changes in LRI develop slowly over time (several days to many weeks). In cases of high doses, initial erythema may be accompanied by inflammation and/or painful oedema with paraesthesia on the erythematous area. The earlier the oedema appears, the higher the dose; the same applies to its severity (see Table 5). Depending on the radiation type and energy, the radiation dose may also affect underlying tissues. Higher energy photons may result in higher doses to tissues below the skin that is deposited into the dermis.

The cause of thermal and electrical burns makes their occurrences immediately identifiable. Radiation injuries have a delayed onset. If the patient is unaware of how/why the skin injury occurred, it may be radiation related.

TABLE 5. GENERAL THRESHOLD DOSES AND TIME OF ONSET FOR DIFFERENT MANIFESTATIONS OF THE LRI SPECTRUM [2]

Manifestation	Threshold dose, Gy	Time of onset**, days
Second phase erythema*	3	14 – 21
Temporary epilation	3	14 -18
Definitive epilation	7	25 – 30
Dry desquamation (Dry epithelitis)	10	20 – 28
Exudative desquamation (Exudative epithelitis)	15	15 – 25
Necrosis	25	>21

* Second phase erythema is a deterministic effect referring to an erythema that develops during the manifestation phase of LRI.
** Time of onset is a reference; it will be influenced by the dose rate, duration of the exposure and individual radiosensitivity, among other factors.

Step 6

Take necessary laboratory samples.

Collect 10 ml of peripheral blood in a lithium heparinized vacutainer tube for cytogenetic dosimetry if the need is anticipated [26] (see Procedure D1).

NOTE

The absolute lymphocyte count is of special importance and needs to be obtained every 6 hours for at least 2 days and then every 12 hours for an additional 5 days. The absolute lymphocyte count could be used as effective criteria for survival prognosis (Table 6).

All samples taken from individuals involved in a known or suspected malicious act involving radioactive material need to be retained as evidence for forensic examination.

TABLE 6. ABSOLUTE LYMPHOCYTE COUNT 48 HOURS AFTER WHOLE BODY EXPOSURE AND SURVIVAL PROGNOSIS [2]

Absolute lymphocyte count per µL	Severity grade of ARS	Survival prognosis
700–1000	Mild	Good
400–700	Moderate	Probable
100–400	Severe	Possible at highly specialized treatment centre
<100	Very severe	Poor

Step 7

If necessary, plan to transfer patients with known or suspected significant total body or local radiation exposure to medical specialists of appropriate medical service or to the referral hospital for continuing care.

NOTE

Radiation dose assessment is necessary to guide medical decisions in the definitive treatment. Assessment methods range from dose reconstruction and calculations to biodosimetric procedures. When admitted into the appropriate medical service, the diagnosis and prognosis will need to be reassessed as time passes to adapt the treatment based on progression of the clinical presentation and associated radiological information.

Performed by: Hospital Emergency Response Team	**PROCEDURE B5** **PATIENT DECONTAMINATION IN THE TREATMENT AREA**	*Page 1 of 5*

Purpose

To provide guidance for patient decontamination procedure in the treatment area.

Discussion

The purpose of decontamination is to reduce the amount of radioactive material to prevent its spread and to minimize radiation doses. Removal of the radioactive material will reduce the risk of intake (and associated radiation dose), minimize the possibility of spreading the radioactive materials to other locations and reduce the radiation dose to the contaminated and adjacent areas.

Since some corrosive or toxic materials may also contain radioactive material (uranium hexafluoride, for instance), medical attention might have to be directed first to the non-radiological problem.

NOTE

If a life-saving or other urgent clinical intervention is necessary, the appropriate medical care takes priority over decontamination. This also applies to the situation when the patient has to be transferred from the treatment area to other areas of the hospital, such as surgery or radiology (CT).

Input

- Indicative results of contamination after radiological survey of patients.

Output

- Decontaminated patient.

Step 1

Wear appropriate personal protective equipment and follow basic principles of contamination control.

Step 2

Explain to the patient the actions you are going to perform.

Step 3

Perform decontamination of the patient in accordance with the results of the radiological survey, using the next steps described in this procedure.

Perform decontamination in accordance with the following priorities: wounds, orifices, highly contaminated skin areas, less contaminated skin areas.

Assess the patient's status on a regular basis during the decontamination process.

Step 4

Document your actions and the efficiency of decontamination.

NOTE

It may be necessary that the wastewater from the decontamination procedure be retained in portable storage containers and analysed before being discharged. Furthermore, the installation of an elaborate holding system might not be justified because of the infrequency of the event. National regulatory requirements for disposal of radioactive waste have to be complied with.

Decontamination of wounds

Step 5

Drape the contaminated wound with waterproof material to limit the spread of radioactive material. Decontaminate the area around the wound, wiping away from the wound, before draping. Take care not to move radioactive materials into the wound.

Step 6

Decontaminate the wound by gently, but thoroughly, irrigating with sterile saline solution or water. More than one irrigation may be necessary. Monitor the wound after each irrigation. Remove contaminated drapes and dressings before each monitoring for accurate results. Irrigation with diethylenetriamine-pentaacidic acid (DTPA) may be considered in specific cases especially where the radionuclides are americium, plutonium, or curium (see Ref. [10]).

Step 7

Treat the wound after repeated irrigation like any other wound. Note that repeated irrigations may be necessary. If the preceding decontamination procedures are not successful, and the contamination level is still of concern, consult with a radiation protection professional for advice.

Step 8

Remove any embedded radioactive foreign bodies and save them for analysis.

Step 9

After decontamination of the wound, cover it with a waterproof dressing.

Step 10

Perform appropriate medical procedures. The decision to suture follows the same general principles for common wounds.

NOTE

In an emergency involving radioactive contamination, follow medical triage and patient radiological survey procedures. When wounds are contaminated, the physician has to assume that uptake (internal contamination) has occurred. Appropriate action is based upon the dose that is expected to be received.

Health physics advice can help guide the decision for excision of tissue. Debrided or excised tissue needs to be retained for further analysis.

Reduction of contamination in a puncture wound containing radioactive material may be achieved by using a full thickness skin biopsy with a punch biopsy instrument. Medical and radiological concerns need to be considered.

Contaminated burns are treated as usual burns. Contaminants can slough off with the burn eschar.

Decontamination of body orifices

Step 11

Decontaminate eyes, ears mouth and nose, using guidance in Table 7.

TABLE 7. GUIDE FOR DECONTAMINATION OF BODY ORIFICES

Contamination area	Method	Technique	Remarks
Eyes	Flushing with water or saline solution	Roll back eyelid. Rinse the eye by directing the stream of water from the inner canthus to the outer canthus of the eye while avoiding contamination of the nasolacrimal duct.	Performed by trained personnel.
Ears	Flushing	Rinse external part of the ear. Use ear syringe to rinse the auditory canal.	Be cautious not to damage tympanic membrane.
Mouth	Flushing	Encourage frequent rinsing of the mouth.	Warn patient not to swallow the rinse solution.
Nose	Nose swab sample collection	Nasal swabs may be useful for dose magnitude estimation.	Nasal irrigation may be considered for the compliant patient, taking care to ensure that no materials are introduced into the throat. Ear/nose/throat department may have equipment to aid irrigation.

NOTE

Contaminated body orifices are of concern because of the increased potential for an uptake of radioactive material via ingestion, inhalation, or absorption.

Decontamination of hair

Step 12

Contamination in the hair may be removed by washing with shampoo, taking care not to allow runoff into the ears or facial orifices. Persistent contamination in the hair may necessitate cutting off the contaminated hair. Take care not to abrade the skin; for this reason, do not shave the skin.

Decontamination of intact skin

NOTE

Begin decontamination with the least aggressive method and progress to more aggressive ones. Whatever the procedure, take care to limit mechanical or chemical irritation of the skin. All cleaning actions are to be performed from the periphery toward the middle. When wounds are present, ensure contamination is not transferred into the wound sites.

Step 13

Attempt contamination removal with baby wipe or similar material. This method minimizes runoff and reduces generated waste.

Step 14

If Step 13 is ineffective, use a mild soap (neutral pH) or surgical scrub soap, taking care not to spread the contamination to uncontaminated areas. Avoid aggressive rubbing, which tends to cause abrasion and erythema. Rinse well, then blot dry. Check the area with a radiation monitor. Repeat steps (including monitoring between each scrubbing and rinsing) as necessary.

NOTE

Use warm, never hot, water. Cold water tends to close the pores, trapping radioactive material within them. Hot water causes vasodilatation with increased area blood flow, opens the pores, and enhances the chance of absorption of the radioactive material through the skin. Take care to control the runoff when using wet decontamination methods.

Step 15

Stop decontamination before skin irritation or when the contamination level cannot be further reduced.

NOTE

For resistant contamination, covering the area with a cotton compress and a thin plastic cover (for hands use a cotton glove covered by a plastic or rubber glove) may be effective. Wait 1–2 hours for sweating. Remove covers and any residual sweat. Survey the area. Repeat the procedure if necessary.

Step 16

In cases of wide-spread contamination, decontaminate using sink, basin or shower, depending on the area of contamination. Caution the patient to avoid splashing water into the eyes, nose, mouth or ears. Repeat washing if necessary. Provide clean towels for drying after each wash. If necessary, the water may be discharged into the sewer (depending on local regulatory guidance/approval).

Step 17

Ensure the patient is on a clean stretcher, and not in a location where residual contamination will affect readings. Perform a methodical survey of the patient prior to transfer from the contaminated area. Once the emergency treatment and decontamination are completed, and final survey reveals no transferable contamination, the patient is ready for transfer.

PROCEDURE B6: MEDICAL MANAGEMENT OF INTERNAL CONTAMINATION

Performed by: *Hospital Emergency Response Team*	**PROCEDURE B6** **MEDICAL MANAGEMENT OF INTERNAL CONTAMINATION**	*Page 1 of 2*

Purpose

To provide guidance for medical management of people internally contaminated in the treatment area.

Discussion

Patients with a significant amount of internal contamination might need to be treated to reduce the radiation dose from an intake of radionuclides, and thus the risk of radiation effects or risks. There are two main approaches for minimizing radiation doses associated with internal contamination. The first focuses on reducing the uptake of radionuclides and their deposition in target organs. The second approach aims to increase the excretion rate of the radionuclides from the body [5, 10].

In general, treatment procedures are most effective if initiated as soon as possible after internal contamination has occurred. The decision to treat internal contamination is based on several factors, such as the strength of the evidence of intake, the clinical condition of the patient, physical and chemical characteristics of the possibly involved radionuclide, rapid radiation dose estimates and other assessments. When deciding on the use of internal contamination treatment, comparison is to be made between the benefit of removing the radioactive contaminants using modalities associated with potential side effects and the health effects of internal contamination without treatment. Additional treatment use needs to be based on more detailed reports of in vivo measurements and bioassay. A multidisciplinary team for organizing the treatment will be necessary [2, 5, 10].

Input

- Results of radiological survey of the patients (Worksheet B1).
- Medical information on patients (Worksheet B2).
- Information for internal dose assessment.
- Results of in vitro and in vivo bioassay measurements.

Output

- Decision on medical management of people internally contaminated in the treatment area.
- Data on the efficiency of decorporation for decision on continuation of treatment (Worksheet B3).

Step 1

Consider information related to the strength of the evidence for internal contamination, clinical aspects related to the patient, physical and chemical characteristics of the possibly involved radionuclide(s), a rapid dose estimate and further assessments (if available). Determine the treatment method to be used.

Step 2

Explain to the patient the actions to be performed.

Step 3

Perform radionuclide specific treatment of the patient in accordance with known information or the results of bioassay analysis and whole body counting. Table 8 provides information on some treatment agents used for internal contamination. Further information can be found in Ref. [10].

Step 4

Request the bioassay team to evaluate and report data on the efficiency of the decorporation treatment already performed. Decide on the continuation of treatment.

NOTE

While early determination of the need for treatment for internal contamination is based on initial internal dose estimates, the efficacy of the treatment can be assessed with repeated in vitro bioassays comparing the expected and observed activities excreted in faeces and urine. This will likely involve the integration of medical and health physics personnel. In addition, internal dose assessments can be a time-consuming process lasting weeks or months.

TABLE 8. SELECTED RADIONUCLIDES AND SOME OF THE TREATMENT AGENTS USED FOR INTERNAL CONTAMINATION [10]

Radionuclide (any radioisotope of concern)	**Treatment agents *,****
Americium, Cobalt, Indium, Plutonium	DTPA
Caesium, Thallium	Prussian Blue
Gallium	Penicillamine
Polonium	Dimercaprol (usually known as British Anti-Lewisite – BAL®)
Technetium	Potassium perchlorate
Tritium	Forced fluids
Uranium	Sodium bicarbonate

* Further information can be found in Refs. [5, 8, 10].

** Clinical evidence about the use of treatment agents in adults is limited. Approval for clinical use by national health authorities and availability differs among countries [5].

SECTION C – MEDICAL FOLLOW-UP

PROCEDURE C1: ARRANGEMENT FOR MEDICAL FOLLOW-UP

Performed by: Public Health Advisor	**PROCEDURE C1** **ARRANGEMENT FOR MEDICAL FOLLOW-UP**	*Page 1 of 6*

Purpose

To provide guidance on arrangements for long term medical follow-up after a nuclear or radiological emergency.

Discussion

The scale of the morbidity and mortality attributable to a particular nuclear or radiological emergency might be unclear for a prolonged period. Without early capture of key data detailing the hazard and identification of the population that has been placed at risk, proper assessment of risk for the health of affected populations and justification of relevant mitigation will not be possible.

It is necessary to arrange for identification, tracking, and long term medical follow-up and treatment of the health effects of people that are at risk of sustaining a detectable increased incidence of cancer or other stochastic effect from radiation exposure. The aim of the criteria for determining who will receive long term medical follow-up is detection of radiation induced stochastic effects at an early stage to allow more effective treatment, based on current knowledge of the risk for radiation induced health effects.

The objectives of the medical follow-up for nuclear or radiological emergencies are described in IAEA Safety Standards Series No. GSG-11 [12] as follows:

(a) To provide for the long term medical care of individuals who have suffered deterministic effects and of individuals incurring doses that exceed the threshold dose for deterministic effects.

(b) To provide for the early detection and diagnosis of stochastic effects (e.g. thyroid cancer) among the exposed population in order to allow for effective treatment.

Input

- Notification of a nuclear or radiological emergency with implications for public health.
- Description of emergency, estimation of number of people involved.
- Results of dose assessment, including organ specific doses (ranges of doses received and projected doses).

Output

- Necessary information (initial register) in place to enable proper epidemiological studies defining the health consequences of the emergency (immediate output).
- Data on need for specialized epidemiological studies (continuing output).
- Data on basic parameters of excess morbidity and mortality in persons recognized as being at significant risk from the emergency (long term output).

Step 1

Define the purpose and determine the need for specialized follow-up of affected people based upon criteria set up in advance. For guidance on establishing these criteria see Tables 9 and 10.

NOTE

The purpose of long term medical follow-up of affected people usually is to perform regular medical examination, which will enable early diagnosis and effective treatment of radiation induced health effects. However, there are statistical and demographical limitations in detectability of radiation induced excess cancer incidence in the population exposed to low doses[5] [18, 19]. In addition to the practical output of the medical follow-up of affected people, there could be a scientific long term follow-up study set up for surveillance. In this case, the size of the population under investigation is defined also by considering not only the limitations in detectability, but the scientific purposes. In both cases, medical, social and economic factors could influence both the size of the cohort and the decision to conduct a follow-up. The detriments and benefits of a follow-up—as well as the affected population's preferences and its ethical and cultural values—need to be considered [38].

Inclusion in the registry needs to be based on objective criteria that indicate a potential for an increase in the incidence of radiation induced cancer or consequences of prenatal exposure (e.g. effective dose of 100 mSv [13, 39] to whole body and radiation weighted dose of 100 mSv to foetus [40]).

Step 2

Request from relevant specialists (e.g. incident commander, the radiation protection team or support group) results of dose assessment and other necessary data for establishment of a specialized registry.

Step 3

Establish a registry of persons to receive long term medical follow-up. The minimum initial data set for persons suspected of having been exposed to significant levels of irradiation or contamination is as follows.

[5] Further information on low doses (beyond the scope of this publication) may be found in several publications and reports, for instance by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the European Nuclear Society's Committee on the Biological Effects of Ionizing Radiation (BEIR) and WHO.

- Basic demographic details (to ensure that the correct identity of persons in the registry can be confirmed over time).
- Location during the emergency.
- Results of contamination survey (internal and external).
- Personal dosimetry results, if available.
- History of any injury (conventional/radiation induced/combined).
- Detail of treatment given.

Step 4

Appoint a responsible organization for maintaining the registry. Establish the places where data will be stored.

Step 5

Ensure that all key national databases are flagged with names of persons in the registry to ensure that key subsequent health events can be linked and examined. The most critical of these databases are death records and cancer registries.

Step 6

Ensure that an adequate system of record keeping is in use by all agencies responding to an emergency.

Step 7

Inform people included in the register of their risks and of the purpose of the register (using a plain language explanation).

NOTE

If no specialized studies are needed, national health authorities are advised, as a minimum, to report annual mortality and cancer registry statistics from among the registered population.

TABLE 9. GENERIC CRITERIA FOR DOSES RECEIVED WITHIN A SHORT PERIOD OF TIME FOR WHICH PROTECTIVE ACTIONS AND OTHER RESPONSE ACTIONS ARE EXPECTED TO BE TAKEN UNDER ANY CIRCUMSTANCES IN AN EMERGENCY TO AVOID OR TO MINIMIZE SEVERE DETERMINISTIC EFFECTS [1]

Acute external exposure (<10 h)		
$AD_{\text{red marrow}}$ [a]	1 Gy	If the dose is projected: — Take precautionary urgent protective actions immediately (even under difficult conditions) to keep doses below the generic criteria; — Provide public information and warnings; — Carry out urgent decontamination.
AD_{fetus}	0.1[b] Gy	
AD_{tissue} [c]	25 Gy at 0.5 cm	
AD_{skin} [d]	10 Gy to 100 cm^2	
Acute internal exposure due to an acute intake (Δ = 30 d[e])		
$AD(\Delta)_{\text{red marrow}}$	0.2 Gy for radionuclides with atomic number $Z \geq 90$[f] 2 Gy for radionuclides with atomic number $Z \leq 89$[f]	If the dose has been received: — Perform immediate medical examination, medical consultation and indicated medical treatment; — Carry out contamination control; — Carry out immediate decorporation[g] (if applicable); — Conduct registration for longer term medical follow-up; — Provide comprehensive psychological counselling.
$AD(\Delta)_{\text{thyroid}}$	2 Gy	
$AD(\Delta)_{\text{lung}}$ [h]	30 Gy	
$AD(\Delta)_{\text{colon}}$	20 Gy	
$AD(\Delta')_{\text{fetus}}$ [i]	0.1[b] Gy	

[a] $AD_{\text{red marrow}}$ represents the average RBE weighted absorbed dose to internal tissues or organs (e.g. red marrow, lung, small intestine, gonads, thyroid) and to the lens of the eye from exposure in a uniform field of strongly penetrating radiation.

[b] At 0.1 Gy there would be only a very small probability of severe deterministic effects to the fetus and only during certain periods post-conception (e.g. between 8 and 15 weeks of in utero development), and only if the dose is received at high dose rates. During other periods post-conception and for lower dose rates, the fetus is less sensitive. There is a high probability of severe deterministic effects at 1 Gy. Therefore, 1 Gy is used as the generic criterion for doses to the fetus received within a short period of time: (i) in the hazard assessment (see para. 4.23), to identify facilities and activities, on-site areas, off-site areas and locations for which a nuclear or radiological emergency could warrant precautionary urgent protective actions to avoid or to minimize severe deterministic effects; (ii) for identifying situations in which exposure is dangerous to health; and (iii) for making arrangements for applying decisions on urgent protective actions and other response actions to be taken off the site to avoid or to minimize the occurrence of severe deterministic effects (e.g. establishing a precautionary action zone).

[c] Dose delivered to 100 cm^2 at a depth of 0.5 cm under the body surface in tissue due to close contact with a radioactive source (e.g. source carried in the hand or pocket).

[d] The dose is to the 100 cm^2 dermis (skin structures at a depth of 40 mg/cm^2 (or 0.4 mm) below the surface).

[e] $AD(\Delta)$ is the RBE weighted absorbed dose delivered over a period of time Δ by the intake (I_{05}) that will result in a severe deterministic effect in 5% of exposed individuals.

[f] Different generic criteria are used to take account of the significant difference in RBE weighted absorbed dose from exposure at the intake threshold values specific for these two groups of radionuclides.

[g] Decorporation is the action of the biological processes, facilitated by chemical or biological agents, by means of which incorporated radionuclides are removed from the human body. The generic criterion for decorporation is based on the projected dose without decorporation.

[h] For the purposes of these generic criteria, 'lung' means the alveolar–interstitial region of the respiratory tract.

[i] For this particular case, 'Δ' refers to the period of in utero development of the embryo and fetus.

TABLE 10. GENERIC CRITERIA FOR PROTECTIVE ACTIONS AND OTHER RESPONSE ACTIONS IN AN EMERGENCY TO REDUCE THE RISK OF STOCHASTIC EFFECTS [1]

Generic criteria		Examples of protective actions and other response actions[a]
Projected dose that exceeds the following generic criteria: Take urgent protective actions and other response actions		
$H_{thyroid}$	50 mSv[b] in the first 7 days	Iodine thyroid blocking[c]
E[d]	100 mSv in the first 7 days	Sheltering[e]; evacuation; prevention of inadvertent ingestion; restrictions on food, milk and drinking water[g] and restrictions on the food chain and water supply; restrictions on commodities other than food; contamination control; decontamination; registration; reassurance of the public
H_{fetus}[f]	100 mSv in the first 7 days	
Projected dose that exceeds the following generic criteria: Take early protective actions and other response actions		
E[d]	100 mSv in the first year	Temporary relocation; prevention of inadvertent ingestion; restrictions on food, milk and drinking water[g] and restrictions on the food chain and water supply; restrictions on commodities other than food; contamination control; decontamination; registration; reassurance of the public
H_{fetus}[f]	100 mSv for the full period of in utero development	
Generic criteria		Examples of protective actions and other response actions[a]
Dose that has been received and that exceeds the following generic criteria: Take longer term medical actions to detect and to effectively treat radiation induced health effects		
E[d]	100 mSv in a month	Health screening based on equivalent doses to specific radiosensitive organs (as a basis for longer term medical follow-up)[h], registration, counselling
H_{fetus}[f]	100 mSv for the full period of in utero development	Counselling to allow informed decisions to be made in individual circumstances

[a] These examples are neither exhaustive nor grouped in a mutually exclusive way.

[b] The equivalent dose to the thyroid ($H_{thyroid}$) only due to exposure to radioiodine.

[c] This generic criterion applies only for administration of iodine thyroid blocking. For the thyroid, iodine thyroid blocking is an urgent protective action that is prescribed: (a) if exposure due to radioactive iodine is involved; (b) before or shortly after a release of radioactive iodine; and (c) within only a short period before or after the intake of radioactive iodine.

[d] Effective dose.

[e] As a less disruptive protective action, sheltering may be ordered at lower doses as long as justified and optimized.

[f] H_{fetus} is the equivalent dose to the fetus, derived as the sum of the dose from external exposure and the maximum committed equivalent dose to any organ of the embryo or fetus from intake to the embryo or fetus for different chemical compounds and different times relative to conception.

[g] Restrictions on food, milk and drinking water using these generic criteria are to be applied before sampling and analysis of food, milk and drinking water are carried out. Such restrictions apply as long as replacements of food, milk and drinking water or other alternatives are available to ensure they would not result in severe malnutrition, dehydration or other severe health impacts.

[h] When results of the health screening indicate that the criteria in Table II.1 are exceeded, then appropriate medical attention on the basis of Appendix II on IAEA GSR Part 7 (see Table II.1) is necessary (adapted from IAEA GSR 7).

SECTION D – DOSE ASSESSMENT

PROCEDURE D1: CYTOGENETIC DOSIMETRY

Performed by: Biodosimetry Team	**PROCEDURE D1** **CYTOGENETIC DOSIMETRY**	*Page 1 of 3*

Purpose

To provide guidance on blood sampling for cytogenetic analysis and on cytogenetic dosimetry.

Discussion

Quantitative evaluation of chromosomal aberrations by various techniques such as Giemsa stained chromosomes, fluorescence in situ hybridization (FISH), micronuclei analysis and Premature Chromosome Condensation (PCC) analysis are useful as biomarkers of dose. The analysis of chromosomal aberrations presents in peripheral blood lymphocytes from individuals exposed to radiation is currently accepted as a validated method for the assessment of absorbed dose in gray [26]. The absorbed dose is estimated by interpolating the observed yield of the chromosomal aberration considered with a pre-established dose response curve generated following ex vivo irradiation of human lymphocytes in controlled conditions. The quantification of unstable chromosomal aberrations is the most widely used method in biological dosimetry, mainly for early dose evaluation of presumed or confirmed acute overexposure to the whole body, or a large part of it, by external exposure and/or internal exposure with radionuclides with wide distribution in the body, such as ^{137}Cs and ^{3}H.

Input

- Information about the patients involved in the emergency (Worksheet A2).
- Medical information form (Worksheet B2).

Output

- Results of cytogenetic analysis (Worksheet B5).

NOTE

Due to the complexity of preparation and scoring of samples, it could be necessary to contact specialized groups, this capability is not available in every country. Assistance could be arranged by the IAEA through RANET [30]. The cytogenetic laboratory may need the information contained in the Worksheet B5. Cytogenetic biodosimetry is discussed in detail in Ref. [26].

Step 1

Collect 10 ml of peripheral blood in a lithium heparinized vacutainer tube.

NOTE

A venipuncture blood sample for cytogenetic biodosimetry needs to be taken, generally 24 hours after radiation exposure. This delayed sampling allows lymphocytes to be uniformly distributed in the body (redistribution pool of lymphocytes is approximately 12 hours). In cases of severe radiation overexposure (>7 Gy), earlier venipuncture blood sampling is recommended.

If dried heparin is used, it is important that the blood be properly mixed by inverting the tube several times.

Step 2

Label appropriately the tubes of blood samples, including identification of the patient, date and time of collection.

NOTE

In the event of a nuclear or radiological emergency involving a large number of casualties, perform analysis in accordance with priorities and procedures set up in advance.

Step 3

Place the samples in contact with a coolant pack in an insulated box. For transport of blood samples, follow national and international regulations, considering classification, packaging, marking, labelling, refrigeration and documentation requirements for the international shipping of blood samples and pellets (i.e. these samples usually are considered under B category UN3373 with packaging requirement P650).

CAUTION

Ensure that the samples do not freeze.

Step 4

Deliver the samples and copies of the Worksheets A2 and B2 as soon as possible to the cytogenetic laboratory, together with copies of Worksheet B5.

CAUTION

The medical specialist needs to record the data provided in order to keep a database of necessary information. Delay in obtaining the cytogenetic dosimetry results could make them less informative for treatment decision criteria.

Step 5

Process the blood samples in accordance with the approved protocol for biodosimetry, if available [26].

NOTE

The interpretation of dose using a calibration curve produced elsewhere might introduce substantial additional uncertainty. Therefore, any laboratory intending to carry out biological dosimetry needs to establish its own dose-response data.

There is strong evidence that for low-LET radiation quality and in the dose range from 0 to 4-5 Gy the yield of chromosome aberrations (Y) is related to dose D by the equation $Y = A + \alpha D + \beta D^2$. The objective of curve fitting is to determine those values of the coefficients A, α and β that best fit the observed yields of chromosomal aberrations scored after ex vivo irradiations of human lymphocytes to known doses. At the planning stage for the medical response to mass casualty events, the use of cytogenetic dosimetry for early triage of radiation casualties could be considered. For a preliminary estimate of dose to confirm medical triage, further information can be found in Ref. [26].

Step 6

Make dose estimation using the results of cytogenetic analysis. Evaluate the uncertainty.

PROCEDURE D2: EARLY ESTIMATION OF THE MAGNITUDE OF RADIATION DOSE

<table>
<tr><td rowspan="2">Health /Medical Physicists</td><td>PROCEDURE D2</td><td rowspan="2">Page 1 of 3</td></tr>
<tr><td>EARLY ESTIMATION OF THE MAGNITUDE OF RADIATION DOSE</td></tr>
</table>

Purpose

To provide general information related to early estimation of the magnitude of radiation dose to help guide medical management in events involving sealed sources.

Discussion

Healthcare professionals are not expected to perform complicated radiation dose calculations. Early estimation of the magnitude of radiation dose is needed for healthcare professionals to establish primary diagnosis, prognosis and treatment planning for individuals that might have been externally exposed to radioactive materials. Therefore, a basic understanding of the process will help with the integration of radiation protection into the medical management of irradiated patients. The dose estimation process is one that evolves over time as new information becomes available. However, an incident reconstruction can provide details needed to calculate radiation doses. Since a calculation is only as good as the information used, it is necessary to carefully gather the data associated with the exposure event. Slight variations in the time of exposure or distance from the source can have a significant effect on the result. While the early dose estimation will guide initial medical management, new information such as expression of signs/symptoms, blood counts, cytogenetic biodosimetry or simply new details about the event might call into question the initially calculated dose.

The patient presentation may be different from that indicated by the initial dose estimate. The intent of this procedure in not to provide a detailed explanation of techniques for the early estimation of radiation dose, but to provide an overview to healthcare providers of the process in an effort to increase understanding and foster communication between the healthcare provider and radiological assessor or other radiation protection professional. An experienced radiation protection professional needs to be consulted for radiation incident reconstruction and associated radiation dose estimations [27].

Input

- Nuclear or radiological emergency scene information.
- Information about the radioactive material of concern.
- Pertinent physical information related to the event.

Output

- An early estimate of radiation dose.

Step 1 – Data Gathering

- Gather relevant radiological data.
  - Radioisotope (radiation emission and energy of emission).
  - Activity of source.
  - Geometry of source.
- Collect physical data.
  - Shielding (if any).
  - Distance of individual from source.
  - Duration of exposure.
  - Area of concern (e.g. hand, finger, whole body; there may be multiple areas of concern).
  - Available physical dosimetry (personal dosimeter, e.g. TLD).
- Collect physiological data.
  - Expression of signs/symptoms.
    - What are the signs/symptoms?
    - When did the signs/symptoms begin?
    - What is the severity of the signs/symptoms?

Step 2 – Determination of the exposed area of the body

- Significant volume of the body exposed.
- Isolated—or local—exposure (small area of the body).
- Shallow or superficial dose (predominantly skin).
- Deep dose from penetrating radiation.

Step 3 – Dose Estimation

- Dose = dose rate (i.e., mGy/h) × time (h)
- Inverse square law: radiation dose is inversely proportional to the square of the distance. This applies to physically small sources and means that if one were to double the distance from a radioactive source, the radiation dose at that distance is 1/4 ($1/2^2$) of the original dose. Triple the distance would result in 1/9 ($1/3^2$) of the original dose. Therefore, if one knows the dose rate at one distance, dose rates for other distances can be calculated. This law does not apply where radioactive material is widespread.
- The specific gamma constant relates the dose rate at a given distance from a specified activity of a radioisotope. If one knows the radioisotope involved in the incident, the activity of the isotope, and the distance of the individual from the source, doses can be calculated at the distance of concern.
- Dose calculations for instances where a small sealed source is in physical contact with the individual require the use of dose conversion factors[6].

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[6] See, for example, REAC/TS, The Medical Aspects of Radiation Incidents, 4th edn., Radiation Emergency Assistance Center/Training Site, Oak Ridge, TN (2017).

Step 4 – Comparison to observed signs/symptoms

- The acute effects of radiation doses are associated with previously discussed dose thresholds (see Section Overview). The signs and symptoms predicted by the early dose estimates need to be compared to observed signs and symptoms of the patient. Since dose calculations are greatly affected by even small changes in time and distance estimates, significant differences in the predicted and observed effects might result from errors in the information. The reasons for the differences need to be investigated.

Step 5 – Perform confirmatory dosimetry

- Early dose estimates need to be revised as new information becomes available. In addition, early dose estimates can be verified by other techniques such as cytogenetic biodosimetry (when applicable) discussed in Procedure D1.

NOTE

Management of internal dose, to include dose estimation, can be complex, and a multidisciplinary team is necessary. It is described in Ref. [10].

SECTION E – MENTAL HEALTH AND PSYCHOLOGICAL SUPPORT

PROCEDURE E1: MENTAL HEALTH AND PSYCHOLOGICAL SUPPORT (MHPS) AT THE PREPAREDNESS STAGE

Performed by: Public Health Advisor	**PROCEDURE E1** **MENTAL HEALTH AND PSYCHOLOGICAL SUPPORT (MHPS) AT THE PREPAREDNESS STAGE**	*Page 1 of 2*

Purpose

To provide general guidance on mental health and psychological support (MHPS) arrangements at the preparedness stage.

Input

- Analysis of possible emergency situations.

Output

- Mental health and psychological support system (MHPSS) for different categories of affected people in case of nuclear or radiological emergency.

Step 1

Development of MHPSS includes, but is not limited to the following activities [41]:

- Identify qualified organizations and resource persons.
- Develop agency and inter-agency national policies and plans for MHPSS emergency response.
- Determine coordination mechanisms, roles and responsibilities at local, regional, national and international levels.
- Identify MHPSS focal points for emergencies in each region and from various agencies.
- Integrate MHPSS considerations into all sectoral emergency preparedness plans.
- Support the provision of MHPSS at all stages of humanitarian action.

Use different ways of providing information to the public in plain language and delivery methods to target audiences (e.g. social media, SMS, smartphone applications, TV/Radio advertisement, leaflets and brochures) [42].

Step 2

Establish an information and education strategy for the public. Samples of communication materials for the public are available in Refs. [14, 17]. Include information about:

1. Radiation:

- What is radiation?
- How it can be readily detected?
- Natural sources of radiation.
- What health effects radiation can and cannot cause?
- Particular examples of threshold doses for specific effects.
- Radiation and pregnancy.
- How to reduce exposure using protective actions?

2. Specific plans for the community:

- Risk of an emergency.
- Types of possible nuclear or radiological emergencies.
- Protective action planned for the facility and for the public.

3. Malicious acts [5]:

- Risk of a malicious act.
- Types of possible nuclear or radiological emergencies during malicious acts.
- Planned protective and countermeasures actions for the public in the case of malicious acts.

NOTE

Use different forms of materials, such as publications, audio and video. Include an executive summary with a clear explanation about the situation and the protective actions planned for the protection of the public [41, 42].

Step 3

Establish specific MHPS programmes for different categories of affected people based on Step 1.

Step 4

Provide general education and training materials for different categories of professionals (e.g. physicians, emergency responders, public officials, nurses, teachers, psychologists and the media). In an emergency, health professionals might need to liaise with authorities communicating with the public to convey the messages of the emergency authorities and decrease psychological stress among the public. Provide training and support to health professionals to communicate efficiently, through the adequate channels, with the authorities liaising with the public [42] .

Step 5

Make provisions to take precautions to avoid violating religious, cultural or social customs when performing surveys and decontamination. Make arrangements for both male and female assistance. Plan to provide privacy as appropriate.

Make provisions for addressing the needs of foreigners and other specific subgroups of the population who might be affected or might be in the vicinity of an emergency.

Make provisions for addressing the needs of pets and pet owners to reduce their anxiety in case of an emergency.

Step 6

Plan to have trained and informed individuals at survey/counselling centres to provide answers and to calm worried persons. Provide training to the people performing these functions [41, 42].

Step 7

Make arrangements to ensure that parents and children are not separated while implementing protective actions. Parents need to know where school children will be taken in event of an emergency during school hours. Recognize that displacement from home is especially traumatic for the elderly. Create transparent information channels for storing data about the location of people and communicate them across the response team. Provide support for those people who might have a lost family member and train mental health professional in providing both information and help in finding these family members. Special care is needed for families with lost children [43].

PROCEDURE E2: MENTAL HEALTH AND PSYCHOLOGICAL SUPPORT FOR THE PUBLIC DURING EMERGENCY

Performed by: Public Health Advisor	PROCEDURE E2 MENTAL HEALTH AND PSYCHOLOGICAL SUPPORT FOR THE PUBLIC DURING AN EMERGENCY	Page 1 of 2

Purpose

To provide general guidance on mental health and psychological support for the public during an emergency.

Discussion

Make the public aware of how the perceived impact of a nuclear or radiological emergency might differ from its actual health impact. Explain how anxiety symptoms might be misaligned with the actual risk that a particular emergency might present to human health. Communicate effectively and in simple language and aim to reassure and inform the public about the events that triggered the emergency [41–43].

This may be especially important if malicious acts involving radioactive material occur or are suspected.

Input

- The public impact of a nuclear or radiological emergency in terms of their mental health impact.

Output

- Minimized effect on the mental health of the public during an emergency.

Mental health and psychological support for the public in the early phase of emergency

Step 1

Ensure adequate training of the leadership within public health authorities, mental health work force or organizations to provide MHPS for the public from the early stages of the emergency and to perform the following actions [44].

1. Coordinate MHPS across sectors.
2. Develop programmes based on identified needs and resources.
3. Work with community members, including marginalized people, to strengthen community self-help and social support.
4. Orient staff and volunteers on how to offer psychological first aid.
5. Make basic clinical mental healthcare available at every healthcare facility.
6. Make psychological interventions available, where possible, to people impaired by prolonged distress.

7. Protect the rights of people with severe mental health conditions in the community, hospitals and institutions.
8. Minimize harm related to alcohol and/or drugs.
9. Take steps to develop a sustainable mental health system during early recovery planning and protracted crises.

Step 2

Establish psychological first aid centres at monitoring and evacuation centres. Provide training on how to implement them.

Step 3

Provide clear instruction for self-help and address privacy issues. Link mental health centres with emergency managers and health authorities.

Step 4

Arrange medical counselling tailored to specific groups' risk profiles (e.g. pregnant, mothers).

Mental health and psychological support for the public after the early phase of the emergency

Step 5

Establish adequate referral pathways to existing MHPSS, if available, and according to the severity of conditions of those affected. If not available, implement MHPSS able to deal with long term problems that may arise from trauma and post-traumatic stress disorder (PTSD). Avoid stigmatization and segregation of those who might have been exposed to radioactive material and actively train medical personnel in dealing with these issues [45].

Step 6

Make provisions for continued mental health support for individuals involved during the emergency. Families of these individuals might also need counselling [45].

PROCEDURE E3: MENTAL HEALTH AND PSYCHOLOGICAL SUPPORT FOR EMERGENCY RESPONDERS

Performed by: Emergency Manager	**PROCEDURE E3**	*Page 1 of 2*
	MENTAL HEALTH AND PSYCHOLOGICAL SUPPORT FOR EMERGENCY RESPONDERS	

Purpose

To provide guidance on mental health and psychological support for emergency responders.

Discussion

During a nuclear or radiological emergency, emergency responders would be expected to perform their duties under extreme and stressful conditions. Responders might be at high risk of developing mental health and psychological problems such as PTSD, substance abuse, burn out or depression [2, 45].

Input

- Action to be taken by emergency responders under stressful conditions.

Output

- Minimized effect on the mental health of emergency responders.

Step 1

Plan enough teams and workers so that work in shifts (if needed) can be arranged. Plan adequate rest periods. Enforce rest periods if necessary. Provide training, if possible, on the issues to be expected and the impact on mental health.

Step 2

Arrange an initial briefing. Ensure the use of protective clothing and personal dosimeters, if appropriate. Explain the objectives (tasks) of the mission and the hazards which the responders may face and summarize the radiation protection and contamination control procedures they have to follow. Discuss the risks and the care pathways that will be available they are if not able to cope. Organize a mental health team in support of the emergency responders [42].

Step 3

Provide training and drills and discuss levels of risk and anxiety that might result from the emergency situations. Ensure that this training includes discussions about issues that the responders will face and the services that will be available in mental health for responders. Provide these counselling services for emergency workers before, during and after the emergency. These services will deal with anxiety issues that might arise from the perceived risk of exposure. After the emergency has been terminated, link these counselling services to the specialist referral pathway in the corresponding health service.

NOTE

There is a wide range of mental health conditions that can result from exposure to nuclear or radiological emergencies. This includes psychosocial distress, depression, different forms and types of anxieties and a change in patterns of substance use.

Ensure that training programmes are followed routinely, since mental health problems might be prevented with appropriate understanding of the risk. The more training responders receive, the lower the probability of developing anxiety and long term mental health consequences such as PTSD.

Step 4

Brief emergency responders about the emergency situation before each shift and periodically during shifts and establish transparent communication channels.

NOTE

When possible, allow emergency responders to check on the status of their families and allow families to be informed about the status of responders.

Step 5

If an emergency responder is given a new task, ensure that adequate instructions and initial assistance is provided, so the responder is not stressed with uncertainty regarding the task.

Step 6

Hold a meeting at the completion of the emergency response activities. Evaluate the mental health status of the team and the levels of stress and anxiety.

PROCEDURE E4: MENTAL HEALTH AND PSYCHOLOGICAL SUPPORT AT HOSPITAL LEVEL

Mental health and psychological support	**PROCEDURE E4** **MENTAL HEALTH AND PSYCHOLOGICAL SUPPORT AT HOSPITAL LEVEL**	*Page 1 of 2*

Purpose

To provide guidance on mental health and psychological support at the hospital level for the persons affected by nuclear or radiological emergency.

Discussion

Persons involved in nuclear or radiological emergencies might experience many instances that might impact their mental health.

In severe cases, patients have to be made aware that the hospitalization may be lengthy and result in isolation from family and friends. Considerations for the privacy for these patients are needed. They may experience severe effects on their well-being and an altered self-image [43].

The healthcare provider needs to be prepared to listen to the patients' concerns, share messages with family members and answer questions honestly with sympathetic concern for individual patient. Health authorities need to receive training in dealing with such instances [41].

Input

- Hospitalized patients with radiation injuries.

Output

- Minimized effect on the mental health of the hospitalized patients with radiation injuries.

Step 1

Arrange the healthcare at the hospital, taking into account the following general considerations:

- Provide information to the healthcare provider and care-givers about radiation and its effects.
- Counsel anxious care-givers and refer to counselling services as soon as possible during and after the emergency.
- Include a mental health professional in the hospital emergency response team [45].

Step 2

Ideally, assign one physician to coordinate the patient care as a case manager. Communicate through this person to provide clear and focused information to family members.

Step 3

Facilitate patient–family communication. Provide instructions to family regarding isolation procedures, if needed. Explain to the family members why an externally exposed person is not contagious and not dangerous for them.

Step 4

Involve the patient (when possible) in decisions about care.

Step 5

Allow the patient to provide self-care when possible. Focus on functionality and independence.

Step 6

Provide patient privacy as much as possible and protect the patient from the media (including social media, public exposure).

Step 7

Refer patients exposed during the emergency to MHPSS according to their usual referral pathway. If not available, implement MHPSS in order to be able to deal with long term problems that may arise from trauma and PTSD in this group of patients. Avoid stigmatization and segregation of those who might have been exposed to radioactive material, and actively train medical personnel in dealing with these issues. Facilitate spiritual support if requested by the patient or family.

WORKSHEETS

The following forms can be used in their present form; however, each organization will want to adapt these forms to its own needs and requirements [37].

WORKSHEET A1: EMERGENCY REGISTRATION FORM

To be completed by: Medical Response Initiator (Dispatcher)	**WORKSHEET A1** **EMERGENCY REGISTRATION FORM**	*No. ______*

Full Name: ______________________________ Date: __________

(Medical Response Initiator)

Provide copy to: ☐ Emergency Medical Responder Time: __________

☐ Medical Transport Team

☐ Public Health Advisor

Name of caller: ____

(Full name)

Member of: ☐ Public ☐ Facility staff

☐ Emergency Services ☐ Medical Emergency Services

Organization or address of caller: ____

Telephone No of caller: __________________ Time of call: ______________________

Emergency location: ____

(Facility address or site location)

Emergency description: ____

____

____

____

____

Public involved: ☐ Yes ☐ No

Number of injured victims:____________

Are victims contaminated? ☐ Yes ☐ No ☐ Suspected

What advice was given (by the phone):

____

____

____

Call verified: ☐ Yes ☐ No

***Signature*_________________**

WORKSHEET A2: EMERGENCY PATIENT REGISTRATION FORM

To be completed by: Medical Response Initiator (Communication coordinator)	**WORKSHEET A2** **EMERGENCY PATIENT REGISTRATION FORM**	*No.* ______

Full Name: ________________________________ Date: ___________

(Medical Response Initiator)

Provide copy to: ☐ Emergency Medical Manager Time: ___________

Identification of informant ____

(Full name)

Member of: ☐ Emergency Services ☐ Medical Emergency Services

Call verified: ☐ Yes ☐ No

Emergency location: ____

(Facility address or site location)

Number of emergency victims:______________________

Medical status of victims:

A*: ☐ Stable ☐ Unstable B: ☐ Stable ☐ Unstable

C: ☐ Stable ☐ Unstable D: ☐ Stable ☐ Unstable

Radiological status of victims:

Radiological survey performed: ☐ Yes ☐ No

Contamination: ☐ Internal: ☐ Ingestion ☐ Inhalation

☐ External: Radionuclide___________________________________

Activity___________________________Body area_____________________________

Victims exposed: ☐ Yes (how many:______) ☐ No (how many_______)

Victims contaminated: ☐ Yes (how many:______) ☐ No (how many_______)

Contaminated wounds: ☐ Yes ☐ No

Initial decontamination done: ☐ Yes ☐ No

Emergency description: Source____________

Distance from the source for the victim:

A_________,B___________,C_____________,D_____________________________

Time of exposure for the victim:

A_________,B___________,C_____________,D_____________________________

Estimated dose for the victim:

A_________,B___________,C_____________,D_____________________________

Expected time of arrival to the hospital:____________ ***Signature***__________________

NOTE: * - A,B,C,D, etc. – letters are used to distinguish different patients at this stage.

WORKSHEET A3: PATIENT CONTAMINATION CONTROL RECORD (ON-SCENE ASSESSMENT)

To be completed by: Radiological Assessor	**WORKSHEET A3** **PATIENT CONTAMINATION CONTROL RECORD (ON-SCENE ASSESSMENT)**	*No.* ______

Surveyed by: ______________________ Date: __________
(Full name)

Provide to: ☐ Emergency Medical Responder Time: __________

Name of victim: ______________________ Sex: ☐ M ☐ F

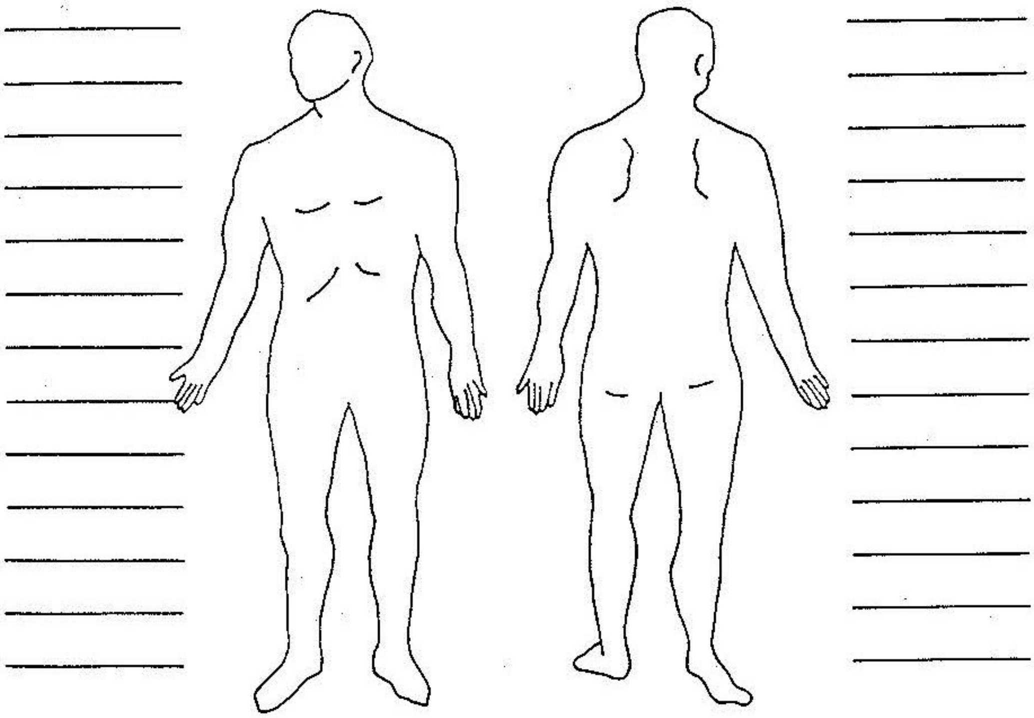
Address: ______________________________________

Date of measurement:_____/_____/_____ Time of measurement:__________

Contamination survey

Instrument type: ________________ Model: __________

Background reading: ____________ Detector active surface: ____________ [cm^2]



Remarks: Indicate readings in the lines provided in the diagram. Indicate location of the readings by arrows. Only record readings greater than background.

Decontamination procedures performed: ☐ Yes ☐ No

Results of thyroid survey: ______________ [ ] ______________ [ ]
(count rate from neck) [Unit] (count rate from thigh) [Unit]

______________ [ ] ______________ [ ]
(background count rate) [Unit] (net count rate) [Unit]

Calibration coefficient:________ [Bq/Unit of count rate] Activity_____ [Bq]

Further evaluation at medical facility necessary: ☐ Yes ☐ No

Surveyor signature: ______________

WORKSHEET A4: REGISTRY FORM FOR PERSON INVOLVED IN EMERGENCY

To be completed by: First responder (Police)	**WORKSHEET A4** **REGISTRY FORM FOR PERSON INVOLVED IN EMERGENCY**	*No.* ______

Full Name: ______________________________ Date: __________
(First Responder)

Provide copy to: ☐ Emergency Medical Responder Time: __________

☐ Public Health Advisor Information

about person involved in the emergency:

Full name:____

Date of birth:______/______/______ Age:__________ Sex: ☐ M ☐ F
Day Month year

ID type and number:____

Current local full address:____

Telephone No____________________

Current permanent full address:____

Telephone No____________________

Member of: ☐ Public ☐ Facility staff ☐ Emergency Services

Radiological survey done: ☐ Yes ☐ No

If YES, attach Worksheet C1 with results.

Decontamination done: ☐ Yes, to level:________ [ ] ☐ No
Unit

Distance from the emergency when it happened:__________________________________

Time of beginning of exposure (if any):________ Time of end of exposure:________

Duration of exposure:________________ Position of the person:______________

Remarks: ____

____

____

Signature:______________

WORKSHEET B1: RECORD OF PATIENT RADIOLOGICAL SURVEY (AT HOSPITAL)

To be completed by: Dosimetry Team	**WORKSHEET B1** **RECORD OF PATIENT RADIOLOGICAL SURVEY (AT HOSPITAL)**	*No.* ______

Surveyed by: ______________________________ Date: ___________

(Full name)

Provide to: ☐ Hospital Emergency Department Response Team

☐ Health/Medical Physicist Time: ___________

Performed in: ☐ Hospital ambulance reception area

☐ Hospital treatment area

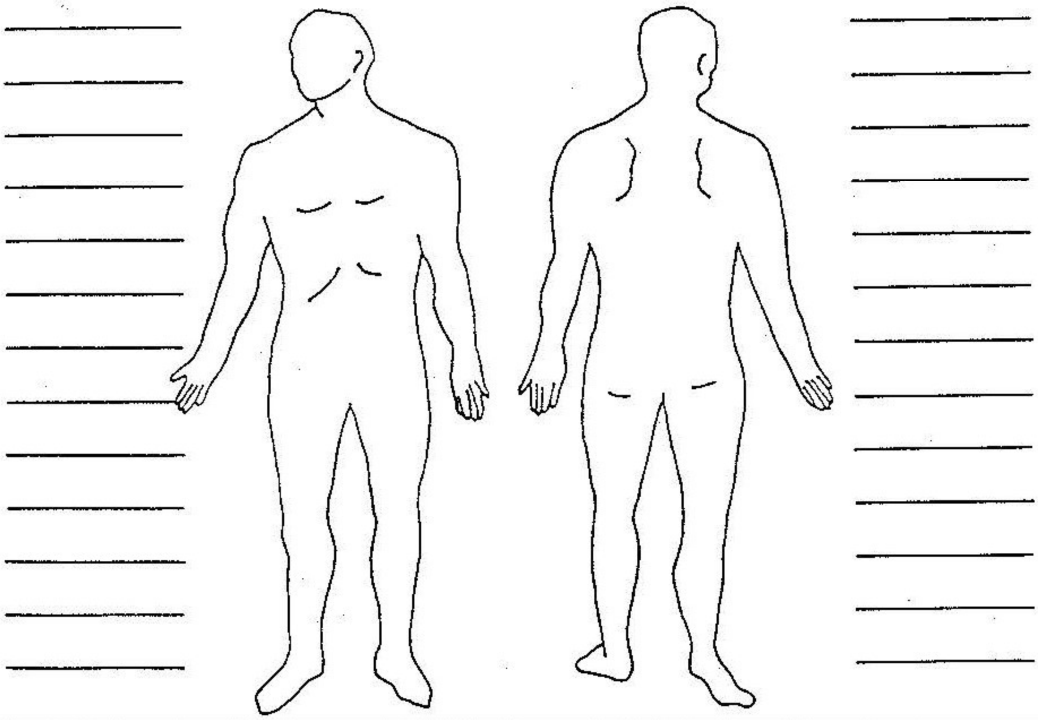
Name of victim: ______________________________ Sex: ☐ M ☐ F

Date of measurement:______/______/______ Time of measurement:___________

Contamination survey

Instrument type: ___________________ Model: ___________

Background reading: _____________ Detector active surface: ____________ [cm^2]



Remarks: Indicate readings in the lines provided in the diagram. Indicate location of the readings by arrows. Only record readings greater than background.

Results of thyroid survey:_________________[ ] _________________ [ ]

(count rate from neck) [Unit] (count rate from thigh) [Unit]

_________________ [ ] _________________ [ ]

(background count rate) [Unit] (net count rate) [Unit]

Calibration coefficient:_________ [Bq/Unit of count rate] Activity_____ [Bq]

Further evaluation at medical facility necessary: ☐ Yes ☐ No

Surveyor signature: _______________

WORKSHEET B2: MEDICAL INFORMATION FORM

To be completed by: Hospital Emergency Department Response Team	**WORKSHEET B2** **MEDICAL INFORMATION FORM**	*Page 1 of 3* *No.* ______

Full Name: ________________________________ Date: ___________

(team member)

Provide copy to: ☐ Emergency Medical Manager Time: ___________

☐ Medical Specialist of Appropriate Service (if necessary)

☐ Referral hospital (if necessary)

Identification of the patient:

Full name:____

Date of birth:_____/_____/_____ Sex: ☐ M ☐ F

Day Month Year

Current local full address:____

Current permanent full address:____

Member of: ☐ Public ☐ Personnel ☐ Emergency Workers

Identification of the exposure conditions:

Date of emergency: _____/_____/_____ Presumed time of emergency:___________

Day Month Year

Time of beginning of exposure:_________ Time of end of exposure:_____________

Duration of exposure:_________________ Position of the patient:_______________

Nature of patient's work:____

The patient had a dosimeter: ☐ Yes ☐ No Dosimeter No:_____________________

Dosimeter readings:________________ Body location of dosimeter(s):_________

Respiratory protection: ☐ Yes☐ No Protective clothing: ☐ Yes ☐ No

Contamination of clothes: ☐ Yes☐ No ☐ Not checked

Medical findings:

Date of examination: _____/_____/_____

First symptoms:

Clinical state

Nausea: ☐ Yes ☐ No Time of appearance_________Number_____ Duration______

Vomiting: ☐ Yes ☐ No Time of appearance_________Number_____ Duration______

Wound: ☐ Yes ☐ No Trauma: ☐ Yes ☐ No Burn: ☐ Yes ☐No

Weakness: ☐ Yes ☐ No Headache: ☐ Yes ☐ No

Diarrhoea: ☐ Yes ☐ No Time of appearance________ Frequency:__________
Temperature:__________________ Pulse:______________________
Blood pressure:________________
Consciousness:

☐ Normal ☐ Abnormal ☐ Agitation

☐ Delirium ☐ Sleepiness ☐ Coma

Equilibrium disturbance: ☐ Yes ☐ No

Coordination disturbance: ☐ Yes ☐ No

Skin and mucosa: Oedema: ☐ Yes ☐ No

Erythema: ☐ Yes ☐ No

Other:____

Past history

Any known treatment with X rays or isotopes: ☐ Yes ☐ No
If 'Yes', reasons for treatment:____
Date of treatment: ______/_____/__________
Place where treatment was given:____

Treatment and investigations:

Measures taken

Undressing: ☐ Yes ☐ No Decontamination: ☐ Yes ☐ No

Decorporation: ☐ Yes ☐ No. If 'YES', provide details:

Administration pathway: ☐ Aerosol ☐ Bathing ☐ Intravenous
Dose:__________________________ Results (activity):______________________

Stable iodine administration: ☐ Yes ☐ No Time of Administration: _____/_____
______________________________ __
Date Hour

Dose:_______________ Duration:______________

Laboratory tests

Blood samples [Perform a complete and record a complete cell blood count (CBC) with full differential]

First sample
(if possible, before the 3rd hour)

Date:______/______/______
Day Month Year
Time_____

Blood lymphocyte count_______________
Cytogenic sample (10 ml) taken: ☐ Yes ☐ No
Sample for radioactivity measurement taken:

☐ Yes ☐ No

Second sample
(if possible, 2 hours after the first one)

Date:______/______/______
Day Month Year
Time_____

Blood lymphocyte count _______________
HLA typing: ☐ Yes ☐ No

Third sample
(if possible, 6 hours after second one)

Date:______/______/______
Day Month Year
Time_____

Blood lymphocyte count________________

Fourth sample
(if possible, 6 hours after fourth one)

Date:______/______/______
Day Month Year
Time_____

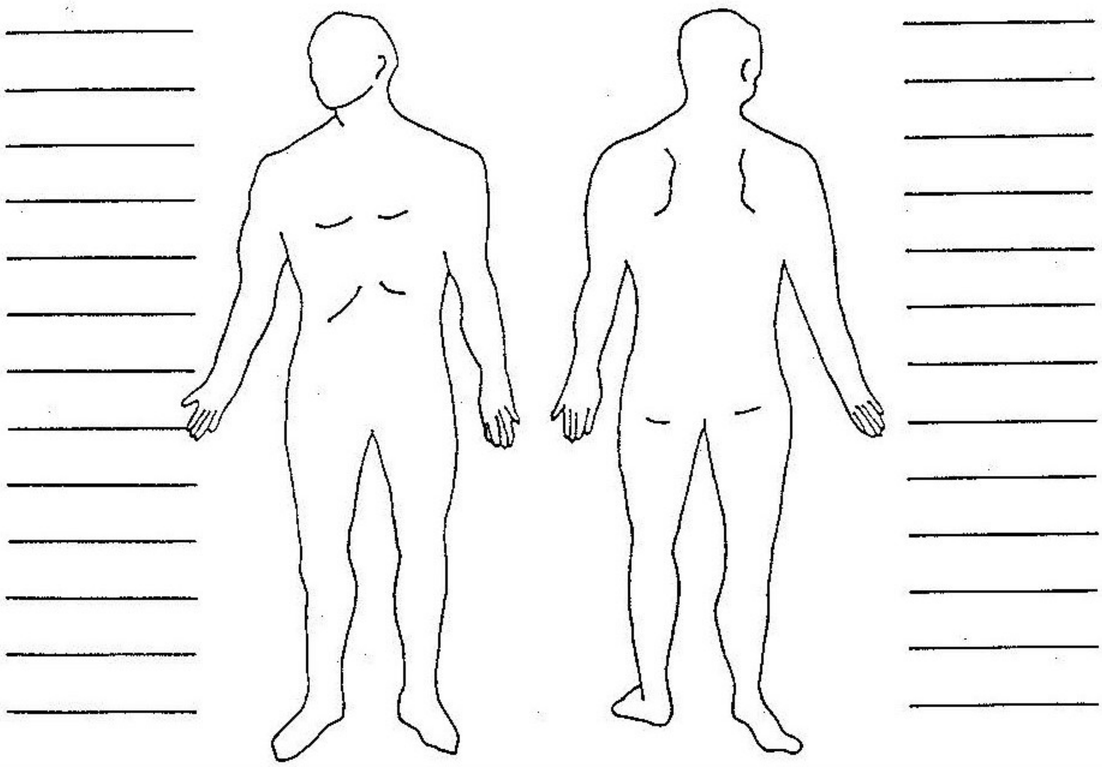
Blood lymphocyte count________________

Urine samples

If applicable, for radioactivity measurement: □ Yes □ No

is the first urination after the emergency: □ Yes □ No

Wound and erythema survey



Remarks: Indicate wound type and erythema in the lines provided in the diagram. Indicate location of the readings by arrows.

Conclusion:

____
____
____
____
____
____

Signature:__________________

WORKSHEET B3: METHODS AMD EFFICIENCY OF DECONTAMATION

To be completed by: *Dosimetry Team*	**WORKSHEET B3** **METHODS AND EFFICIENCY OF DECONTAMINATION**	*No.* ______

Decontaminated by: ______________________________ Date: __________
(Full name)

Provide to: ☐ Hospital Emergency Department Response Team

☐ Health/Medical Physicist Time: __________

Performed in: ☐ Hospital ambulance reception area

☐ Hospital treatment area

Name of victim: ______________________________ Sex: ☐ M ☐ F

Contamination survey

Instrument type: __________________ Model: __________

Background reading: _____________ Detector active surface: ____________ [cm^2]

Method:____

Results of decontamination:

Method used for decontamination	Area decontaminated	Activity before decontamination	Activity after decontamination

Remarks: ____

Signature:____________________

WORKSHEET B4: RESULTS OF DOSE ASSESSMENT

To be completed by: Health/Medical Physicist	**WORKSHEET B4** **RESULTS OF DOSE ASSESSMENT**	*No.* ______

Full Name: ______________________________ Date: __________
(Health/Medical Physicist)

Provide copy to:
- □ Hospital Emergency Department Response Team
- □ Medical Specialist of Appropriate Service
- □ Public Health Officer

Identification of the patient:

Full name:____

Code: _______ Date of birth:_____/_____/_____

Weight [kg]:__________ Height [cm]: _______

Sex: □ M □ F (Pregnant: □ Yes □ No)

Results of dose estimation:

Dose	**Effective dose, Sv**
External	
Internal	
Total	

Radiation weighted dose to thyroid: _________________________, **Sv**

Organ or tissue	**RBE-weighted absorbed dose, Gy-Eq**		
	External	**Internal to date** ___/___/___	**Index to date** ___/___/___
Lung			
Colon			
Red marrow			
Thyroid			

Recommendations: ____

____

____

Signature:___________________________

WORKSHEET B5: RESULTS OF CYTOGENETIC DOSIMETRY

To be completed by: *Biodosimetry Team*	**WORKSHEET B5** **RESULTS OF CYTOGENETIC DOSIMETRY**	*No.* ______

Full Name: ________________________________ Date: ___________

(Responsible Cytogeneticist)

Provide copy to:
- □ Health/Medical Physicist
- □ Hospital Emergency Department Response Team

Identification of the patient:

Full name:____

Code: _______ Date of birth:______/______/______

Date of blood sampling:______/_____/_____ Date of analysis:______/_____/_____

Results of analysis:

2.5.17.3.3 Number of scored cells	
Frequency of dicentrics	
Frequency of centric rings	
Frequency of acentrics	
Estimated absorbed dose [Gy] and 95% CI	

Reference *in-vitro* calibration curve: ___________________________________

Radiation type (R): __________________ Radiation quality ($\overline{Q}$):_____________

Absorbed dose rate: __________________ RBE: _________

Calibration curve: ____

Coefficients of calibration curve used for dose assessment: ____________________________

Remarks: ____

____

____

Signature:____________________________________

APPENDICES

APPENDIX I: CONSIDERATIONS ON EMERGENCY PREPAREDNESS AND RESPONSE FOR NATIONAL HEALTH AUTHORITIES

Requirement 12 of GSR Part 7 [1] states:

> "**The government shall ensure that arrangements are in place for the provision of appropriate medical screening and triage, medical treatment and longer term medical actions for those people who could be affected in a nuclear or radiological emergency.**"

Requirements 12 and 16 of GSR Part 7 [1] and GSG-11 [12] provides recommendations on the roles and responsibilities of the national authorities regarding the medical preparedness for and response to nuclear or radiological emergencies.

In general terms, it is expected that national health authorities:

- Ensure that a plan for the medical response to a nuclear or radiological emergency is available;
- Provide adequate facilities and resources for the management of the medical consequences of such emergencies;
- Ensure that staff are trained in the necessary skills is available;
- Regularly exercise their ability to respond efficiently to various emergency scenarios.

The resource allocation for the planning of a medical response to nuclear or radiological emergencies will be based on the assessment of actual risks in a given country. A nationwide hazard mapping and inventory of potential risks and potential emergency scenarios are essential elements of planning for emergency response.

Preparedness:

Developing an emergency preparedness strategy begins with awareness of what type of ionizing radiation and radioactive materials are used in a country and where they are used. A national registry or database of radioactive sources could provide relevant information for the preparedness stage. Access to this database may assist relevant health authorities in supporting policy development and decision making with regard to medical response plans. Such a registry or database includes at least the following information:

- Locations where radioactive sources and sources of radiation are used;
- Types and activities of radioactive sources;
- Types of radiation generating devices;
- Information regarding the transportation of radioactive materials through any respective area;
- A spectrum of possible emergencies.

On the basis of this information, the relevant medical organizations need to prepare a list that includes:

- The estimated number of people potentially affected; the estimated number of casualties (different types) for each potential scenario for a nuclear or radiological emergency [1];
- The estimated number of medical facilities at the local, regional and national levels [1];
- The identification of an international notification process, if needed;
- Trained healthcare professionals and their locations;
- Specialized national medical centres or other facilities for treating patients with LRI, ARS and contamination, considering that hospitals with surgical burn and haematological departments may provide part of the treatment [2];
- Identification of the equipment and supplies needed for emergency response;
- Estimated number of ambulances and agreements with transport services.

Data on the number of casualties for the potential scenario of malicious use of radioactive materials or estimates based on a nuclear power plant incident (as applicable) may be used for establishing preparedness to handle mass casualty emergencies [5]. In case of an emergency resulting from malicious use of radioactive materials, the probability of a mass casualty event is very high [5]. Furthermore, different categories of injuries or individuals involved will request medical assistance.

Medical authorities need to be prepared to attend to a number of different persons [1]. Three groups of people may arrive at a hospital in a nuclear or radiological emergency with mass casualties:

- The worried-well, who are not injured but worried. They get to the hospital on their own and get there fast. If staff are not prepared for them, they can obstruct the operation of the hospital and interfere with the treatment of casualties that will arrive later.
- The injured rescued by the public and bystanders. These might arrive next and, while injured, they may not be the most severely injured.
- The injured rescued by emergency response personnel. They might be the most severely injured.

The people arriving first will probably not have been monitored or decontaminated. While those transported to the hospital by emergency response personnel will have likely been monitored to some extent, radiological surveys are still necessary at the hospital after medical stabilization has occurred.

Therefore, it is crucial to prepare a designated place (not at the hospital or other crucial facility) as a reception centre to assess concerned people (worried-well) for radiation exposure, as seen from the experience in the Goiânia radiological accident [8].

At the local level, it is necessary to have a hospital with the necessary supplies and expertise designated to manage radiation victims, if an appropriate hospital exists within the area. However, in a particular situation, depending on the type of the emergency and the patients' condition, casualties could be admitted to a hospital located closer to the scene of the emergency. Specialized advice might not be available at the scene of the emergency; it may only exist at medical facilities that use radiation sources, where medical professionals are experienced in dealing with radiation injuries or have some relevant knowledge.

Response:

Paragraph 2.7 of GSG-11 [12] states:

> "Early in the emergency, the response organizations focus their response actions on mitigating the potential consequences of the emergency so that undesirable conditions are prevented from developing, or their development is delayed, making it possible to take effective protective actions on the site and, as necessary, off the site. Such mitigatory actions are accompanied by protective actions and other response actions that are aimed at the potentially or actually affected individuals."

The duties of a national health authority in the event of an emergency are conducted in cooperation with all appropriate agencies. National health authorities need to consider the following generic actions:

Short term:

- Provide an effective system for the care of those victims affected by an emergency;
- Provide for public health advice to minimize the risk to the general public (in particular, provide advice on stable iodine prophylaxis [3]);
- Ensure that a significant number of clinical services for the general public not affected by the emergency are maintained;
- Establish a trained multidisciplinary team of healthcare professionals [46];
- Promote effective communication [47, 48];
- Gather data on the persons at risk and other available information to produce a register and later an effective post-emergency epidemiological surveillance [12].

Mid term:

- Reassess and review, with allied departments and agencies, intermediate to long term protective actions [49];
- Provide the population with information as to the likely health effects of the emergency by reference to existing knowledge [47, 48];
- Provide for detailed clinical and radiological review of affected persons [4];
  Establish a registry of persons to receive longer term medical follow-up [12];
- Establish and maintain appropriate disease surveillance programme for those who may need to be under medical follow-up [12].
- Assist civil authorities in planning a return to normal life for the population affected [12].

Long term:

- For persons at risk, provide a possibility of medical follow-up by specialized services as needed to ensure early diagnosis and treatment of the stochastic consequences of nuclear or radiological emergencies [1, 12];
- Make arrangements to promptly provide the public with the results of medical examinations;
- Arrange to provide useful, timely, truthful, consistent and appropriate information to the public regarding health consequences of the emergency; use a plain language explanation [48];
- Maintain an appropriate disease surveillance programme when this intervention is justified [12].

APPENDIX II: GENERIC CONSIDERATIONS FOR DEVELOPING A HOSPITAL PLAN FOR MEDICAL RESPONSE TO A NUCLEAR OR RADIOLOGICAL EMERGENCY

The following Appendix describes some generic considerations when a plan for medical response to nuclear or radiological emergencies is to be implemented at a hospital. These are based on experts' opinions and do not represent recommendations. This Appendix contains useful information that might be included in the plan, depending on its scope.

TITLE (COVER) PAGE

On the title (cover) page, provide the title of the plan, approval date, version number and signatures. The title needs to clearly indicate the organization addressed by the plan (hospital). The signatures need to include those of the heads of any participating organizations.

CONTENTS

1. INTRODUCTION

1.1. Purpose

Describe the purpose of the plan, for example: The plan provides the basis for the medical response by (name of the participating organization or jurisdictions) to a nuclear or radiological emergency.

1.2. Participating organizations

List all organizations participating in the plan

1.3. Scope

Describe the scope of the plan, for example: The plan addresses the response by (name of participating organization) whereby it performs (list major functions) under the Hospital Plan for Medical Response to a nuclear or radiological emergency in the event of an actual or perceived radiation hazard.

The plan is to be an overarching guidance document and is not intended to provide detailed response guidance. This level of detail will instead be contained in procedures that are developed on the basis of the plan.

1.4. Legal basis

1.5. Related plans and document

Describe the relationship to other plans that are to be used simultaneously with this plan. Provide a complete list of all the supporting documents in an appendix.

2. PLANNING BASIS

2.1. Types of hazards

Give a brief description of the characteristics of potential radiation hazards that are important in planning for medical response.

2.2. Definition of Terms

2.3. Scenarios of potential emergencies and related consequences: types, severity and magnitude (number of patients, types of injury)

2.4. Response roles and responsibilities

Describe the roles and responsibilities of the hospital and of other organizations that have cooperative activities with the hospital in performing tasks of emergency medical response (e.g. transport service, waste removal). The availability of specific subject matter expertise needs to be considered [46].

2.5. Response organization

Provide a block diagram of the sections, groups, teams or positions within the hospital, with a brief description of responsibilities of each 'block' and the emergency facility where these organizational elements will probably perform their responsibilities. A detailed discussion of authorities, responsibilities and duties of the sections, groups, teams or positions needs to be provided in the implementing procedures.

2.6. Response facilities

Provide a list and brief description of hospital facilities that will be used in the response.

2.7. Response communications [48]

2.8. Logistics/resource commitments

2.9. Concept of operations

Give a brief description of the ideal response of the hospital in the context of the total response. Provide a separate description of arrangements for a mass casualty event.

3. EMERGENCY RESPONSE PROCESS

3.1. Notification, activation and request for assistance.

Describe the level of activation (normal mode, standby, activated and recovery mode) and criteria for activation levels. Describe how national authorities will be notified of an emergency recognized by physicians (first recognition and triggering the general response). The call lists used for activation and notification need to be in the procedures.

3.2. Emergency management of medical response

Describe the command and control system used to manage the medical response in the hospital and the relationship to the national medical command-and-control system.

3.3. Taking urgent protective action

The plan needs to include the criteria (in an appendix) and organizational components responsible for implementing (or advising on) thyroid blocking (if applicable). Describe the arrangements for coordination with other involved organizations [1, 12, 49].

3.4. Providing information, warnings and instructions to the public

Describe the arrangements for providing the information to the relevant organization to be disseminated to the public [47, 48].

3.5. Protecting emergency medical personnel

Describe general principles, personal monitoring and control arrangements, dose recording and follow-up.

3.6. Providing medical assistance and mitigating the non-radiological consequences

Describe the general principles; provide the criteria for triage, screening, and monitoring and decontamination of evacuees.

Describe the general principles for treatment, transfer of patients to the other national or international medical centres, patient release, contamination control, personal monitoring, dose assessment and psychological support.

3.7. Financial matters

3.8. Maintaining records and management of data

4. EMERGENCY PREPAREDNESS PROCESS

Identify the responsible parties and describe the arrangements to perform their functions, listed in the following subsections, that are needed to develop and maintain the capability to respond to an emergency described in the plan.

4.1. Authorities and responsibilities

4.2. Organization and coordination

4.3. Plans and procedures

4.4. Logistical support and facilities

4.5. Training and exercises

4.6. Quality assurance and programme maintenance

5. LIST OF ABBREVIATIONS

6. DISTRIBUTION LIST

List (and distribute to) all individuals/organizations that are parties to this plan or that will be developing response arrangements consistent with this plan.

7. APPENDICES OF THE HOSPITAL PLAN TO CONSIDER

Appendix 1: Organization authorities, responsibilities and capabilities

Describe the organization authorities, responsibilities, capabilities and resources in emergency situations.

Appendix 2: Agreements

List (or refer to document listing) and summarize agreements to provide medical assistance (national/international) or memoranda of understanding concerning common response (e.g. with non-medical organizations involved in medical response).

Appendix 3: Maps and plans related to medical response

Provide plans of emergency areas (reception, decontamination, treatment) for events with several casualties and mass casualties. Provide the map with pre-established monitoring locations and emergency facilities.

Appendix 4: Supporting documentation and plans

List all the supporting documentation and plans relevant for the maintenance and implementation of the plan. This includes the plans for various functional areas, such as command and control, logistical and financial support, public affairs and radiological monitoring.

APPENDIX III: EQUIPMENT AND SUPPLIES

This appendix presents a list of equipment and supplies for use in the immediate medical response to nuclear or radiological emergencies, to be performed at pre-hospital and hospital levels (depending on national arrangements for distributing or stockpiling, some of the medicine, equipment and supplies could be basic or extended).

I. Preparation for dealing with internally contaminated patients

Collecting samples for counting and bioassays

Supplies for collecting samples [2]:

- Cotton tipped applicators for nasal swabs;
- Containers for collecting urine or faeces samples;
- Gauze for collecting blood samples from wounds;
- Shielded containers for storage of radioactive shrapnel;
- Lithium heparinized vacuum container tubes (for cytogenetic biodosimetry).

Medical agents for treatment of internal contamination

- Aluminium hydroxide [10];
- Calcium gluconate;
- Deferoxamine (DFOA);
- Diethylenetriamine-pentaacidic acid (DTPA)—calcium and zinc forms [10, 49];
- Dimercaprol (usually known as British Anti-Lewisite—BAL®);
- Dimercaptopropansulphonate (DMPS);
- Penicillamine;
- Potassium iodide (KI) for thyroid blocking [3];
- Prussian Blue (ferric hexacyanoferrate [II]) [8, 10, 50];
- Sodium bicarbonate.

Further information on treatments for internal contamination is provided in Refs. [5, 8, 10, 50].

Direct/in vivo dose assessment for internal contamination

Whole body counters (WBCs), thyroid monitors and lung counters are used for direct measurement of internal contamination. Most hospitals do not have these detectors, but patients may be moved to other facilities after medical stabilization, where direct monitoring is available. Portable devices can also be used to avoid removal of the patient. Urine, faeces, blood and other samples can be sent to specialized centres with appropriate counting/measuring equipment for bioassays when necessary.

II. Supplies that might be necessary for handling of contaminated patients[7]

Personal Protective Equipment (PPE) [34]

- Coveralls or surgical scrub suits, plastic aprons, surgical caps, plastic or rubber gloves, surgical masks;
- Shoe covers;
- Respiratory protection devices (e.g. N95 mask or any other mask that filters 95% or more of airborne particulates);
- Eye protection equipment; tape to close open ends of clothing.

Radiation detectors [2, 27]

- Personal dosimeters;
- Portal monitors;
- Geiger-Müller survey meters (for beta/gamma radiation);
- Zinc sulphide scintillation survey meters (for alpha radiation);
- Ion chambers (for gamma radiation);
- Sodium iodide scintillation survey meters (for gamma radiation);
- Spectrometers (for identification of radionuclides);
- Whole body counters, lung and thyroid counters.

Contamination control [2, 10]

- Material to cover floor and waterproof sheets to cover beds;
- Tape, rope and radiation warning signs;
- Radiation tags, radiation tape for marking areas;
- Plastic bags (various sizes) for collecting wastes or contaminated clothes;
- Adhesive labels and tags for labelling contaminated samples;
- Bags for contaminated clothing;
- Waste bins.

Decontamination supplies [2]

- Soap, detergents, shampoo; soft brush or sponges;
- Physiological saline solution; water or solution for wound irrigation; eyewash solution;
- Drapes and surgical tape for covering non-contaminated skin or area during decontamination;
- Indelible felt pens for marking contaminated spots;
- Data forms (e.g. decontamination forms);
- Large towels and clean patient gowns or clothing.

Others

- Medical equipment supplies and medicines for conventional medical emergency assistance.

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[7] Supplies need to be in compliance with medical and radiation protection protocols to deal with patients contaminated with radionuclides.

APPENDIX IV: MENTAL HEALTH AND PSYCHOLOGICAL SUPPORT SERVICES IN NUCLEAR OR RADIOLOGICAL EMERGENCIES

Mental health and psychological effects can seriously affect the wellbeing of those affected and can be long lasting, thereby constituting some of the most significant and challenging consequences of a nuclear or radiological emergency. Consideration of mental health and wellbeing needs to be an integral part of emergency preparedness and response [4, 11, 41].

Serious events can cause profound mental health effects and produce trauma. The perceived risk plays a pivotal role in individual reactions to the consequences of an emergency, even if these consequences have not yet materialized [2].

The mental health effects during a nuclear or radiological emergency have often been underestimated or even ignored. Following the accidents at the Chornobyl and Fukushima nuclear power plants, mental health effects were reported to be the largest public health concern and remain an important issue to this day, with long term consequences still affecting people and continuing to be an important cause of disability [2, 8, 41, 42, 51–53]. For this reason, it is important for physicians to have a good general understanding of the psychosocial aspects of trauma and PTSD in a nuclear or radiological emergency [42].

Prolonged periods of psychological stress can result in physiological changes, psychiatric and mental health problems and cognitive effects [11, 39, 42, 51, 52].

Aspects related to affected population and people exposed to radiation

MHPSS requires the involvement not only of mental health professionals, but also of medical practitioners and other allied professionals. MHPSS may be needed during the entire period of the emergency and for a considerable time thereafter [4, 11, 40, 50, 51].

As a specific example, the mental health impact associated with the treatment of radiation induced injuries needs to be minimized, and, therefore, the treatment needs to be provided as close to the individual's home as possible, facilitating access to health services when possible, or (at the very least) in a region with the same language and culture [48, 51]. Consideration needs to be given to providing for family members to accompany the patient when treated. Religious, cultural or social considerations have to be addressed when performing surveys, decontamination or other procedures [10].

People that might develop mental health problems might also face discrimination and stigma; measures have to be provided to minimize these problems [2, 4, 8, 51, 52].

Aspects related to responders

During a nuclear or radiological emergency, stress also affects emergency responders (firefighters, police, monitoring teams and emergency medical responders). They would be expected to perform their usual duties, in addition to duties that are not an ordinary part of their job (i.e. monitoring, decontamination, evacuations) [2, 8, 9].

Periodic training, trauma and stress prevention, repeated evaluation of mental health status and health control of responders, conducted by mental health professionals, is advisable. Mental health support has also to be provided to families of responders in the event of a nuclear or radiological emergency [4].

APPENDIX V: CONSIDERATIONS FOR RESPONSE TO MALICIOUS ACTS INVOLVING RADIOACTIVE MATERIAL

This appendix provides information for an emergency resulting from malicious acts involving radioactive material. These terrorist scenarios include radiological exposure devices, radiological dispersal devices and the detonation of a nuclear weapon. Each scenario might produce multiple casualties, although there are distinctions to be made regarding lethal, non-lethal and psychological consequences [2, 5, 54].

The generic procedures for the medical management of a nuclear or radiological emergency are the same, whether for a single casualty or for mass casualties. However, the consequences of malicious acts involving radioactive material resulting in potentially large numbers of casualties, rapid depletion of medical resources and limited personnel dictate a different medical management strategy for emergency response [54]. The role of the medical response will focus on triage and medical management, aspects already discussed in the different sections of this publication.

Emergency medical responders need to be vigilant for potential malicious acts involving radioactive material. Reporting to appropriate authorities of even a single radiation exposure case can contribute to the initial identification of a malicious act involving radioactive material. It is important to emphasize that healthcare providers are extremely unlikely to receive a medically significant acute radiation dose when providing patient care to casualties with radioactive debris in wounds, provided that they observe basic radiation protection principles [55].

A radiological exposure device (RED) is a sealed radioactive source placed in a position where it will irradiate people (external exposure); it does not represent a contamination hazard unless the source is unsealed [5]. Sealed sources can result in exposure of persons who remain in close proximity to the source. Persons who handle these sources might suffer significant local radiation injury to the skin and underlying tissues [2]. Some medical and industrial equipment contains radioactive sources that could function as a RED, for example brachytherapy and industrial radiography sources [55].

Radiological dispersal devices (RDDs) are intended to spread radioactive material in order to contaminate a large area and/or number of people [5]. The spread of the radioactive material can be performed by an explosive, also called a ‘dirty bomb’, but can include non-explosive means to spread the radioactive material. The environment, and persons in the immediate area, will become contaminated as the radioactive material disperses. As the distance from the area of the dispersal increases, the potential for medically significant levels of contamination decreases.

All hazards approach in response to malicious acts involving radioactive material

For malicious acts with a strategy focused on creating a large number of victims, the concern is not only focused on the radiological risk. In the event of a malicious act, other hazardous materials may be present, and the conventional explosion may represent the most significant hazard to persons in the area. The potentially high number of victims, dealing with radioactive contamination in a populated area, and addressing the effects of radiation exposures necessitates the establishment of a standardized methodology in order to optimize the efficiency of the response.

Principles of medical management

The same principles for medical management will apply as for any other nuclear or radiological emergency, i.e. [2, 5, 55]:

— Patients should be evaluated and treated based on current triage standards.
— The use of universal precautions by healthcare professionals will significantly mitigate concerns to contamination with radioactive material.
— Medical stabilization of the patient has priority over any external or internal radiation risk to the patient.
— Treatment of internal contamination to minimize the deposition of radionuclides into target organs, needs to be considered if high internal doses are estimated.
— Basic radiation protection and contamination control guidelines will need to be always followed (see Appendix VII).
— Concerns of hospital staff regarding responding to nuclear or radiological emergencies need to be addressed.
— A multidisciplinary approach for the treatment of patients might be necessary.
— The responders need to receive appropriate training regarding the risk and potential consequences of malevolent acts.

APPENDIX VI: DIFFERENCES BETWEEN RADIOACTIVE AND CHEMICAL OR BIOLOGICAL HAZARDS

There are differences between radioactive and chemical or biological hazards, and these are important from a safety perspective, and are relevant for planning the response to a nuclear or radiological emergency. Some of the main differences are summarized in Table 11 [10].

TABLE 11. DIFFERENCES BETWEEN RADIOACTIVE AND CHEMICAL OR BIOLOGICAL HAZARDS

Agent	**Radiological**	**Chemical or biological**
Detection	Small amounts of radioactive material can be detected and located with appropriate portable radiation detection equipment.	Requires specialized laboratory testing.
Decontamination	The radioactive material cannot be destroyed by chemicals or fire. Medical stabilization is the first action indicated on scene and not internal or external decontamination.	Substances can be destroyed or neutralized. In some instances, there is an absolute need for on-site chemical or biological decontamination, which is not the case for radiological contamination.
Protective clothing	Any outer clothing protects the wearer from alpha and most beta radiation, but it will not protect against gamma radiation (external exposure). However, outer clothing will help prevent contamination from all types of radioactive material and appropriate PPE is to be worn if any possibility of radioactive contamination exists.	Some types of protective clothing provide protection against chemical or biological agents.
Respiratory and eye protection	Respiratory protection normally used by emergency responders reduces the risk of inhalation of radioactive particles and therefore the risk of internal contamination with radioactive material. Eye protection reduces the risk of radioactive material being absorbed by the tissues of the eyes.	Different types of respiratory protection can protect against inhalation of some biological or chemical agents. Eye protection reduce the risk of chemical or biological material being absorbed by the tissues of the eyes.
Decay	The quantity of radioactive material always decreases over time, and in some instances this characteristic provides an advantage in radiation protection.	No decay.

APPENDIX VII: BASIC PRINCIPLES OF RADIATION PROTECTION IN AN EMERGENCY

Protection of healthcare providers

Healthcare providers in a nuclear or radiological emergency need to be protected from unnecessary radiation exposure. Ideally, all responders will be trained in radiation protection and participate in regular drills or exercises. Information about risks from radiation exposure is an essential part of the training programme. In many instances, radiation protection professionals might not be available to support first responders and medics responding to an emergency. This underlines the importance of training so that they understand radiation risks, and the need to implement protection measures against undue radiation exposure.

The optimization of protection and safety, in order to keep radiation exposures ALARA (As Low As Reasonably Achievable) is a key principle associated with protecting people from ionizing radiation. ALARA and the fundamentals of radiation protection — time, distance and shielding [8] — need to be used to minimize external doses to responders. In many past radiological emergencies, the exposure to radiation for responders, including healthcare staff, has been in the normal range of occupational exposures [8, 9] [8], [9].

Radioactive contamination can be external, internal or both. External contamination can be transferred to other individuals through contact with the contaminated patient's clothes or skin. Protective clothing, if used properly, offers protection against radioactive contamination but not against external exposure from penetrating radiations such as gamma rays. In most instances, when full protective clothing is not available, usual biosafety practices, such as the use of universal precautions and proper patient handling techniques, will be sufficient to protect against exposures due to radioactive contamination [10]. Besides protective clothes and good biosafety practices, there might be rare occasions when other personal protective equipment (PPE), such as respiratory protection devices, can be used, specialized guidance based on national regulations or international recommendation is necessary.

Personal dosimetry, selected on the advice of radiation protection professionals, needs be used during response activities. Appropriate personal dosimeters need to be used to monitor external doses to ensure they are ALARA. Dosimeter types include film badges, thermoluminescent dosimeters (TLD) and optically stimulated luminescent dosimeters (OSLD). The use of electronic dosimeters with a dose display and pre-set alarms has many practical advantages, in particular they allow the users to continually track their accumulated dose [55].

General Occupational Safety Instructions

- Responding personnel always needs to be aware of the hazards, both radiological and non-radiological, that may be encountered in the field, and take necessary precautions.
- For field activities, the appropriate safety equipment and PPE need to be worn.
- Staff responding in the field needs to be trained to use safety equipment and to observe safety procedures, keeping in mind the basic radiation protection principles of time, distance and shielding.

[8] It is often difficult to take advantage of shielding on the scene.

— The radiation exposure received by responding staff is to be ALARA during response operations. If actions into high-dose risk areas are unavoidable for specific reasons (e.g. a lifesaving operation), responders need to be informed of the risk, they need to consent to being exposed to this risk and be provided with radiation protection professionals' support.
— Emergency responders should not take unnecessary risks, and, when in doubt, need to seek advice from the response team leader or coordinator.

Protective Personal Equipment (PPE)

Protective clothing needs to be chosen according to the hazards present during the emergency. The purpose of protective clothing is to keep radioactive contamination off skin or personal clothing [55]. Heat stress needs to be considered, since most people are not likely to be used to working in extra layers of clothing [2, 55]. In case the risk of suspended radioactive material dust is high, appropriate respiratory protection needs to be used.

Figure 9 shows an example of a complete PPE assemblage for managing a case of radiological contamination in a hospital. When removing PPE, staff need to ensure that appropriate precautions are taken to prevent the contamination of the person taking off the PPE. A complete survey needs to be performed before leaving the area to ensure the absence of external contamination [55].

FIG. 9. Complete PPE assemblage for radiological contamination in a hospital (courtesy National Institute Radiological Sciences-Quantum Institute) [2, 10].

NOTE

The purpose of protective clothing is to keep bare skin and personal clothing free of contaminants. This protective clothing is effective in stopping alpha and some beta particles but not gamma rays. Lead aprons, such as those used in the X ray department, are not appropriate since they give a false sense of security—they will not stop most gamma rays. Members of the team using liquids for decontamination purposes will need to wear a waterproof apron [2].

Shoe covers need to be waterproof.

Tape all open seams and cuffs.

Electronic dosimeters are to be attached to the outside of the surgical gown where they can be easily removed and read. If available, a film badge or other type of passive dosimeter (TLD) can be worn under the surgical gown**.**

Removing clothes from a contaminated patient

Use the following steps to remove the clothing (see Fig. 10):
- Cut the clothing from head to toe and down the sleeves;
- Fold cut parts of the material back under itself as it is cut, trapping any radioactive contamination in the folds and away from the skin;
- Roll up the material in a direction away from the patient's airway.

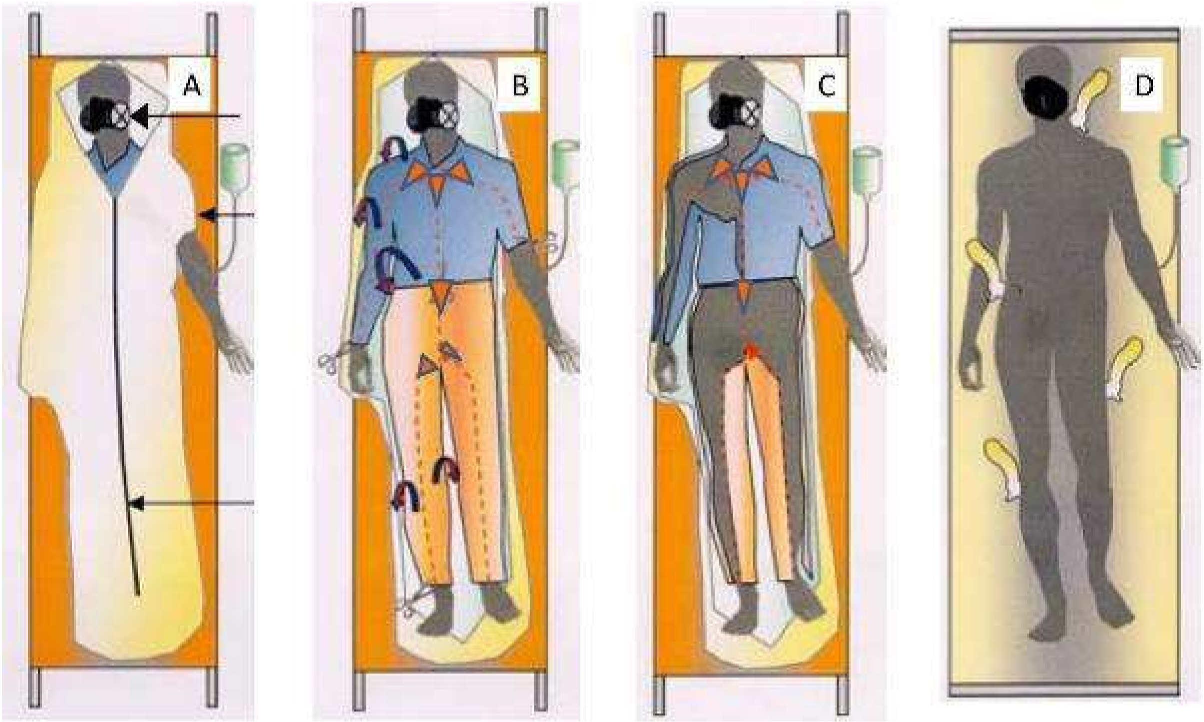


FIG.10. Undressing lying individual: A) The three black arrows in this figure point out respiratory protection to protect the patient's airway, the covered stretcher and the blanket or cover of the individual (from top to bottom); B) Cutting clothes after opening of the cover (from the centre to the periphery); C) Clothes are folded up from inside to outside along the individual; D) Transfer of undressed individual to uncontaminated bed or stretcher. The orange arrows show the direction for opening the clothes. (Modified from Ref. [2]).

This Appendix provides stand-alone ‘OIL charts’ (a practical tool for using the OILs during the response to an emergency) relevant for healthcare professionals, together with important practical information that needs to be considered when using the OILs. The charts are structured as shown in Fig. 11.

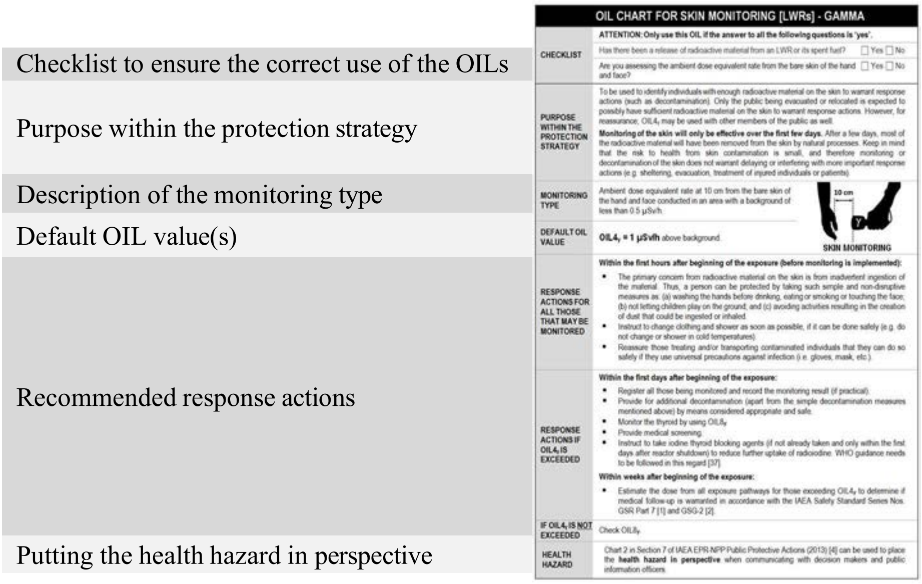


FIG. 11. Left side, general structure of the OIL charts; right side an OIL table is only used as a reference to illustrate the structure [56].

The charts are modified versions of those provided in Section 2 of Ref. [56], which contains. further details on the basis and the use of OILs (see Tables 12, 13). Ref. [56] also explains the role of OILs within the protection strategy, the evaluation of monitoring results and the communication with decision makers and public information officers.

TABLE 12. OIL CHART FOR SKIN MONITORING (modified from Ref. [56]).

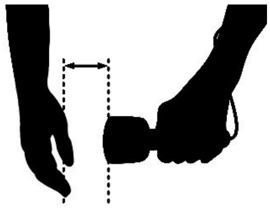
OIL CHART FOR SKIN MONITORING	
CHECKLIST	**ATTENTION: Only use this OIL if the answer to all the following questions is 'yes'.** Are you assessing the radioactive contamination of bare skin of the hand and face? ☐ Yes ☐ No
PURPOSE WITHIN THE PROTECTION STRATEGY	To be used to identify individuals with enough radioactive material on the skin to warrant response actions (such as decontamination). For reassurance, OIL4 may be used with other members of the public as well. **Monitoring of the skin will only be effective over the first few days.** After a few days, most of the radioactive material will have been removed from the skin by natural processes. Monitoring or decontamination of the skin does not warrant delaying or interfering with more important response actions.
MONITORING TYPE	Ambient dose equivalent rate at 10 cm from the bare skin of the hand and face conducted in an area with a background of less than 0.5 µSv/h. or Beta count rate at 2 cm from the bare skin of the hand and face or Alpha count rate at 0.5 cm from the bare skin of the hand  **SKIN MONITORING**
DEFAULT OIL VALUE	**$OIL4_{\gamma}$ = 1 µSv/h** above background. or **$OIL4_{\beta}$ = 1000 cps** or **$OIL4_{\alpha}$ = 50 cps**
RESPONSE ACTIONS FOR ALL THOSE THAT MAY BE MONITORED	**Within the first hours after beginning of the exposure (before monitoring is implemented):** ▪ The primary concern from radioactive material on the skin is from inadvertent ingestion of the material. Thus, a person can be protected by taking such simple and non-disruptive measures as: (a) washing the hands before drinking, eating, smoking or touching the face; (b) not letting children play on the ground; and (c) avoiding activities resulting in the creation of dust that could be ingested or inhaled. ▪ Instruct to change clothing and shower as soon as possible, if it can be done safely (e.g. do not change or shower in cold temperatures). ▪ Reassure those treating and/or transporting contaminated individuals that they can do so safely if they use universal precautions against infection (i.e. gloves, mask, etc.).
RESPONSE ACTIONS IF ANY OF THE OIL4s IS EXCEEDED	**Within the first days after the beginning of the exposure:** ▪ Register all those being monitored and record the monitoring result (if practical). ▪ Provide for additional decontamination (apart from the simple decontamination measures mentioned above) by means considered appropriate and safe. ▪ If radioiodine is involved, monitor the thyroid by using $OIL8_{\gamma}$. ▪ Provide medical screening. **Within weeks after the beginning of the exposure:** ▪ Estimate the dose from all exposure pathways for those exceeding OIL4 to determine if medical follow-up is warranted in accordance with the IAEA Safety Standards Series Nos. GSR Part 7 [1] and GSG-2 [36].
HEALTH HAZARD	Chart 2 in Section 7 of IAEA EPR-NPP Public Protective Actions (2013) [49] is an example that can be used to place the **health hazard in perspective** when communicating with decision makers and public information officers.

TABLE 13. OIL CHART FOR THYROID MONITORING (modified from Ref. [56]).

OIL CHART FOR THYROID MONITORING		
CHECKLIST	**ATTENTION: Only use this OIL if the answer to all the following questions is 'yes'.**	
	Are you assessing the ambient dose equivalent rate measured in front of the thyroid in contact with the skin?	□ Yes □ No
	Was the person decontaminated and the contaminated outer clothing removed before monitoring?	□ Yes □ No
	Was the measurement taken in the first week after the intake of I-131?	□ Yes □ No
	Did you use an instrument with an effective window area of ≤ 15 cm^2 and a response of ≥ 0.1 µSv/h per kBq of I-131 activity in the thyroid? Further details are given in Section 3.7.1.3. of Ref. [56].	□ Yes □ No
PURPOSE WITHIN THE PROTECTION STRATEGY	To be used to identify individuals warranting registration and medical follow-up due to the intake of radioiodine. For reassurance, OIL8$_\gamma$ may be used with other members of the public as well. The thyroid needs to be monitored within the first week to detect if an individual has inhaled or ingested sufficient radioiodine to warrant medical follow-up. Identifying the individuals is difficult later on. The early identification of those with an increased risk of developing thyroid cancer is paramount in their later medical follow-up and treatment. However, keep in mind that monitoring of the thyroid does not warrant delaying or interfering with other urgent response actions.	
MONITORING TYPE	Ambient dose equivalent rate in front of the thyroid: ▪ In **contact with the skin**; ▪ Measured **within the first week** after the intake of radioiodine; ▪ Conducted in an area with a background of less than 0.25 µSv/h; ▪ Measured after the person has been decontaminated and contaminated outer clothing has been removed; and ▪ Measured with an instrument with an effective window area of ≤ 15 cm^2 and a response of ≥ 0.1 µSv/h (ambient dose equivalent rate in front of the thyroid in contact with the skin) per kBq of I-131 activity in the thyroid (as described given in Section 3.7.1.3. of Ref. [56].	 **THYROID MONITORING**
DEFAULT OIL VALUE	**OIL8$_\gamma$ = 0.5 µSv/h** above background.	
RESPONSE ACTIONS FOR ALL THOSE TO BE MONITORED	**Before monitoring:** ▪ Instruct those to be monitored to reduce inadvertent ingestion by: (a) washing their hands before drinking, eating or smoking or touching the face; (b) not letting children play on the ground; and (c) avoiding activities resulting in the creation of dust that could be ingested or inhaled. ▪ Instruct those to be monitored to change clothing and shower as soon as possible, if it can be done safely (e.g. do not change or shower in cold temperatures). ▪ Reassure those treating and/or transporting contaminated individuals that they can do so safely if they use universal precautions against infection (gloves, mask, etc.).	
RESPONSE ACTIONS IF OIL8$_\gamma$ IS EXCEEDED	**Immediately following the monitoring:** ▪ Register all those monitored and record the monitoring result. ▪ Instruct to take iodine thyroid blocking agents to reduce further uptake of radioiodine (if not already taken and only within the first days after reactor shutdown). WHO guidance needs to be followed in this regard [3]. ▪ Provide medical screening. **Within weeks after the beginning of the exposure:** Estimate the dose from all exposure pathways for those exceeding OIL8$_\gamma$ to determine if a medical follow-up is warranted in accordance with the IAEA Safety Standards Series Nos. GSR Part 7 [1] and GSG-2 [36].	
IF OIL8$_\gamma$ IS NOT EXCEEDED	Register all those monitored and record the monitoring result (if practical). No further actions are necessary.	

APPENDIX IX: INTEGRATED REGISTRATION FORM FOR MEDICAL RESPONSE

The following integrated registration form is designed for the convenience of pre-hospital and hospital level response by providing a single, simple worksheet for each patient in case of mass casualties or multi-site incidents. It can be modified by the user and/or adapted to fit local procedures for meeting response and documentation needs.

INTEGRATED REGISTRATION FORM FOR MEDICAL RESPONSE

Person Code		**Incident Code**		**Page No**

Registration form for person involved in emergency

A. Incident information			
1. Accident location			
2. Onset time	Date _ _/_ _/_ _ _ _		Time _ _: _ _
3. No. of person involved			
4. Source of irradiation	□ Known ↓	□ Unknown	
	Specify:		
5. Victim(s) contaminated	□ Yes	□ No	□ Suspected
6. General incident description			
7. Additional comments			

B. Information of caller		
1. Full name (first/last)		
2. Position/ Organization		
3. Contact information	Tel:	E-mail:
4. Time of call	Date _ _/_ _/_ _ _ _	Time _ _: _ _

Completed by	
Name/Position/Organization:	
Time of record/Signature: Date _ _ / _ _ / _ _ _ _ Time _ _ : _ _	

Person Code		**Incident Code**		**Page No.**

C. Personal information				
1. Arrival time	Date _ _/_ _/_ _ _ _ (dd/mm/year)		Time _ _: _ _	
2. Full Name			☐ Unknown	
3. Date of birth	_ _/_ _/_ _ _ _ (dd/mm/year)		Age: _ _ Years	
4. Sex	☐ Male		☐ Female ↓	
	Pregnancy: ☐ Yes ☐ No ☐ Unknown			
5. Member of	☐ Public	☐ Facility staff	☐ Emergency worker	
	☐ Other (specify):			
6. Medical triage category	☐ Immediate (↓9)	☐ Delayed	☐ Expectant	☐ Minor
7. Chief complaint				
8. Combined injuries				
9. Referred facility				
D. Exposure information				
1. Duration of exposure	Beginning:	Date _ _/_ _/_ _ _ _	Time _ _: _ _	
	End:	Date _ _/_ _/_ _ _ _	Time _ _: _ _	
2. Location/Address when it happened?				
	☐ Indoors	☐ Outdoors		
3. Personal dosimeter	☐ Yes ↓	☐ No		
	Readings:	Dosimeter No:		
4. Personal protective equipment	Protective clothing:	☐ Yes	☐ No	
	Respiratory protection:	☐ Yes	☐ No	
5. Additional comments				

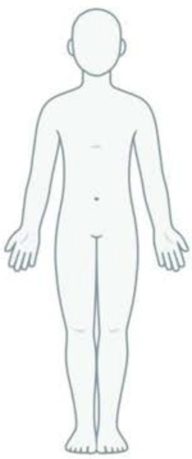
Completed by	
Name/Position/Organization:	
Time of record/Signature: Date _ _ / _ _ / _ _ _ _ Time _ _ : _ _	

Person Code		**Incident Code**		**Page No.**

E. Radiological status			
1. Survey performed	☐ Yes	☐ No	
2. Contamination	☐ Yes ↓	☐ No	☐ Undetermined
	☐ External ↓	☐ Internal ↓	
	Contaminated wounds ☐ Yes ☐ No	☐ Indigestion ☐ Inhalation	
3. Decontamination procedures performed	☐ Yes ↓	☐ No	
	☐ Fully	☐ Partially	

F. Contamination survey and control record	
1. Measurement	Date _ _ / _ _ / _ _ _ _ Time _ _ : _ _
2. Instrument type/model	
3. Background reading	

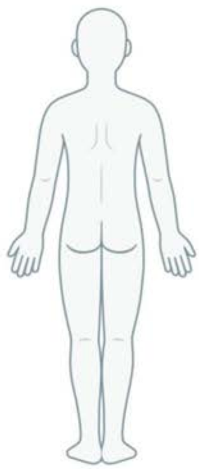
4. Diagram



Front

Site/ Number	Count rate (cps)	
	Before	After

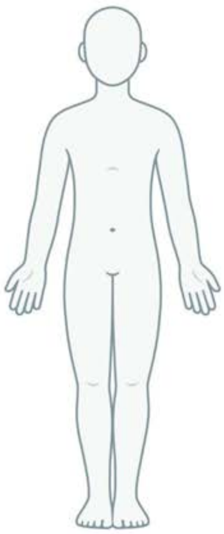
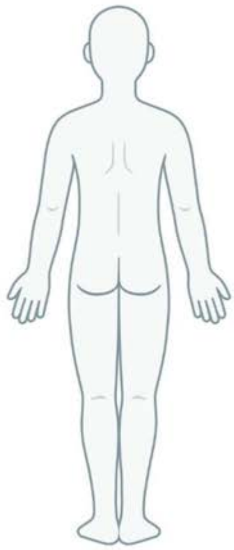
Remarks:
Indicated reading in the table. Indicate location of the readings by arrows/circles/numbers. Only record readings greater than background.



Back

Completed by	
Name/Position/Organization:	
Time of record/Signature: Date _ _ / _ _ / _ _ _ _ Time _ _ : _ _	

Person Code		Incident Code		Page No.

G. Medical information		
1. Chief complaint		
2. Individual incident description		
3. Symptom	Vomiting ☐ Yes↓ Number ___/day	☐ No
	Onset: Date _ _ / _ _ / _ _ _ _ Time _ _ : _ _	
	Diarrhoea ☐ Yes↓ Number ___/day	☐ No
	Onset: Date _ _ / _ _ / _ _ _ _ Time _ _ : _ _	
4. Other positive finding (including vital sign)		
5. Wound and erythema survey		
 Front	Use code: Ⓑ - Thermal burn, Ⓒ - Contamination Ⓔ - Erythema, Ⓕ - Fracture Ⓞ - Other injury/trauma/wound (specify) Remark: Indicate wound type and erythema. Indicate location of the lesion by arrow.	 Back

Completed by	
Name/Position/Organization:	
Time of record/Signature: Date _ _ / _ _ / _ _ _ _ Time _ _ : _ _	

Person Code		Incident Code		Page No.

H. Measure taken at the scene/hospital		
1. Decontamination	□ Yes↓	□ No
	Details:	
2. Decorporation	□ Yes↓	□ No
	Details:	
3. Stable iodine administration	□ Yes↓	□ No
	Start: Date _ _ / _ _ / _ _ _ _	Time _ _ : _ _
	Dose:	Duration:
4. Bioassay sample	□ CBC with differential	
	Date _ _ / _ _ / _ _ _ _	Time _ _ : _ _ (The first)
	□ Cytogenetic sample	
	Date _ _ / _ _ / _ _ _ _	Time _ _ : _ _
	□ Urine (spot/24hour)	□ Faeces
	□ Others (specify):	
5. Disposition	□ Transfer/Referral↓	□ Released↓
	Specify:	
	When: Date _ _ / _ _ / _ _ _ _	Time _ _ : _ _

I. Supplementary information		
1. Height and weight	_ _ _._ (cm)	_ _ _._ (kg)
2. Contact information	Tel.:	E-mail:
3. Address/ Next destination		
4. Medical exposure to ionising radiation	□ Diagnostic radiology	□ Radiotherapy
	□ Interventional radiology	□ Nuclear medicine
	Specify:	

Completed by	
Name/Position/Organization:	
Time of record/Signature: Date _ _ / _ _ / _ _ _ _ Time _ _ : _ _	

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ABBREVIATIONS AND ACRONYMS

ALARA	As low as reasonably achievable
ARS	Acute radiation syndrome
BAL®	British Anti-Lewisite
DTPA	Diethyltriamidepentaacetate
LRI	Local radiation injury
MHP	Mental health and psychosocial
MHPSS	Mental health and psychosocial support services
OIL	Operational Intervention Level
PPE	Protective Personal Equipment
TLD	Thermoluminescence dosimeter

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