# Prevalence of Radioactive Signals from Surveillance of an Emergency Department

**Frank Guyette, MD, MS;[1] Joe Suyama, MD;[1] Jerry Rosen, MS;[2] Michael Allswede, DO[3]**

1. Department of Emergency Medicine, University of Pittsburgh, Pittsburgh, Pennsylvania USA
2. Environmental and Occupational Health, University of Pittsburgh Medical Center Presbyterian Hospital, Pittsburgh, Pennsylvania USA
3. Department of Emergency Medicine, University of Pittsburgh Medical Center Center for Biosecurity, University of Pittsburgh, Pennsylvania USA

**Correspondence:**
Joe Suyama, MD
Department of Emergency Medicine
University of Pittsburgh
230 Mckee Place
Suite 500
Pittsburgh, PA 15213 USA
E-mail: suyamaj@upmc.edu

**Keywords:** contamination; detector; dirty bomb; emergency department; radiation; weapons of mass destruction

**Abbreviations:**
ED = emergency department
DHS = Department of Homeland Security
RDD = radiological dispersal device

**Received:** 12 August 2005
**Accepted:** 19 September 2005
**Revised:** 11 October 2005

**Web publication:** 13 September 2006

**Abstract**

**Introduction:** Since the 11 September 2001 terrorist attacks in the United States, concerns have been raised regarding the threat of a radiological terrorist weapon. Although the probability of the employment of a nuclear device is remote, the potential of a radiological dispersal device (RDD) or "dirty bomb" is of concern. While it is unlikely that such a device would produce massive numbers of casualties, it is far more likely that it would result in public panic and perhaps even disable the local healthcare system. The utility of surveillance with radiation detectors in the healthcare setting has not been fully evaluated.

**Objective:** The objective of this study was to characterize the prevalence of radioactive sources entering an urban emergency department (ED).

**Methods:** A retrospective review of data obtained from a radiation detector positioned to detect radioactive people entering an ED of an urban academic hospital that serves 45,000 patients/year was performed. Graphical outputs of radioactivity were recorded in Microsoft Excel™ (Microsoft, Redmond, WA, US) spreadsheets in microREM/hour. Data were collected continuously from 22 December 2003 to 22 January 2004. An event was defined as any elevation in radiation levels >95% confidence interval from the mean level of background radiation over 72 hours (h).

**Results:** A total of 215 events were observed over a 28-day period, with a mean value of 7.7 events/day, and a maximum of 15 events/day. During the 28-day period, the baseline mean level of background radiation was 2–4 microREM/h. Readings ranged from 2,148.28–17,292.25 microREM/h with a maximum sustained detector exposure of 684.37 microREM. Distinct signal patterns were seen at both detectors including tonic, phasic, dual, and short duration spikes.

**Conclusion:** The number of radioactive signals detected from persons entering the ED was much higher than expected. While the vast majority of these signals pose no health threat, they may make routine screening for a radiological terrorist event difficult. Further study is needed to determine this correlation.

**Guyette F, Suyama J, Rosen J, Allswede M: Prevalence of radioactive signals from surveillance of an emergency department.** ***Prehosp Disast Med*** **2006:21(4):276–281.**

## Introduction

Since the 11 September 2001 terrorist attacks in the United States, concerns have been raised regarding the threat of radiological attacks. Although the probability for the use of a nuclear device is remote, the potential for the employment of a radiological dispersal device (RDD) or "dirty bomb" is of greater concern. Radiological dispersal devices combine readily available radiological materials with conventional explosives.[1] The materials used in an RDD or clandestine source emit some combination of gamma (high energy photons), alpha, and beta (particulate) radiation. Neutron sources require access to rare materials and are not likely to be encountered. While it is unlikely that such a device would produce massive numbers of casualties, it is far more likely that it would result in public panic and perhaps even disable



https://doi.org/10.1017/S1049023X00003836 Published online by Cambridge University Press

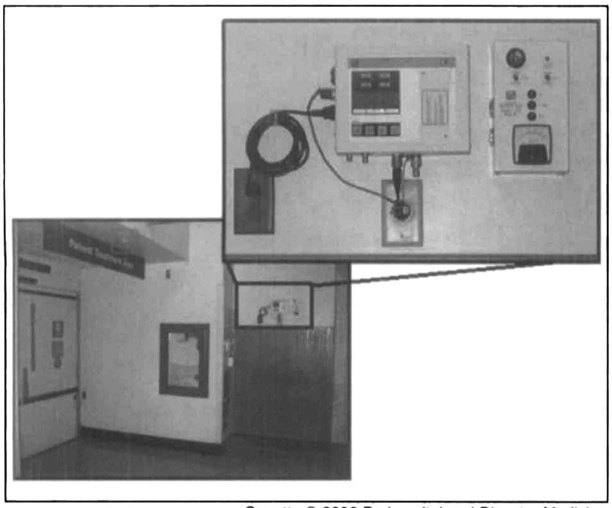



**Figure 1**—Ambulatory Radiation Detector Placement (Model 375 Digital Area Monitor, Ludlum Measurement, Sweetwater, TX US)

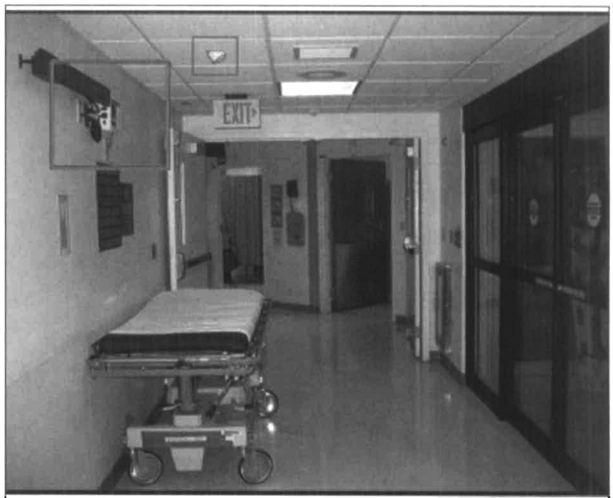




**Figure 2**—Trauma Entrance Radiation Detector

the local healthcare system. Elcock *et al* state, "a RDD could produce significant social and economic damage, the extent of which would depend largely on how quickly and effectively cleanup levels were established and on public acceptance of those levels."[2] If it were to occur, the contamination of local hospitals and EDs could be incapacitating. The possibility of healthcare facility contamination is real, as the injured patients likely would present prior to decontamination, and the presence of radioactive material may not be known immediately. Current plans to detect and treat such patients would require screening of individual patients with a Geiger-Muller counter after a threat already had been recognized.[3] This is problematic because the screening requires a large amount of manpower. Furthermore, for every victim with a legitimate concern regarding their exposure risk, it is anticipated that 5–10 additional people will seek treatment despite insignificant exposure. Ring suggests the risks for most people are small: "For most people directly involved, the exposure would have an estimated lifetime health risk that is comparable to the health risk from smoking five packages of cigarettes or the accident risk from taking a hike."[4] Furthermore, in contrast to a "dirty bomb", the clandestine dispersal of highly radioactive material without an explosive mechanism is more difficult to identify, and ED personnel would not be aware of the contamination hazard until several patients already had entered the ED with symptoms of radiation poisoning.

In order to prevent such disabling events, it may be prudent to monitor the entrances to EDs with radiation detection devices. Currently, the US Department of Homeland Security (DHS) is deploying radiation detection equipment at portals of entry into the US in order to identify the presence of illicit radioactive materials entering the country.[5] These screening devices are designed to detect gamma or neutron emissions from vessels that then can be scanned to identify the isotope and its source. In the same fashion, patients emitting radiation could be stopped, surveyed, and, if necessary, decontaminated, prior to entering the ED. The number of events would be infrequent, allowing time to evaluate these sources and protect the facility from contamination without disrupting ED operations. These simple actions could prevent harm to patients and staff while preserving the function of the healthcare institution. Presently, EDs lack even the most rudimentary plans for dealing with radiological events. However, an article from the *Journal of Emergency Department Management* has suggested that all patients be screened for radiation following any explosion and that ED staff be trained for and drill "dirty bomb" scenarios.[6]

The utility of surveillance with radiation detectors in the healthcare setting has not been evaluated fully. This study was designed to describe the use of the ED radiation detectors in one urban hospital setting.

## Methods

This is a retrospective review of data obtained from radiation detectors intended to identify radioactive people entering an ED. These data were described using simple statistics and graphic representations. Interpretations were made based on information known about patient flow through the ED.

Two radiation detectors (Model 375 Digital Area Monitor, Ludlum Measurement, Sweetwater, TX, US), placed at the entrances to an urban, academic ED, detected gamma radiation. This information was recorded. The ED staff evaluates 45,000 patients per year and is a Level-1 Trauma Center. The detection devices were wall-mounted and located several feet from the ambulatory (Figure 1) and trauma (Figure 2) entrances to the ED. The devices measure gamma radiation in microREM/h and are designed to detect the presence of radioactive material. Patients who present after being irradiated (exposed to a radioactive source without contamination) will not be detected.

Data were collected from 22 December 2003 to 22 January 2004. The data collected for 32 consecutive days were analyzed. The detector signal was monitored using Visual Designer (Intelligent Instrumentation, Tucson, AZ) computer

| | Signal Frequency (per day) | Maximum Signal Output (microRem/h) | Average Signal Output (microRem/h) |
|---|---|---|---|
| Ambulatory Detector | | 2,148.3 | 2.2 |
| EMS Detector | | 17,292.3 | 2.7 |
| Combinded Detectors | 7.7 ±3.6 | | |



**Table 1**—Detector findings

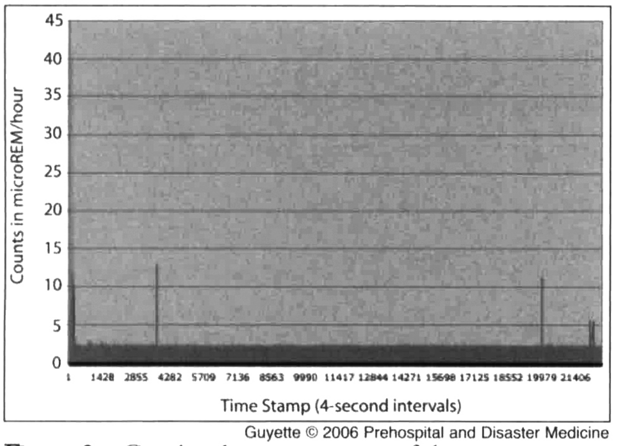




**Figure 3**—Graphical representation of the events recorded by the radiation detection devices over a 36-hour period at the triage enterance. Several spikes are observed during this observation period.

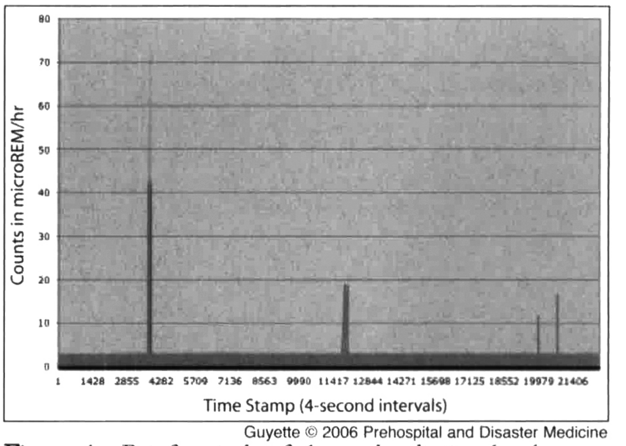




**Figure 4**—Brief periods of elevated radiation levels were observed several times within a 36-hour interval.

program, which compiled the data in Microsoft Excel™ spreadsheets (Microsoft, Incorperated, Redmond, Washington) in microREM/h. Data were collected in four-second intervals, as that is the sampling rate of the detector. These data were displayed in a graphical format to facilitate recognition of patterns of events detected by the instruments. Data were analyzed using descriptive statistics to compare the data obtained for individual days and events. Graphic representations of certain events were used to demonstrate patterns identified over the course of the study period. The mean values and standard deviation for the exposures were calculated. Events were determined as readings >95% confidence interval of values in a 72-hour time period.

## Results

Data were collected in a continuous fashion with exception of four non-contiguous days when all or parts of the data were lost due to equipment failures. Complete data are available for 28 days, and a total of 215 events were recorded during this period. The average amount of radiation detected from the devices mounted in the ambulatory triage area and over the trauma bay doors was 2.18 and 2.73 microREM/h respectively. The maximum output from each detector was 2,148.28 microREM/h and 1,7292.25 microREM/h respectively. The average number of daily events was 7.7 with a standard deviation ±3.58. (Table 1) The maximum number of events per day was 15, with a minimum of one; none of the days during the observation period were without an event. The maximum number of events witnessed in one hour was five. The maximum sustained exposure was 684.37 microREM over two minutes. Events varied in length from four seconds to nine min and 58 sec.

Distinct patterns were seen at both detectors including tonic, phasic, dual, and short duration spikes. Examples of these particular patterns are represented graphically and defined as:

1. *Tonic*—Observations made over long periods of time (24–48h) demonstrate a background level of radiation recorded at 2–4 microREM/h with little variation as represented by the ambulatory detector (Figure 3) and trauma detector (Figure 4);
2. *Phasic*—An average of 7.67 events per 24-hour period was observed in which the signal levels were elevated >2 standard deviations above background levels. These events are the result of radiation sources passing in front of the detectors during the observation period. When these events are analyzed individually, they demonstrate patterns lasting for several minutes, which are thought to be representations of radiation sources, possibly individuals or materials passing near the area monitors (Figure 5) and remaining in the vicinity of the detectors (Figure 6). Variation in the signal intensity is thought to represent the sources movement toward and away from the detector;
3. *Dual*—Occasionally, events were observed at one area monitor and then, in a time-locked fashion, observed at the second monitor. It is believed that



https://doi.org/10.1017/S1049023X00003836 Published online by Cambridge University Press

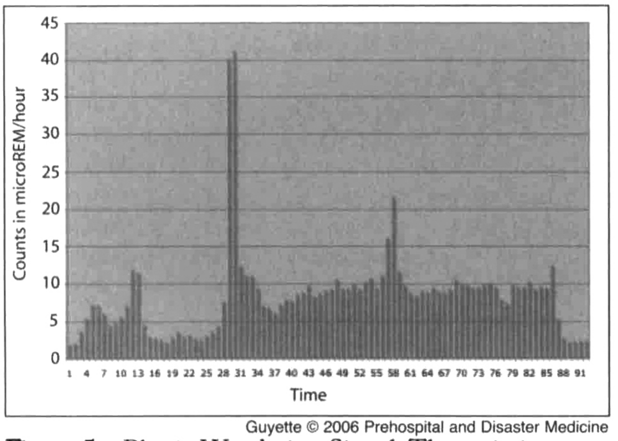




**Figure 5**—Phasic Wandering Signal: The variations in amplitude may represent movement towards and away from the detector as well as movement behind structural elements such as walls, door, and partitions

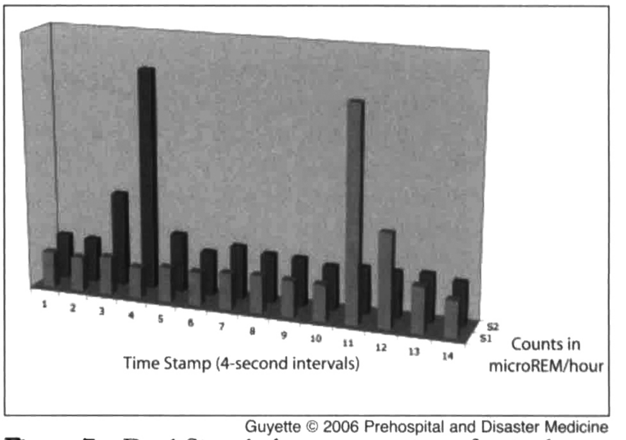




**Figure 7**—Dual Signal: A representation of a single time locked event detected by both area monitors. The black histogram represents the triage detector and the gray the trauma detector

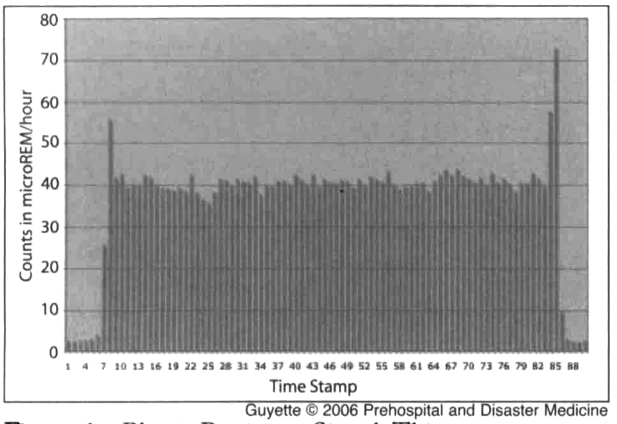




**Figure 6**—Phasic Persistent Signal: This event, lasting approximately five minutes represents an emission source approaching the rear door and remaining in place for several minutes

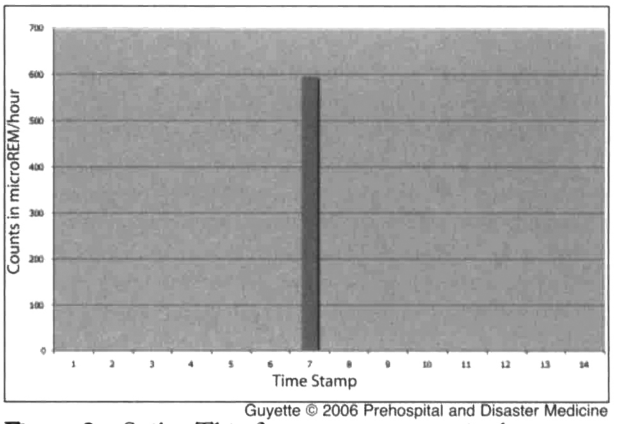




**Figure 8**—Spike: This figure represents a single recorded spike lasting four seconds or less recorded by the detector. This spike represents a total exposure of >1 microRem.

these events represent movement of the source down the main corridor of the ED thus, triggering both detectors (Figure 7); and

4. *Short duration spikes*—Brief events lasting less than four seconds were observed but not counted in the analysis. These events may represent some type of electronic interference (Figure 8).

## Discussion

The detection of radioactive patients or materials prior to entering the ED may prevent widespread contamination of the hospital and unnecessary exposure of hospital personnel. Radiation detectors may not be the panacea to this problem. However, radiation detectors are susceptible to false positive alarms from individuals treated with radiopharmaceuticals or who had undergone nuclear testing.[7] In the healthcare setting, the task of monitoring incoming patients is complicated by the frequent relatively presentation of patients who have recently undergone diagnostic or therapeutic nuclear medicine procedures. Anecdotally, the nuclear medicine and nuclear cardiology departments at this facility conduct approximately 600 diagnostic and therapeutic procedures per month.[8] Patients who have undergone diagnostic or therapeutic nuclear medicine procedures normally are not discharged through the ED. Since these patients emit radiant energy well above background radiation, protocols must be created to allow these patients to pass freely into the ED without evoking a full response when their elevated ambient levels of radioactivity are detected.

In the current experience, the number of persons passing into the ED who emit a detectable level of radiation was much higher than expected. As many as 15 events per day had levels of radioactivity well above that of background radiation. Fortunately, the maximum sustained exposure detected only was 0.69 REM. This is above the 500 microREM exposure allowed for pregnant women, but well below the 5 Rad limit for occupational exposure, and 25 Rad maximum exposure allowed for emergency workers.[9] While these levels do not represent an immediate health hazard, they do complicate the task of detecting patients exposed to radioactive materials in a terrorist event. Patients coming from such a scene would have a wide range of contamination levels based on the differences in radioactive materials, dispersal devices, and their distance from the source material. In addition, the quantity of the radiation determined by the detector would vary with the amount of time the patient spent in proximity to the detection device.

While none of the observed events are likely to represent a health hazard, they may represent a risk to the facility. In the case of a hospital serving as the receiving facility in a terrorist event, the protection of the facility may be challenging. The low level of contamination that may result from these events is unlikely to threaten patients and staff, but may necessitate extensive clean-up, and could decrease the ability of the ED to continue functioning. Furthermore, the International Atomic Energy Agency and the World Health Organization, through the publication *Generic Procedures for Medical Response during a Nuclear or Radiological Emergency*, stress the importance and utility of radiation detection equipment in order to identify and triage contaminated patients.[10]

Distinct patterns of exposure were observed in the ED. These observations are demonstrative of background levels of radiation with the appearance of events lasting for minutes that have readings >95% confidence interval of values in a 72-hour time period. When these events are examined more closely, phasic patterns of increased radiation are observed. The two representative patterns shown in Figures 5 and 6 are suggestive of individuals moving in proximity to the area monitors. The event seen at the triage detector has a high degree of variability and may represent a patient moving about in the waiting room within view of the area monitor. The second pattern has less variability and might represent a source remaining stationary near the rear monitor over our trauma entrance. Notably, this area near the trauma entrance detector is used to board patients briefly, prior to being transported to the floors. A dual event, involving a similar and temporally related event pair observed at both detectors, also was noted. In these events, a source was registered at one area monitor and a short time thereafter at the second monitor. This could be caused by patients arriving in for invasive cardiac procedures. They must pass the first detector at triage, and then again on their way to the cardiac catheterization lab. As many of these patients have had recent cardiac stress tests, these patients probably register on both detectors within a period of minutes, as they were seen in triage and then transported to the cardiac catheterization lab. Finally, frequent, brief signals were recorded by both detectors. While these are unlikely to represent patients, they may be indicative of electrical interference or portable radiographs taken near the detectors. These events were not counted in the analysis.

For healthcare facility-based radiation detectors, thresholds for concern could be set at levels above those seen with nuclear medicine patients. However, this may result in missing contaminated patients. There is a broad range of patients who receive radioactive agents that may emit detectable radiation. Detection may depend on the type of procedure, the half-life of the medical isotope, and the length of time since the procedure. Accurate detection of radioactive contamination may be complicated further by the type of contaminant. Due to the increased number of radiation detectors deployed for homeland security measures, the sensitivity of common radiation detectors and their ability to identify patients undergoing nuclear medicine studies and therapy varies. Some isotopes, such as Flourine-18, are poorly detectable while others, such as Iodine-131, can be detected at a distance of one meter for up to 95 days after administration.[11]

These findings coincide with the concerns expressed by the DHS regarding the high frequency of false positive detection of radiological sources in the community. The concerns of DHS are amplified in the hospital setting given the extensive use of nuclear medicine and radiopharmaceuticals. Furthermore, while radiation thresholds for life safety and occupational exposure have been described, these levels may be too high to provide adequate protection to personnel. Levels of detection set too low would result in an unacceptable commitment of time and resources, as frequent alarms would be disruptive to activities in the ED.

### *Limitations*

This study has several limitations, including a brief study period, the limitations of the detection equipment, and the limitations in understanding of how best to interpret the available data. The study consisted of data available for a single urban ED for a period of only one month. This is likely to be an insufficient sample to make generalizations about the number of radioactive events in all EDs. The detection equipment used in this study was unsophisticated, and could not differentiate the type of radioactive source (person, object, isotope, quantity). However, this is offset by the fact that the equipment is inexpensive and easy to maintain. In addition, this exercise is descriptive and although distinct patterns exist within the data, this remains to be validated. As this method of surveillance is novel, it is unknown how best to interpret the data obtained. Optimal strategies for determining which "hot" patients to sequester for questioning and possible decontamination are being investigated. Furthermore, the actual number of people in the general population who have had some exposure to nuclear medicine and potentially are able to set off the detectors is thought to be large, but is unknown.[7] Patients with positive stress tests at other facilities are reffered to the study hospital for invasive fluoroscopic procedures. In this institution alone, nearly 7,000 nuclear medicine and nuclear cardiology procedures are conducted per year.[8]

## Conclusion

The number of radioactive signals detected from persons entering this ED is much higher than expected. While the vast majority of these sources pose no immediate threat to heath, they may make detection of radiological terrorist events difficult. Further study is needed prior to full implementation of radiation detectors in the healthcare setting.

**References**

1. Livingston N: Dirty bombs: The impossible becomes possible. *Domestic Preparedness TIPS* 2005;1(9):1–3.
2. Elcock D, Klemic GA, Taboas AL: Establishing remediation levels in response to a radiological dispersal event (or "dirty bomb"). *Environ Sci Technol* 2004 May 1;38(9):2505–2512.
3. Schleipman AR, Gerbaudo VH, Castronovo FP Jr.: Radiation disaster response: Preparation and simulation experience at an academic medical center. *J Nucl Med Technol* 2004;32(1):22–27.
4. Ring JP: Radiation risks and dirty bombs. *Health Phys* 2004;86(2 Suppl):s42–47.
5. Aloise G: *Combating Nuclear Smuggling: Efforts to Deploy Radiation Detection Equipment in the United States and Other Countries. Testimony Before the Subcommittees on the Prevention of Nuclear and Biological Attack and on Emergency Preparedness, Science, and Technology.* Committee on Homeland Security, House of Representatives. 2005 June 21:1–11.
6. "Dirty bomb" threat puts spotlight on unprepared emergency departments: Do you have a plan? *ED Manag* 2002;14(9):97-100.
7. Toltzis RJ, Morton DJ, Gerson MC. Problems on Pennsylvania Avenue. *N Engl J Med* 1986;315(13):836–837.
8. Personal Communication, Department of Nuclear Medicine, UPMC, Pittsburgh, PA, February 2005.
9. Standards for Exposure to Ionizing Radiation, Guidelines for Protecting the Safety and Health of Health Care Workers. NIOSH 28 April 1998.
10. International Atomic Energy Agency and the World Health Organization: *Generic Procedures for Medical Response During a Nuclear or Radiological Emergency.* Emergency Preparedness and Response Section, International Atomic Energy Agency; Austria, April 2005.
11. Zuckier L, Garetano GS, Monetti MA, Lanka VK, Stabin MG: *Sensitivity of Personal Homeland Security Radiation Detectors to Medical Radionuclides and Implications for Counseling of Nuclear Medicine Patients.* Radiological Society of North America. 90th Scientific Assembly and Annual Meeting, Chicago, 28 Nov–03 Dec 2004.