THE LOCAL EFFECTS OF A GLOBAL DISASTER: CASE STUDY ON THE FUKUSHIMA RADIOLOGICAL EMERGENCY MANAGEMENT IN ITALY

Armando Abate[1], Alessandro Sassolini[1], Gian Marco Ludovici[1], Pasquale Gaudio[1,2], Jean-François Ciparisse[2], Orlando Cenciarelli[1,2], Romeo Gallo[3], Mariachiara Carestia[1,2], Daniele Di Giovanni[1,2], Alba Iannotti[1], Lidia Strigari[4], Leonardo Palombi[5], Carlo Bellecci[1,2] & Andrea Malizia[1,2,5]

[1]International Master Courses in Protection Against CBRNe Events, Department of Industrial Engineering - School of Medicine and Surgery, University of Rome Tor Vergata, Italy
[2]Department of Industrial Engineering, University of Rome Tor Vergata, Italy
[3]Comando Provinciale dei Vigili del Fuoco di Matera, Italy
[4]Laboratory of Medical Physics and Expert Systems, National Cancer Institute Regina Elena, Rome, Italy.
[5] Department of Biomedicine and Prevention, School of Medicine and Surgery, University of Rome Tor Vergata, Italy

[*]Email: armando.abate@yahoo.it

ABSTRACT

CBRNe events that occur in a geographic location can have consequences on human health and/or infrastructures, even in places very far away from that where the event happened. Thus, the effects of such events often have an influence on the response systems of various countries, from a socio-economic point of view, from where the event had its origin. In this work, the authors dealt with the evaluation of the consequences of the accident at the Fukushima (Japan) nuclear power plant and in particular with the management of the effects of this event in a European country (Italy). The study was focused on the clinical examination of 50 people coming back to Italy from Japan in the days immediately following the disaster that occurred at the Fukushima nuclear power plant as an effect of the tsunami. During the screening, external and internal contaminations were checked; thyroidal monitoring was carried out to estimate the exposure to Cs and I. For all the 50 monitored persons, the measured values of contamination were not higher than the attention value, so the basic level analyses were sufficient, without the need to do further and more thorough examinations.

Keywords: *Chemical, biological, radiological, nuclear & explosives (CBRNe); Fukushima nuclear power plant; health protocol; monitoring; scintillation counts.*

1. INTRODUCTION

The Fukushima power plant accident, which happened as a consequence of the seismic event of 11 March 2011 has been one of the worst in history: the global relevance of the event has been clear since the first phases (Chino *et al.*, 2011) and has reached the seventh degree in the INES (International Nuclear and Radiological Event Scale) scale of the International Atomic Energy Agency (IAEA) (IAEA, 2008). Unlike the Chernobyl disaster of 1986, in Fukushima, there was no direct damage to the reactor and thus, there was no huge emission of transuranic elements in the environment.

The diffusion of radioactive nuclei in the environment has mainly concerned cesium and iodine (Katata *et al.*, 2012; Terada *et al.*, 2012), whose effects have been measurable on a global scale (for example by the European net) (Masson *et al.*, 2011). As a result of the great media interest, one of the indirect consequences of the event has been called “iodine rush” (Durigon & Kosatsky, 2012), i.e. a rush to purchase iodine doses to use as a preventive prophylaxis to contrast the accumulation of radioactive iodine in the human body. This rush happened although the excessive consumption of iodine by a healthy person was not recommended by World Health Organization (WHO), as it can cause serious health problems (Pennington, 1990).

The Fukushima accident, because of its geographical location, has been made global because it has involved a highly industrialized and interconnected country, so the people coming from other nations, when they returned to their homeland, weighed on the local health systems. The Fukushima accident is an example of how a chemical, biological, radiological, nuclear and explosive (CBRNe) event can have a global relevance and several local effects. The preparedness in the management of such emergencies cannot be abstract. In addition to technical points of view (Malizia *et al.*, 2012, 2014; Gallo *et al.*, 2013; Cacciotti *et al.*, 2014; Sassolini *et al.*, 2014; Di Giovanni *et al.*, 2014, Pirelli *et al.*, 2014), psychological perspective is also important, as the recent Ebola epidemic has demonstrated (Cenciarelli *et al.*, 2014, 2015a, 2015b).

The aim of this work is to illustrate the protocol concerning the management of the Italian citizens coming back from Japan in the weeks which immediately follow the accident, and to report and study the results of analyses that were carried out.

2. MATERIAL AND METHODS

2.1 Control Protocol

On 25 March 2011, the Italian Ministry of Health regulated the care pathway for people coming back from Japan (Ministry of Health, 2011). The activities, carried out by Reference Centers, were monitored in collaboration with the National Institute of Health, in order to harmonize and rationalize the response. The procedures were developed to respond to citizens that voluntary went to the hospitals previously identified by the Regions as reference centers.

In the document issued from the Italian Ministry of Health, three situations were considered, depending on the distance from the area where the people had stayed/transited to the epicentre of the disaster: a) distance greater than 80 km; b) distance less than 80 km; c) close to the epicentre. It is important to recall that the recommendations of WHO, at the moment of the publication of the document, foresaw the need of controls after the return from Japan exclusively for those who had stayed/transited in the surroundings of the power plant and inside the evacuation zone (20 km) (Ministry of Health, 2011).

In case (a), the protocol does not foresee radiometric or dosimetric examinations on the person, but it just suggests giving information and an adequate psychological support. The latter tends to reduce anxiety by means of a correct communication on the absence of an exposure to radioactivity higher than that to the natural one.

In case (b), the protocol foresees the gathering of information and an instrumental evaluation of the eventual exposure, by following these steps: 1) Taking charge using the structure individuated by the Health Direction (for example, nuclear medicine, first aid, etc.); 2) Gathering of information on: place of origin, duration of permanence in the area, time elapsed since the re-entry into Italy (to be excluded if longer than 30 days), eventual data on thyroidal and renal activity, alimentary habits, eventual ingestion of iodine or medicine against thyroidal pathology, and eventual recent medical treatments by administration of radioactive nuclei; 3) Carrying out experimental survey. The results of these controls will then be communicated to the National Health Institute (ISS, *Istituto Superiore di Sanità*) for the formation of a national information archive.

In case (c), which should already have been treated by the local authorities, the protocol foresees to gather more detailed information about the place, the exposure duration and the modality of staying in the surroundings of the nuclear power plant, and about what happened between the period during which the person stayed in that area and the request of controls in the hospital. Further instrumental examinations can be done. In cases where the results of these medical surveys indicated a risk for health, the recovery in a hospital and the start of appropriate medical treatment will be initiated.

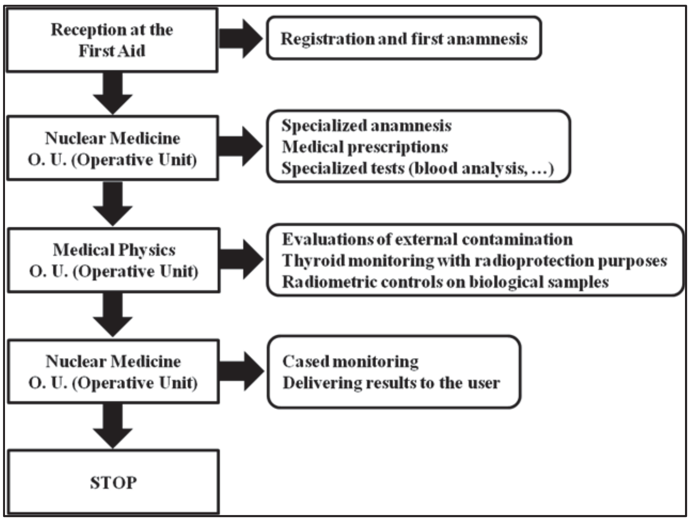

Figure 1: Path scheme for returning people from Japan with suspected radioactive contamination.

2.2 Instrumental Measurements

The radiometric measurements suggested by the protocol follow the guidelines elaborated in the frame the IDEAS Project (EU 5th Framework Programme) (Doerfel *et al.*, 2006) for the estimation of the absorbed radioactivity dose on the basis of individual monitoring data. The guidelines are based on three fundamental principles: harmonization, accuracy and proportionality. Following these principles, the guidelines use measurement levels to estimate the yearly taken dose, considering values ranging from 0.1 to 6 mSv.

Each measurement level is characterized by specific procedures. At the laboratory where this work was carried out, in order to evaluate the measurement level, the measurements described in the paragraphs below have been done.

2.2.1 Verification of the External Contamination

Measurement of the dose rate in contact with the whole body; for the verification of the external contamination, in Antero-Posterior (AP) and Postero-Anterior (PA) projections, an environmental ionisation camera Inovision Victoreen, model 451P_DE_SI_RYR s/n 009 (Fluke) was used.

2.2.2 Thyroidal Monitoring

The measurement of the absorption by the thyroid with an external scintillation probe was done to estimate the exposure to Cs and I by the recording of the scintillation counts obtained by a Atomlab 950 Biodex Medical System s/n 1194013 system, which is constituted by a NaI(Tl) scintillator.

In both cases, a measurement of the environmental radioactivity has been done in the measurement room, with the following settings:

- Window for ^{131}I (309-420 keV) with the probe set at 20 cm from the thyroid and with an acquisition time equal to 5 min;
- Window for ^{137}Cs (560-759 keV) with the probe set at 2 m from the patient sitting down and with an acquisition time equal to 5 min.

As foreseen by the 0 Level of the IDEAS guidelines, it has been verified that the yearly absorbed dose does not exceed the reference value of 0.1 mSv. To this end, in the case of the measurement of the counts performed with the Atomlab 950 system, a procedure to convert the number of counts in the taken dose was applied.

Thus, the constancy of the conversion ratio between the number of counts and the radioactivity was calculated. By a range of measurements of the activity of known sources, the following conversion value from counts per second (cps) to activity (Bq) was estimated:

$$6{,}091 \text{ cps} \rightarrow 37 \text{ KBq} = 37{,}000 \text{ Bq} \quad [1]$$

Based on this:

$$A(Bq) = \frac{37000}{6091} cps = 6.07 cps = 0.101 cpm \quad [2]$$

After having done that, the absorption curve of ^{131}I versus the thickness of a Plexiglas sheet put in front of a source whose activity is known was determined. Plexiglas is considered as a material tissue-equivalent. Considering that the mean depth of the thyroid can be estimated to 1.75cm, the attenuation value of 0.75 can be obtained from the curve shown in Figure 2.

Taking into account the attenuation value (= 0.75), the following conversion value was obtained:

$$A(Bq) = \frac{0.101}{0.75} cpm = 0.135\ cpm \quad [3]$$

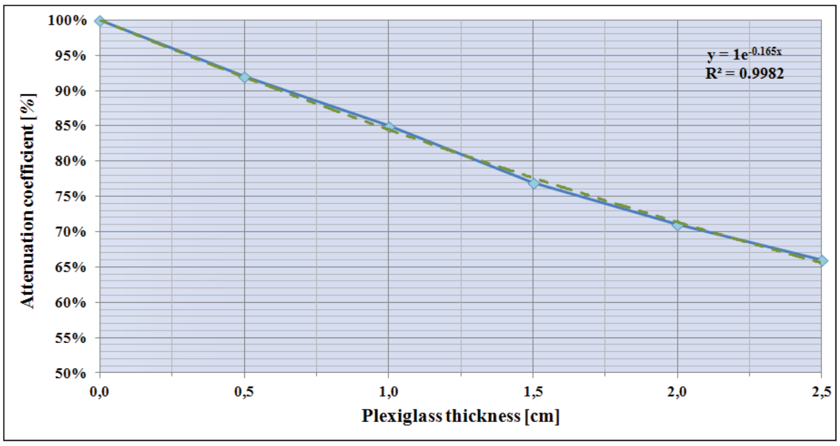

Figure 2: Absorption curve of ^{131}I versus thickness.

The yearly effective dose was calculated from the expression:

$$\sum_j h(g)_{j,ina} J_{j,ina} \qquad [4]$$

where:

$h(g)_{j,ina}$ is the committed effective dose per introduction of the radio nucleus j ($\frac{Sv}{Bq}$) that is inhaled by a person belonging to the age group g and $J_{j,ina}$ is the introduction by means of inhalation of the radio nucleus j (Bq).

3. RESULTS AND DISCUSSION

In this section, the results of the radiometric measurements carried out in March 2011 on 50 people in Italy coming back from Japan are presented. The results of the verification of the external contamination using an ionisation camera are reported in Figure 3. The maximum measured value of external contamination is equal to 0.6 μSv/h and the normalization from the background values does not exceed, except in a few cases, the background level itself. In those rare cases where the difference was greater than twice the background value, the measures were not considered to be high enough to proceed to a phase of more thorough analysis.

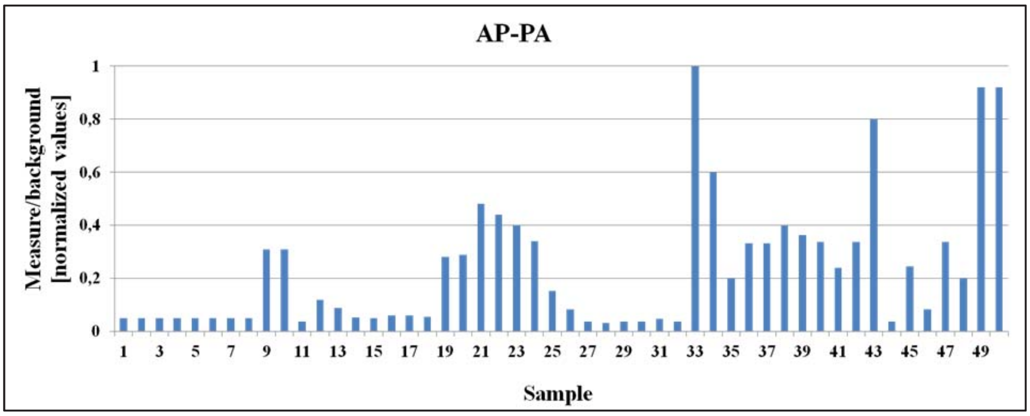

Figure 3: Ratio between external contamination and environmental radioactivity (normalized values).

The results of the thyroidal counts for the ^{131}I estimated annual dose with respect to the background are shown in Figure 4. The measured values are practically comparable to the ones caused by the natural background. In the case of the measurement with the whole body in order to estimate the contamination from ^{137}Cs, on the basis of the obtained results for thyroid, the measures with difference with respect to the background were analysed and a reference threshold of 1.5 times the background was set. In Figure 5, it is shown that this value has never been exceeded.

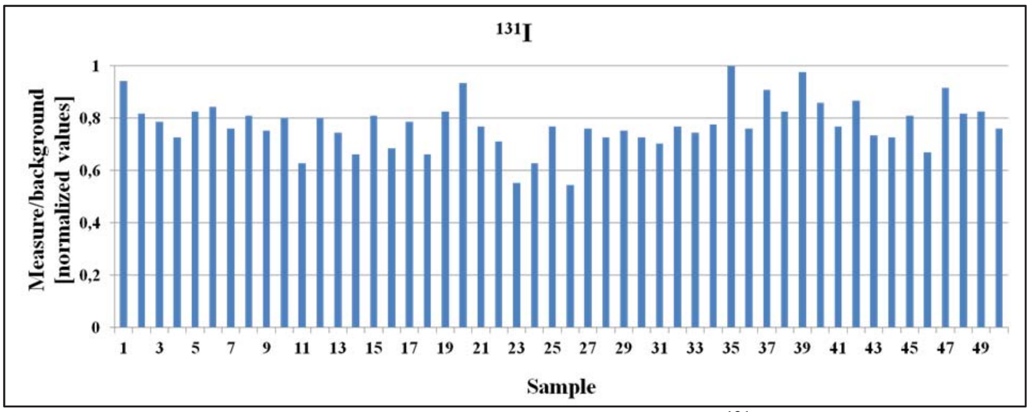

Figure 4: Ratio between the estimated annual taken dose of ^{131}I and the one due to natural background (normalized values).

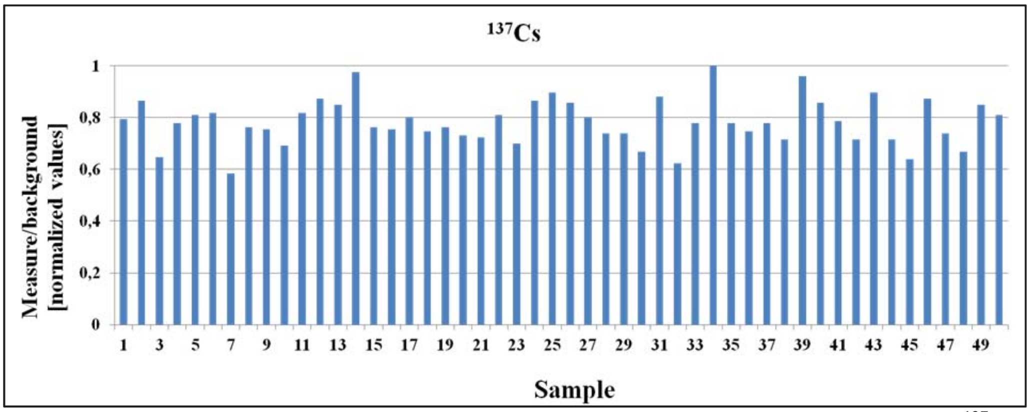

Figure 5: Ratio between the number of scintillation counts per minute measured for ^{137}Cs and the ones due to background.

4. CONCLUSION

In this work, the monitoring activity carried out by a medical physics laboratory in Italy after the Fukushima disaster in Japan has been presented. As shown from the results, for all the 50 monitored people, the measured values of contamination were not higher than the attention value, so the basic level analyses have been sufficient, without the need to do further and more thorough examinations. However, in the opposite case, as foreseen by the IDEAS guidelines, more accurate examinations would have been done with methods such as gamma spectrometry of urine and faeces, which would have made it possible to evaluate in a more precise manner the absorbed dose. In the case that it would have been necessary, on the basis of the results obtained in the second phase, models and mathematical expressions with the corresponding values of the parameters as suggested by the IDEAS guidelines will be used, in order to satisfy the fundamental harmonization principle.

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