July 2018

CNS Global Incidents and Trafficking Database

Tracking publicly reported incidents involving
nuclear and other radioactive materials

2017 Annual Report

CNS

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Acknowledgments

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Executive Summary

Since the fourth and final Nuclear Security Summit (NSS) in April 2016, the issue of nuclear and other radioactive materials security has faded in prominence within the international community. The conclusion of the summit series removed an important global spotlight on the issue, as well as a high-profile forum for action and accountability. In some cases, reductions in funding and focus are the natural result of programs that have successfully completed their mandates, but research for this report suggests such cases are in the minority.

In the United States, funding devoted to nuclear and radioactive materials security has fallen to its lowest level in ten years, even as nuclear weapons programs are receiving significant increases.[1] International tensions have brought U.S.-Russian joint nuclear security efforts to a near-standstill, and the United Kingdom's withdrawal from the European Union and the European Atomic Energy Community (EURATOM) will necessitate new security arrangements.[2,3] The set of rules and regulations ensuring security of nuclear materials mostly comprises voluntary measures, vulnerable to official neglect or politicization.

Yet, as illustrated by several 2017 incidents, the threat of nuclear or other radioactive materials falling into the wrong hands remains significant. For example, in the United States, the FBI discovered a neo-Nazi cell in possession of radioactive americium and thorium, as well as homemade explosives.[4] While it is unclear whether the cell wanted to attempt an act of radiological terrorism, and the materials it possessed were likely unsuitable in quantity and isotopic composition, the fact that malicious actors can and do acquire controlled radioactive materials is troubling.

In 2017, the James Martin Center for Nonproliferation Studies' (CNS) review of open source reports found a total of 171 incidents of nuclear or other radioactive materials outside of regulatory control, which occurred in 14 countries. Since CNS began comprehensive tracking in 2013, researchers have identified a total of 870 incidents occurring in 51 countries.

Incidents involving nuclear materials (uranium, plutonium, and thorium) are of special concern, because of their potential nuclear weapons applications. In 2017, nine incidents involved nuclear materials. Of these, two were particularly serious: one incident involved the loss of 1.4 grams of highly enriched uranium (HEU), while the other involved the attempted illicit sale of plutonium-239 and plutonium-241 taken from a stolen static-electricity control device.

In addition to the dangers of nuclear materials out of control, other radioactive materials also carry significant safety and security risks, as discussed in greater detail throughout this report. The IAEA uses a five-level categorization system for radioactive materials and sources, where Category 1 poses the greatest danger to human health and Category 5 poses the least risk. The IAEA's categorization system is based on the type and amount of activity of radioactive material involved, and the relative danger posed by exposure to that material.

Incidents involving the most dangerous (Category 1 and 2 materials) are relatively rare. In 2017, zero Category 1 incidents were reported and only eight Category 2 incidents were reported. This is consistent with the lack of reports of Category 1 and 2 sources in prior years. In total, from 2013 to 2017, four cases involved a Category 1 source, and 32 involved a Category 2 source. Although these numbers are low, it is impossible to know whether the relative scarcity of Category 1 and 2 cases is artificially low because of incidents going unreported.

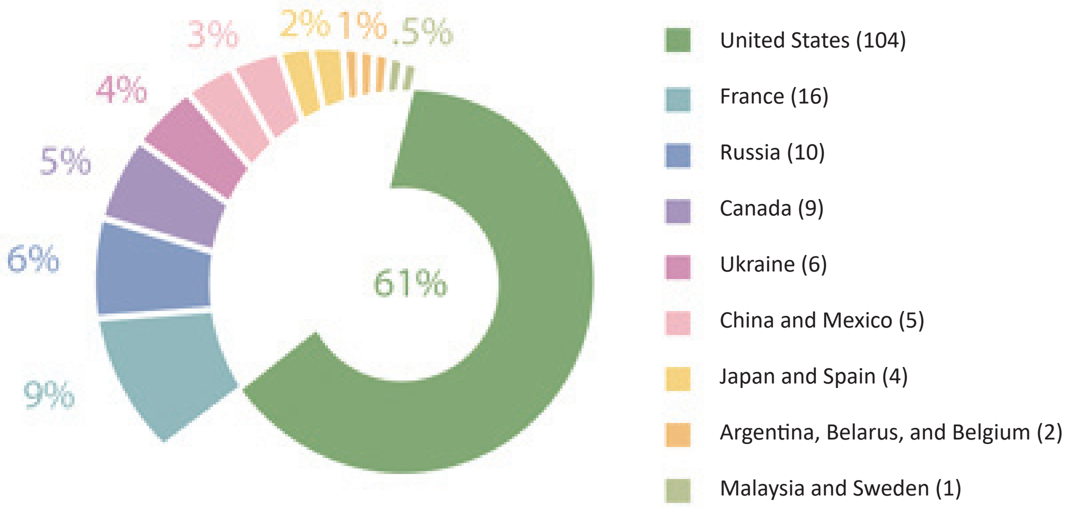
Categories 3-5 materials are classified as presenting a lower risk than Categories 1 and 2. However, in sufficiently large quantities these materials can still pose significant safety and security risks. The majority of 2017 incidents involved Categories 3-5 materials, accounting for approximately 68 percent of total reported incidents. In 27 percent of cases, there was insufficient publicly reported information for CNS researchers to categorize the material properly.

The 2017 data reinforces the trends and key findings identified in previous editions of this annual report

The consistency of the data trends over five years lends additional weight to the key findings and related policy recommendations outlined below.

Key Finding 1: Voluntary reporting yields variable, low transparency, results

Figure 1. Reported Incidents for 2017



The total incident count varies widely by country. In some cases, the variance is logically consistent with the state's overall material holdings. States that do not possess large quantities of nuclear and other radioactive materials would be expected to have fewer incidents than those with much larger holdings.

However, disparities in holdings are only one small part of the global variance in incident numbers. The transparency, completeness and correctness of states' reporting are also important factors. Very few countries systematically report to the public all incidents involving the loss of radioactive material. The few countries that do routinely publicize incidents therefore constitute the bulk of entries in this database. Approximately 79 percent of 2017 cases occurred in the six countries that routinely publish incidents online: the United States, Canada, France, South Korea, Belgium, and Japan. The other 21 percent of 2017 incidents were located by CNS researchers through exhaustive multi-language searches of media and government sources.

The IAEA maintains a confidential Incident and Trafficking Database (ITDB), which is generated from voluntary reporting by countries. However, the ITDB is only available to member-state governments. The IAEA publicly releases only a summary of the ITDB data by type of incident and year of occurrence. The IAEA does not release details of individual incidents, how serious they were, or where the incidents occurred. Furthermore, countries decide for themselves what to report to the ITDB, and there is no legally binding obligation to report the loss of even the most dangerous radioactive materials. This piecemeal reporting structure complicates efforts to evaluate the state of nuclear and radiological security worldwide.

Policy Recommendation: Develop a common standard for incident reporting that requires reporting Category 1 and 2 losses; encourage wider reporting transparency

Past reports recommended that states adopt a universal reporting standard, and the 2017 report is no exception. A common standard is not adequate, however, if it remains voluntary. At a minimum, governments should be legally required to publicly report losses involving the most dangerous Category 1 and 2 radioactive materials. These materials have the potential to pose significant dangers across borders. Several states already routinely report Category 1 and 2 incidents to increase public awareness and enlist the public's aid in materials recovery.

Greater reporting transparency would also enable a wider pool of analysts to work on identifying areas of concern and developing policies to improve security.

Key Finding 2: Transportation creates the greatest vulnerabilities, especially when materials are unattended

Materials in transit are more vulnerable to both loss and theft. Of the 82 incidents (44% of total incidents) that occurred while material was in transit, approximately one-third resulted from theft.

Disturbingly, transit vulnerabilities remained a clear, continuing trend for materials security. Between 2013 and 2017, approximately 40 percent of all incidents occurred in transit, and 55 percent of the incidents that occurred in transit were thefts.

In most cases involving theft, it is unclear whether the thieves were specifically attempting to steal radioactive material. In many cases, radioactive material theft may have been incidental to the thief's efforts to steal a vehicle or other valuable equipment.

Of all 2017 thefts, three cases involving the attempted illicit sale of radioactive material pose the greatest concern. In Malaysia, police arrested several individuals for attempting to sell Iridium-192. Police suspect the thieves stole the material from a local oil company (#2017021). In Ukraine, police arrested a man in possession of radioactive lead, which they believe he intended to sell (#2017148). Finally, in Kazakhstan, police arrested several individuals for attempting to sell plutonium-239, plutonium-241, and americium-241 (#2017094). Despite their overall rarity, these incidents demonstrate a continued interest by criminals in trafficking radioactive materials for profit. The possibility that similar trafficking cases go undetected or unreported cannot be discounted.

Policy Recommendation: Improve physical security measures; Expand electronic tracking of dangerous radioactive sources

Physical security improvements could help prevent losses and thefts during transit, especially of the most dangerous sources. There has been some progress on this front, but more work remains.

Most states with dangerous sources require electronic tracking of vehicles and containers holding Category 1 sources. Unfortunately, enhanced security for Category 2 sources is not as universal. States should require electronic tracking of Category 2 sources and, where appropriate, encourage its use for some lower category materials and sources as well.

While the IAEA released an implementation guide on transportation security in 2015, the creation of an IAEA Technical Guidance (T) document on the subject would encourage sharing best practices. Past versions of this report have made similar recommendations, yet little progress has been made on this issue.
Given the frequency with which incidents occur as a result of a licensee leaving a device or source unattended, state regulators should also consider making it illegal for users of radioactive materials to leave Category 1-3 sources unattended in vehicles (unless the vehicle itself is in a secured enclosure and protected against theft).

Since regulatory progress remains elusive, licensees in possession of Category 1-3 materials and sources should consider implementing enhanced policies of their own governing transit. The expense of replacing the material combined with the potential for negative press may be substantial enough to warrant such preventive policies, regardless of existing state regulations.

Key Finding 3: Human failure is a security risk

Human failure played a role in 104 reported incidents in 2017, including most cases of loss and many incidents of theft. Humans are the ultimate implementers of safety and security policies. Improving the rate at which safety and security policies are fully implemented could dramatically reduce incident numbers. In many reported incidents, published standards were not adhered to or were incorrectly applied, pointing to an insufficient human security culture.

Policy Recommendation: Improve security culture

Past reports have recommended creating policies designed to improve security culture at entities in possession of nuclear and other radioactive material. However, given that human failure was a contributing factor in more than half the 2017 incidents, weak security culture clearly remains a problem.

Licensees should train employees to understand the reasons behind rules and regulations rather than just the regulations themselves. This understanding could provide better motivation for following the rules. Regulatory agencies (or licensees themselves) should conduct personnel audits, assess existing protocols, and improve training as warranted.

Progress is being made on this front, although it is limited. The World Institute for Nuclear Security (WINS) currently provides resources to industry to improve security culture. The IAEA published an implementing guide, "Nuclear Security Culture" in 2008, and is in the process of creating guidance for states on developing security cultures within organizations responsible for nuclear or other radioactive materials.

Key Finding 4: Viable alternative technologies exist

Many incidents involved sources or devices for which there are viable non-radioactive alternative technologies (e.g., some cancer treatment machines).

Policy Recommendation: Encourage material replacement efforts

Where appropriate alternatives exist, policymakers should use a mix of incentives and new regulations to accelerate the replacement and end new manufacturing of devices containing radioactive material. A 2008 report from the National Academy of Sciences concluded that non-isotopic devices existed to fulfill nearly all Category 1 and 2 radioactive material applications.[5] For example, non-radioactive x-ray devices can replace cesium-137 blood irradiators, and linear accelerators (LINACs) can replace cancer treatment machines that use radioactive cobalt-60. A decade later, global replacement efforts have progressed but slowly and unevenly.
However, 2017 saw several significant milestones on implementing this recommendation. As of October 2017, Japan replaced 80 percent of its cesium-137 blood irradiators with alternative technologies, while Norway and France finished replacing all of their blood irradiators.[6] Replacement efforts for cobalt-60 teletherapy devices with linear accelerators in developing countries remain slow due to high costs, a lack of awareness and/or prioritization of the issue, as well as doubts about the effectiveness of non-radioactive alternatives. More work is needed at the international level to reduce these costs for developing countries and increase education.

Conclusions

Nuclear and radiological security may have faded in prominence on the global agenda, yet the risk that malicious actors could acquire and misuse radioactive materials remains heightened. It is incumbent upon national governments, non-governmental organizations, and industry to improve security through transparent reporting practices and better transit security practices. There is a need for training to enhance human security, and a need for enhanced efforts to replace nuclear and other radioactive materials with equally effective non-radioactive alternatives. Even a single incident is one incident too many, yet hundreds of incidents continue to occur annually.

I. Introduction

In a 2017 article for the *Bulletin of the Atomic Scientists,* Belfer Center analysts Matthew Bunn and Nickolas Roth presented a grim assessment of the effects of a single terrorist nuclear device.[7] They warned that the detonation of such a device would be an unprecedented catastrophe: tens or hundreds of thousands could die immediately, and it could precipitate global economic and political disaster. The effects of a radiological dispersal device (RDD), while less catastrophic than those of a nuclear device, could nonetheless result in persistent radiological contamination, severe economic losses, and societal disruption.[8] Yet, although the issue of nuclear and other radioactive material security remains salient at the IAEA, no international forum emerged in 2017 to replace the Nuclear Security Summit process (2010-2016), and high-level international attention to securing materials that could be used for nuclear or radiological terrorism has decreased. In this context, this database and report aim to highlight the importance of nuclear and other radioactive materials security for national policymakers and industry stakeholders. Additional measures are needed to prevent nuclear and other radioactive materials from falling out of regulatory control—and possibly into the hands of malicious actors.

The CNS Global Incidents and Trafficking Database, prepared by the James Martin Center for Nonproliferation Studies (CNS) and funded by the Nuclear Threat Initiative (NTI), offers researchers and policymakers insights into the successes and failures of the global nuclear and radiological security regime. It is the only database of its type that is generated from publicly available data, and whose collected data and analysis is freely available to the public. By contrast, the IAEA's official Incidents and Trafficking Database (ITDB) is generated exclusively from voluntary member state reporting, and its full data is only available to participating states' governments and specified international organizations.

The CNS database contains detailed information on incidents involving the loss of regulatory control over nuclear and other radioactive materials. Loss of control refers to both unintentional acts (such as loss or misrouting), and intentional acts (such as theft or attempted trafficking). Some incidents also involve materials that were never under regulatory control, but which should have been. The database may include publicly reported incidents that are not reported to the IAEA, as some states may only report incidents involving higher activity sources (e.g. Category 1-3) to the IAEA's ITDB. Information in the database is collected by CNS researchers using the official reports of national governments and the IAEA, as well as searches of media reports in a wide range of languages.

The level of detail in each entry is limited by the accuracy and comprehensiveness of the underlying reports. At a minimum, all entries include an incident report date, a location, and a unique, 7-digit entry code, which is used to identify them in this report in order for the reader to easily locate incidents in the accompanying database (e.g., #2016643). Researchers have attempted to piece together additional details for each entry, including the type of material or device involved, its typical application, and details of its recovery (when recovered). The full excel database is available for download at www.nti.org/trafficking.

CNS researchers found 171 incidents in 2017. Trends in the 2017 data remained consistent with data collected between 2013 and 2016, providing increased confidence in their validity.

- 57 reported losses, constituting approximately 33 percent of total incidents
- 39 reported thefts, constituting approximately 22.8 percent of total incidents
- 76 reported incidents occurred while the material was in transit, constituting approximately 44 % of total incidents

As in previous years, the 2017 database includes several incidents involving the illicit trafficking of nuclear and other radioactive materials. Fortunately, reported trafficking incidents remain rare, relative to the overall number of incidents recorded in the database. However, it is highly likely that more trafficking incidents occur and are either unreported or not intercepted by law enforcement.

Key findings and policy recommendations are discussed in greater detail in subsequent sections. The large number of cases documented highlights the global need for increased efforts to ensure that nuclear and other radioactive materials are used responsibly and securely—or where possible, replaced with alternative technologies that do not make use of radioactive materials.

II. Materials and Data Overview

Securing nuclear and other radioactive materials is the first and most critical line of defense against nuclear and radiological terrorism. An improvised nuclear explosive device (IND) requires the acquisition of large (kilogram) quantities of weapons-usable nuclear material, such as highly enriched uranium or separated plutonium. Whereas nuclear weapons are typically only made from highly enriched uranium or select isotopes of plutonium, radiological weapons could employ a wide range of nuclear or non-nuclear radioactive materials. Although many types of radioactive materials exist, only about a dozen exhibit characteristics qualifying them as serious security threats, such as half-life, radioactivity, portability, dispersibility, and availability.[9] These materials pose the greatest risk for radiological terrorism, as they could be effectively employed in a radiological dispersion or a radiological emission device (RDD and RED).

Nuclear Material

Between 2013 and 2017, 52 incidents (or approximately 6 percent of total reported incidents), involved nuclear material—defined as various forms (or isotopes) of uranium, plutonium, and thorium. The breakdown of cases by isotope is presented in Table 1. Troublingly, several incidents involved multiple nuclear materials, and as such, the subtotal of cases (67) is greater than the number of unique incidents.

In 2017, eight reported incidents (approximately 5% of 2017 incidents) involved nuclear material. Two of these cases involved more than one type of nuclear material.

Table 1. Reported Incidents Involving Nuclear Materials

Nuclear Weapons	Incidents, 2017	Incidents, 2013-2017
Uranium, total cases:	**6**	**48**
Depleted	1	17
Natural	1	8
Low-enriched uranium (LEU)	0	1
Highly-enriched uranium (HEU)	2	3
Unknown enrichment	2	19
U-233	0	0
Plutonium, total cases:	**3**	**7**
Plutonium-238 (Pu-238)	0	2
Plutonium-239 (Pu-239)	2	2
Plutonium-241 (Pu-241)	1	1
Unknown plutonium isotope	0	2
Thorium (Th), total cases:	**5**	**12**
Subtotal, all nuclear materials:	**14**	**67**
Total Unique Cases:	**8**	**52**

Not all nuclear materials involved in 2017 incidents were recovered. Incident #2017176 involved a nuclear dosimeter containing 1 gram of Plutonium-239. The device had been returned to the manufacturer for repair and the report states that the manufacturer misplaced the device. As of June 2018, the device had not been recovered. Incident #2017165 is even more alarming. According to the official report, a professor at the University of Nevada at Las Vegas requested 1.4 grams of highly enriched uranium (HEU) for an experiment. The professor received the material on October 30, 2017 and placed it under his or her desk. The professor planned to move the material to a research lab but forgot, and last saw the material on November 3, 2017. On November 6, 2017, the professor discovered that the HEU improperly left under his or her desk was missing but failed to report it until the following day. Investigators believed the material might have been accidentally disposed of, so a search of the dumpsters was initially launched and then called off once it was realized they had just been emptied.

The University of Las Vegas case is a blatant example of human failure, wherein regulations designed to prevent the loss or theft of nuclear material are disregarded by an individual, resulting in the theft, or in this case, loss (of an admittedly small quantity) of weapons-useable nuclear material. This serious lapse in security protocols suggests that careless practices may be widespread, or at least tolerated, among some licensees. The reports do not state whether the University conducted an internal investigation and revised its policies and procedures for handling nuclear or other radioactive materials. It is also unclear whether there were any disciplinary consequences for the professor in question. Perhaps more worryingly, international standards for what constitutes protection of small quantities of nuclear material are vague. For material of this quantity, IAEA INFCIRC 225 on *The Protection of Nuclear Material* states that only “prudent management practice” be followed when securing material of this type and quantity.[10] Prudent management practices likely do not include leaving the material under an office desk and waiting a day to report a loss.

Finally, in incident #2017094, four individuals in Kazakhstan were arrested for attempting to sell unspecified quantities of plutonium-239, plutonium-241 and americium-241.[11] They obtained the material from an industrial static neutralizer, which is believed to have been stolen. This case demonstrates that at least some criminals view nuclear and other radioactive materials found in stolen devices to be valuable and possibly worth targeting for theft.

Other cases that involve incidental, rather than intentional, thefts point more to lax security standards than black market demand for nuclear and other radioactive materials (e.g., a thief steals a car without realizing it contains a device with valuable nuclear or other radioactive materials, making the theft of those materials purely incidental to the vehicle theft).

Other Radioactive Material

Between 2013 and 2017, roughly half of all reported incidents involved one or more materials of principal concern for use in radiological terrorism (between 410 and 423 unique incidents).[12] Unfortunately, 2017 was not an outlier in this regard (81 such incidents or approximately 47 percent). Many incidents involved more than one material of concern, highlighting the possibility that a radiological dispersal device (RDD) might be cobbled together using multiple types of dangerous radioactive materials.

Table 2. Reported Incidents by Material Type

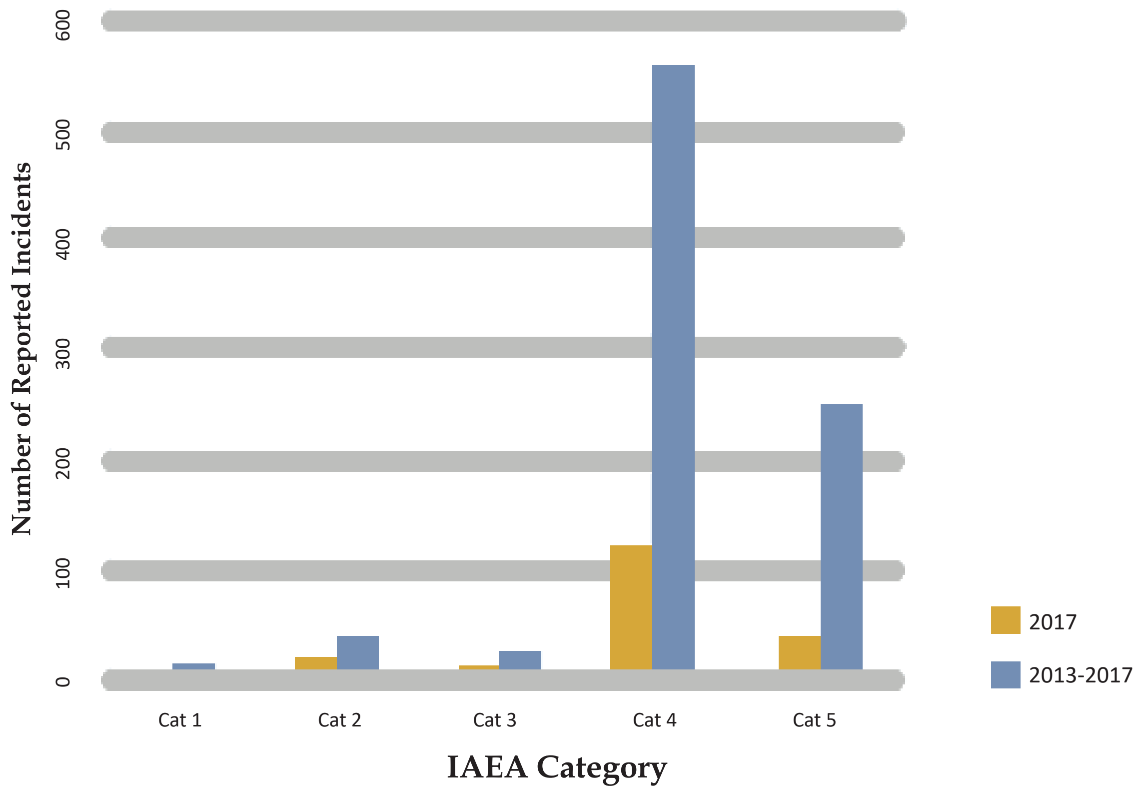
Material of principal RDD concern	Incidents, 2017	Incidents, 2013-2017
Cesium-137 (Cs-137)	51	242-245
Americium (Am-241)	41 to 42	195 to 201
Iridium-192 (Ir-192)	10	51 to 52
Radium-226 (Ra-226)	7	39 to 43
Cobalt-60 (Co-60)	3	29
Strontium-90 (Sr-90) and its decay product, Yttrium-90 (Y-90)	2 to 3	23 to 24
Californium-252 (Cf-252)	1	5
Selenium-75 (Se-75)	0	3
Plutonium-238 (Pu-238)	0	2 to 4
Plutonium-239 (Pu-239)	2	2 to 4
Ytterbium-169 (Yb-169)	0	1
Thulium-170 (Tm-170)	0	0
Subtotal	117 to 119	592 to 611
Total unique cases	**81**	**410 to 423**

While RDD and RED attacks are of the greatest overall security concern, "inhalation, injection, and immersion attacks" are comparatively simple.[13] These attacks involve a radioactive substance being forcibly placed or injected into the victim's body in order to deliver a dose of radiation. To date, this is the only known type of attack to have occurred using radioactive material. The most well-known case involved the assassination of Russian dissident Alexander Litvinenko using Polonium-210.

In 2017 there was another attack of this sort, but it failed to do any serious harm to the target (#2017218). On May 9, 2017, at the Atucha nuclear power plant in Argentina, the water in a union leader's water bottle was replaced with heavy water and possibly an additional, unknown radioactive substance. Unlike regular water, heavy water has an extra neutron in the nucleus of the hydrogen atoms. Heavy water has many applications in the nuclear industry, and many workers at the plant likely had easy access to it. Security guards discovered the incident after the individual attempted to leave the facility and set off radiation alarms. Upon inspection they concluded he had ingested heavy water from his water bottle. Fortunately for the individual, heavy water is not particularly dangerous to human health in such small quantities.[14] Furthermore, the material itself is not radioactive, suggesting other radioactive materials were inserted into the individual's water bottle which set off radiation alarms. Investigators believe someone intentionally placed material in the individual's water bottle as a malicious act or as a bad joke. Given the number of individuals at the facility with access to the material, investigators were never able to identify the perpetrator(s), whose motivation remains unknown.

The IAEA categorizes radioactive sources according to their potential harm to human health on a scale of 1-5, as detailed in IAEA Safety Standards Series RS-G-1.9. Category 1 sources present the greatest health risk (e.g., a large quantity of Cobalt-60, the source radiation in a radiation therapy machine), and Category 5 the lowest (e.g., the source radiation for X-ray fluorescence devices). This grading system is intended to assist states in allocating scarce human and financial resources to the highest priority risks. Most countries use this categorization scheme to develop national-level regulations, but non-governmental reports on incidents relating to radioactive material frequently do not report the category of the materials in question. For this reason, some cases in the CNS database do not have a listed IAEA category. Figure 2 shows the breakdown of reported incidents by IAEA category.

Figure 2. Incidents by IAEA Category

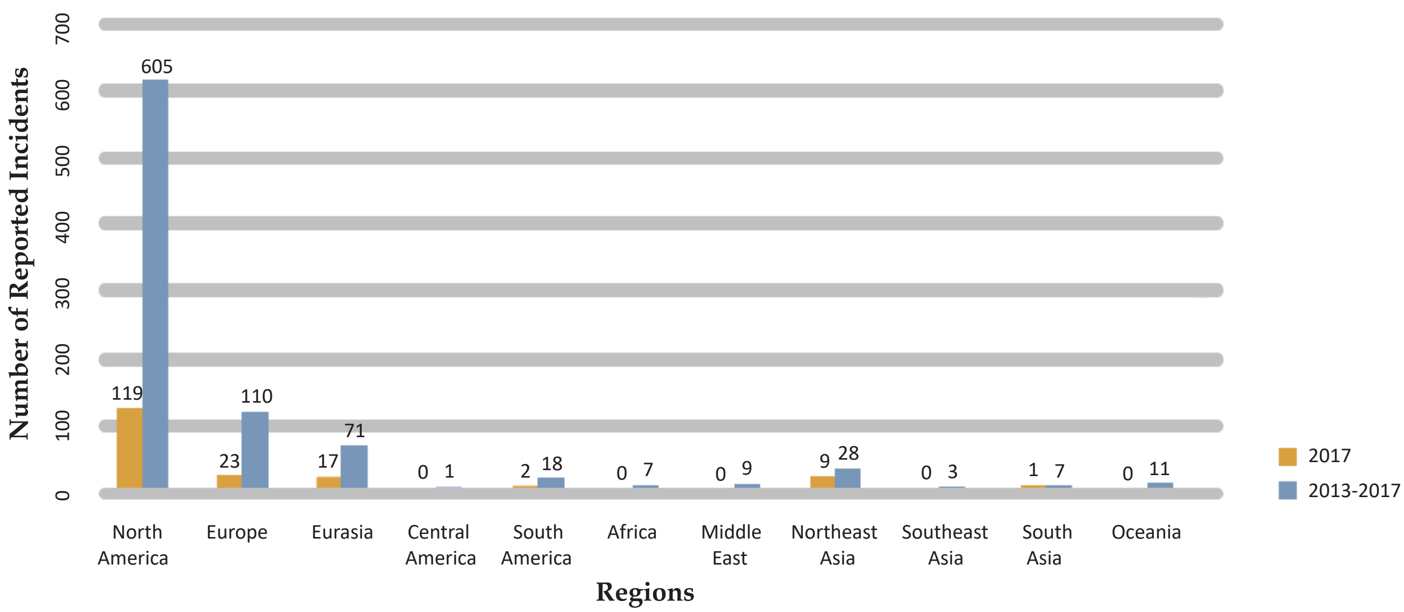


III. Key Findings and Policy Implications

Key Finding 1: Variable reporting transparency yields variable, low transparency, results

CNS researchers found a total of 870 reported incidents occurring in 51 countries between 2013 and 2017. The newly added 2017 case subset consists of 171 incidents occurring in 14 countries. The case breakdown below shows the wide case disparity among regions.

Figure 3. Reported Incidents by Region



The database records a disproportionately high number of incidents from North America because both the United States and Canada have policies requiring systematic and public reporting of incidents involving nuclear and other radioactive materials. Outside of North America, France, Belgium, Japan, and South Korea all maintain similar policies.[15] (All six countries also possess relatively large numbers of nuclear and/or radioactive materials, sources, or devices subject to regulatory control, but they are far from unique in this regard.)

Beyond these six countries, transparency and reporting standards are irregular. Some countries, such as Mexico, publicly report incidents involving dangerous radioactive sources in order to alert the public of potential danger and to enlist its help in recovering the source. Ukraine's Security Service reports incidents involving smuggling, attempted illicit sales, and other trafficking incidents but does not report other types of incidents, such as the loss of a source.[16]

As in past years, in 2017 the United States recorded the most incidents:

- United States (104 incidents, 61 percent)
- France (16 incidents, 9.4 percent)
- Russia (10 incidents, 5.9 percent)
- Canada (9 incidents, 5.3 percent)
- Ukraine (6 incidents, 3.5 percent)
- China/Mexico (5 incidents each, 2.9 percent each)
- Japan/Spain (4 incidents each, 2.3 percent each)
- Argentina/Belarus/Belgium (2 incidents each, 1.2 percent each)
- Malaysia/Sweden (1 incident each, 0.6 percent each)

This breakdown is consistent with past years, with two exceptions. Canada reported slightly fewer incidents than in past years, and France reported slightly more incidents. Additionally, researchers found incidents in Malaysia and Sweden for the first time. The aggregate reported incidents by country between 2013 and 2017 are:

- United States (528 incidents, 60.7 percent)
- Canada (63 incidents, 7.2 percent)
- France (58 incidents, 6.7 percent)
- Russia (29 incidents, 3.3 percent)
- Ukraine (21 incidents, 2.4 percent)
- Japan (14 incidents, 1.6 percent)
- Belgium/Mexico (12 incidents each, 1.4 percent)
- Australia/China (10 incidents each, 1.1 percent)
- United Kingdom (8 incidents, 0.9 percent)
- Italy/Spain (7 incidents each, 0.8 percent)
- Georgia/Kazakhstan (6 incidents each, 0.7 percent)
- Argentina/Poland (5 incidents each, 0.6 percent)
- Brazil/Chile/Moldova/South Korea (4 incidents each, 0.5 percent)
- Belarus/Israel/Lebanon/Peru/South Africa/Vietnam (3 incidents each, 0.3 percent each)
- Algeria/Colombia/Costa Rica/Finland/India/Iran/Iraq/Lithuania/Macedonia/Slovakia/Sri Lanka (2 incidents each, 0.2 percent each)
- Austria/Bangledesh/Germany/Guetemala/Ireland/Latvia/Malaysia/Malta/Nepal/Nigeria/Sierra Leone/Sweden/Turkey (1 incident each, 0.1 percent each)

The level of global reporting is inconsistent and presents an incomplete picture. The majority of reported incidents have occurred in wealthy industrialized democracies, which tend to have the most robust and transparent reporting mechanisms. While some countries may have few incidents due to their comparatively smaller number of materials, sources and devices, poor incident detection and/or reporting are significant contributors to regional inconsistencies.

Even countries that do not report incidents involving nuclear or other radioactive material to the IAEA or to the public may maintain internal records. In some cases, these are ultimately reported long after the fact and in the aggregate. For example, Ukraine reported the results of two joint Ukraine-U.S. projects that retrieved aging radiation sources from bankrupt enterprises. According to Ukrainian authorities, 14,755 spent radiation sources representing a total activity of 1.27 petabecquerel (PBq, a measurement of radioactivity), or 34,324 curies (Ci, an alternative measurement of radioactivity) were collected between 2009 and 2015.[17] Because the incidents were aggregated when publicly reported, it is impossible to incorporate them into, or individually cross-check them with, incidents in the CNS database. However, if each individual source had been publicly reported as a single event, this total would represent more than 15 times the number of cases in the entire CNS database and over 5 times the total number of incidents in the IAEA's confidential database. This suggests that only a small fraction of those incidents, if any, were reported publicly or to the IAEA.

There are a number of reasons why a government might choose not to report an incident publicly, either in a timely fashion or at all. The government might fear that transparent reporting could compromise an ongoing investigation or embarrass the government, or believe that the relatively low-category radioactive materials involved do not warrant reporting. Regardless, these enormous global reporting disparities limit the efficacy of efforts to find the worst gaps in radioactive materials security and address them.

Policy Recommendation: Develop a common standard for incident reporting that requires reporting Cat. 1 and 2 losses; encourage wider reporting transparency

Transparency in incident reporting serves the interests of all states by informing the development of better security policies. In 2017 there was some progress in national transparency measures, as three countries (Gabon, Libya, and Swaziland) joined the ITDB as participating states, bringing the total number of participating member states to 134.[18] Several IAEA member states still do not participate, including some that possess a nuclear infrastructure and/or are countries of concern for trafficking and terrorism (e.g., Angola, Egypt, Myanmar, Syria, and Turkmenistan).

Since 2013, the CNS annual reports have advocated the adoption of a legally binding international instrument that would mandate reporting of incidents involving IAEA Category 1 and 2 radioactive materials. While voluntary instruments such as the IAEA's Incident and Tracking Database (ITDB) play an important role in incident reporting, they are not adequately comprehensive or transparent. Many states still do not participate in the ITDB, and even participating states may elect not to report an incident (or may fail to do so in a timely manner).

As George Moore, a former senior analyst in the Office of Nuclear Security at the IAEA, has noted, "[…] there is no binding international instrument that requires states to report the loss of regulatory control over hazardous radioactive sources or significant amounts of radioactive materials."[19] Moore recommends that states work through the IAEA to establish a mandatory reporting standard for Category 1 and 2 radioactive materials and sources. Despite such expert recommendations, there has been little to no progress toward mandatory reporting of Category 1 and 2 incidents—which involve the most dangerous radioactive materials.[20] Yet the safety and security risks of lost or stolen Category 1 and 2 materials and sources can easily transcend national borders.

A proposed legal instrument would likely resemble the Convention on Early Notification of Nuclear Accidents, adopted in 1986, which mandates the prompt reporting of any nuclear accident capable of physically affecting another state. A more recent treaty, the International Convention on the Suppression of Acts of Nuclear Terrorism, which entered into force in 2007, demonstrated that states recognize an interest in cooperating to prevent international terrorism involving nuclear or other radioactive material. International political will to adopt these treaties existed because of catastrophic events: the former was adopted in the wake of the Chernobyl disaster in the USSR, and the latter after September 11, 2001 and other terrorist attacks raised concerns about nuclear and radiological terrorism. It would be preferable if the international community were to address the need for mandatory Category 1 and 2 incidents reporting without being compelled to do so by a catastrophe.

Key Finding 2: Transportation creates the greatest vulnerabilities, especially when materials are unattended

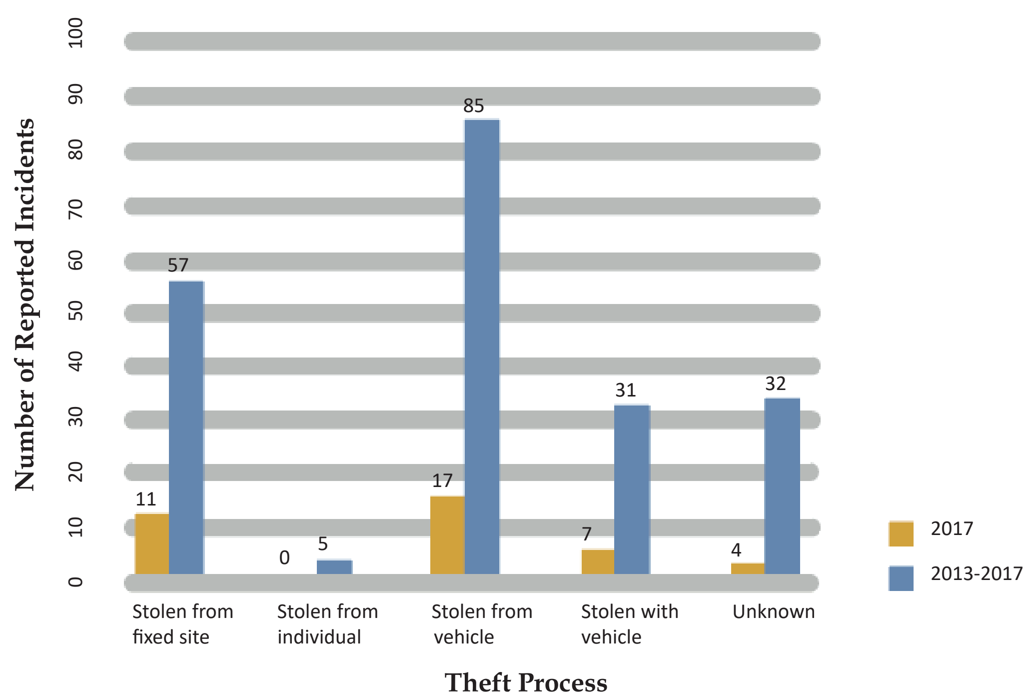
The IAEA has identified the transportation of nuclear and other radioactive materials as the part of the supply chain most vulnerable to loss or theft.[21] Cases involving the theft of radioactive materials – whether deliberate or incidental to a separate theft – deserve special scrutiny. All such cases involve illicit access by malicious actors to what are supposed to be tightly controlled materials.

In 2017, 39 incidents involved the theft of radioactive material, constituting approximately 23 percent of all 2017 incidents. This number is consistent with past trends. From 2013 to 2017, the database recorded 211 incidents involving theft, approximately 24 percent of total incidents. The number of reported thefts has remained relatively consistent since 2015 (there were 38 thefts in 2015, 42 in 2016, and 39 in 2017).

The CNS database categorizes thefts by type: theft from an individual; theft from a fixed site; theft from a vehicle (where the vehicle itself is not stolen); theft with a vehicle (vehicle stolen with source inside); and unknown. This granular categorization of thefts illustrates how thieves typically obtain sources.

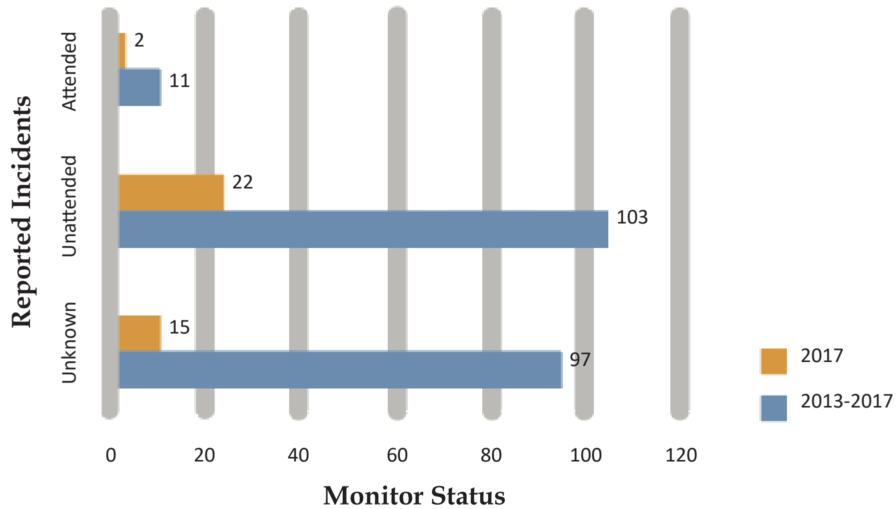
Of the 211 thefts which occurred between 2013 and 2017, 115 (approximately 55 percent) occurred while the material was in transit, 61 thefts occurred when the material was stored at a fixed site, and in 35 cases there was not enough information in the reports to determine where the material was stolen.

Figure 4: Types of Thefts



Theft cases are also categorized by whether the source was attended or unattended at the time of theft. Knowing how many cases involved theft of an attended source provides a good estimate for the number of thieves that were undeterred by the presence of an individual, and therefore threatened or used violence, or were likely willing to do so.

Figure 5: Whether someone was present during the theft



In 103 cases, the material or device was unattended when the theft occurred. In 71 of these cases, accounting for approximately one-third of all thefts, the unattended material was *also in transit* at the time of its theft. This statistic clearly highlights just how high the risk of theft becomes for materials in transit when they are also left unattended.

In some cases, thieves were likely unaware of what they had stolen. For example, on November 14, 2017 a Florida man stole a car from a construction site, in the back of which was a moisture density gauge containing amercium-241/beryllium (AmBe) and cesium-137 (#2017151). Police later located the device in a ditch and returned it to the licensee undamaged.

Trafficking

Cases involving the attempted trafficking of nuclear and other radioactive material thankfully remain rare. In 2017, there were three definitive cases of trafficking in nuclear and other radioactive material recorded. Although reported cases are rare, it is likely that more cases occur and are either not caught or not publicly reported.

- In Malaysia, police arrested several individuals for the theft and attempted sale of iridium-192 (#2017021). Police believe the individuals obtained the material by stealing it from a local oil company.

- In Ukraine, police arrested an individual for attempting to remove 15 kilograms of radioactive lead. Police believe the individual intended to sell the material (#2017145).

- In Kazakhstan, police arrested four individuals for the theft and attempted sale of plutonium-239, plutonium-241, and americium-241.[22] The thieves attempted to sell the material for $130,000 to undercover members of Kazakhstan's security services. Police say the individuals obtained the material by stealing a static electricity control device used in heavy industry and that the thieves claimed they could obtain more material using similar means (#2017094).

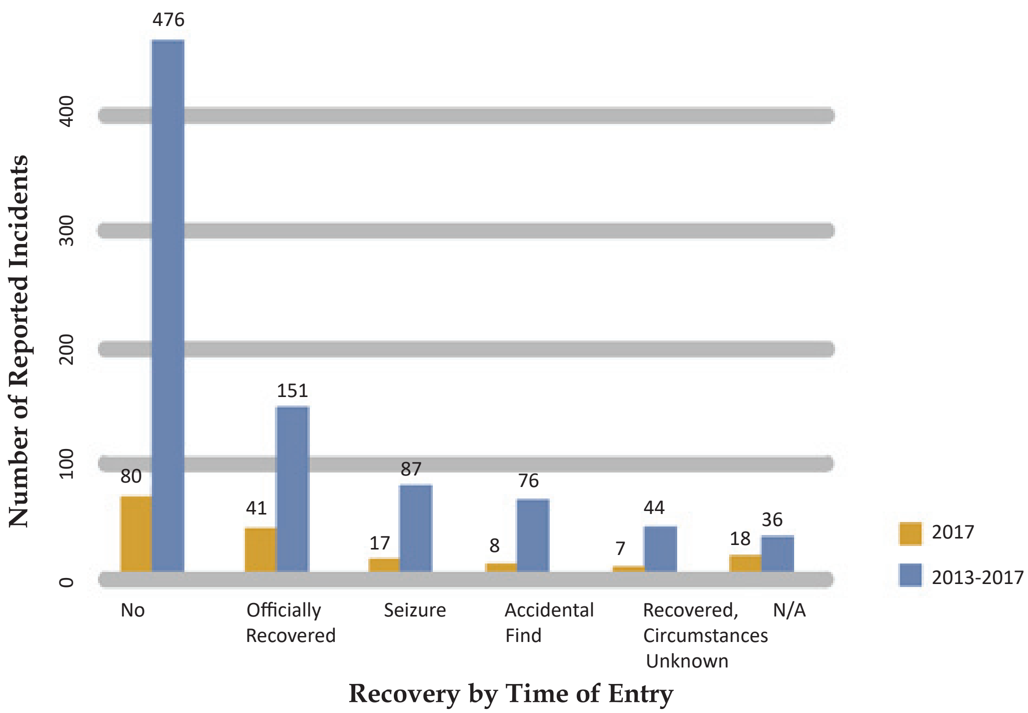
In each of these cases, it is difficult to determine whether the individuals involved were part of a larger criminal or terrorist network or simply opportunistic profit-seeking criminals. The case involving the four Kazakhstani individuals is uniquely concerning as it suggests some malicious actors may specifically see devices containing nuclear and other radioactive material as valuable commodities they can exploit for profit.

Recovery Data

The CNS database tracks whether materials outside of regulatory control are recovered, and if so, how. The data is likely incomplete because recoveries are rarely reported in the press. Additionally, even in those (rare) countries that legally require reporting the loss of materials, reporting whether they are recovered can be discretionary.

A recognized limitation of the CNS database is that entries are not routinely revisited once they are input, even in the unlikely event that updated information becomes available. For example, a source entered as lost and unrecovered would remain flagged as an unrecovered case even if it were reported found two years later. Therefore, the recovered incidents in the database can only be interpreted as the minimum number of recovered sources. Figure 6 sorts incidents by whether the material was recovered, and, for those that were, the manner of recovery.

Figure 6: Recovered by Time of Entry?



Recovering lost radioactive material can be difficult, time consuming, and expensive. Often a loss is not discovered until well after it has occurred. The material and devices involved are often small and difficult to spot. Responses often involve large search parties, specialized (and expensive) detection equipment, rewards for the safe return of the material, and inventory searches. Even then, there is no guarantee that recovery efforts will be successful.

Policy Recommendation 2: Improve physical security measures; expand electronic tracking of dangerous radioactive sources

Improving physical security and tracking of materials is vital, especially for the most dangerous radioactive materials in transit. There was meaningful international progress on improving security for Category 1 sources in 2017. Following the 2014 Nuclear Security Summit (NSS) 23 states committed to securing all Category 1 sources within their jurisdictions, and as of this report's publication, all 23 had met their NSS commitments.[23] States met their commitments through a variety of measures. Several states created and deployed electronic tracking systems for all Category 1 sources within their jurisdictions as one component of meeting their commitments.[24]

The news is less encouraging for Category 2 sources, which have not received similar high-level international attention. Some countries, like the United States and South Korea, have recognized the threat of Category 2 sources falling into the wrong hands, and have worked to expand electronic tracking to Category 2 sources within their jurisdictions. However, information on other countries is limited.[25] Even in the United States, authorities often lack information critical to safeguarding the transport of Category 2 sources. According to a 2017 U.S. Government Accountability Office (GAO) report, the Nuclear Regulatory Commission does not collect information on the shipment of Category 2 sources or the mode by which these sources are transported.[26]

Given the high costs and difficulties of recovering lost materials, as well as the attendant safety and security risks, licensees should consider taking additional measures (beyond those legally required by governments) to protect materials in their charge. Waiting for comprehensive action by national governments is not in the interests of licensees; convincing them of this could reap significant security improvements (and thus decrease the need for licensees to expend resources attempting to recover and replacing lost or stolen sources).

A 2014 U.S. GAO report describes a few effective, low-cost measures to reduce instances of theft and loss.[27] One such measure is for owners and operators of industrial radiography equipment, the most common Category 2 source reported lost or stolen, to install high-security locks, which cost approximately $50 each. Another measure is the installation of GPS tracking devices on vehicles transporting Category 2 sources. One large radiography company installed GPS trackers on all 120 of its trucks in 2011 at a cost of approximately $50 to $100 per truck, and equivalent devices are even less expensive today. Given the low cost and availability of these security measures, and the typically high costs of searching for and replacing lost or stolen sources, licensees should strongly consider implementing these or similar measures.

Some states have incorporated these types of security measures into national legal and regulatory frameworks. An encouraging step in 2017 was Mexico's passage of "Regulations for the Safe Transport of Radioactive Material," which, among other requirements, mandates that all cobalt-60, cesium-137, iridium-192 and other sources of principal concern have locks and GPS tracking devices while in transit.[28] This is significant progress, as Mexico has been the site of some of the most serious incidents involving vehicle theft. The only reported Category 1 incident involving vehicle theft recorded by this database since 2013 occurred in Mexico (#2013070), as did a 2017 vehicle theft of a Category 2 source (#2017066).

Key Finding 3: Human failure is a security risk

In 2017, 104 incidents (60.8 percent) were at least partially caused by carelessness, inattention to appropriate procedures, or other behaviors that fall under the heading of "human failure." This designation is primarily associated with cases involving lost nuclear or other radioactive material, although it is also a factor in some cases of theft.

The prevalence of incidents involving human failure calls for a stronger security culture in organizations that handle nuclear and other radioactive materials. A major 2017 case study in human failure occurred in a university setting (#2017165). A professor at the University of Nevada at Las Vegas lost 1.4 grams of highly enriched uranium. The material disappeared after the professor improperly stored it underneath the desk in his or her office for several days. The material's whereabouts and the mechanism of its disappearance remain unknown.

Such acts of negligence are thankfully rare when it comes to nuclear material. Unfortunately, they are much more common with other radioactive materials used in industry. For example, on February 20, 2017, a radiography crew in New Mexico failed to secure a device properly before moving between job sites (#2017038). As a result, the device fell out of the back of the crew's truck. Thankfully, a contractor working at the site discovered the device and was able to return it to the licensees.

Policy Recommendation: Improve security culture

Human error is unavoidable. However, a robust organizational security culture can help to mitigate the frequency and severity of incidents involving nuclear and other radioactive material. Proper employee training that inculcates respect for security regulations, understanding of the rationale behind protocols, and proper procedures for working with radioactive materials can reduce human failure.

In 2008, the IAEA released a guidebook, *Nuclear Security Culture: Implementing Guide,* which underscores the importance of security culture in preventing security incidents.[29] In 2016, the IAEA drafted a technical guide: Enhancing Nuclear Security Culture in Organizations Associated with Nuclear and/or Radioactive Material. The document is now with the IAEA Publications Committee and is expected to be released in 2019.[30]

The draft IAEA technical guidance suggests specific policies for enhancing security culture, some of which are applicable to any organization responsible for the handling of nuclear and other radioactive materials. These include:

1. Organizational self-assessment to determine the prevailing beliefs and attitudes toward security
2. Development of an action plan to enhance security culture, based on results of the self-assessment
3. The designation of an individual as a Culture Coordinator, who is responsible for developing the action plan and ensuring its implementation.[31]

Studies published in 2017 offer insight into the development and maintenance of a strong security culture. The IAEA released a technical guide for the administration of security culture self-assessments, using tools like surveys, interviews, document reviews, and observations to identify an organization's strengths and weaknesses in security culture.

The 2017 University of Georgia *Nuclear Security Culture for Users of Radioactive Sources* focuses on the unique circumstances for users of radioactive material in settings such as healthcare, academia, and industry, which represent a large percentage of the incidents recorded in the database.[32] According to the UGA report, these sectors often have well-established organizational *safety* cultures, but less well-developed *security* cultures. Organizations in these sectors could likely benefit from integrating security into their already existing safety culture, as they are supported by overlapping values (e.g. personal accountability, vigilance, reporting), as well as similar consequences for failure (e.g. negative impacts on human health, politics, economics, and the environment). This entails making employees aware of the consequences of security incidents involving radioactive material, and management treating security violations as seriously as it typically does safety violations.

Key Finding 4: Material Replacement

Materials used in medical and industrial applications continue to constitute a high percentage of reported incidents. In 2017, there were 105 such incidents, approximately 61.4 percent of the total. More broadly, between 2013 and 2017 there were 535 such incidents, constituting 61.1 percent of all incidents. Moreover, incidents involving the most dangerous radioactive materials are almost always tied to medical and industrial uses. Of the 36 incidents involving Category 1 or 2 materials, 34 incidents involved materials or devices used in industrial or medical applications.[33]

Policy Recommendation: Governments should encourage replacement efforts

Minimizing the use of the most dangerous radioactive materials (i.e., especially Category 1 and 2 sources), is among the highest priority ways to reduce the likelihood malicious actors will acquire the materials required for radiological terrorism. Fewer radioactive materials in circulation—especially in low-security settings such as hospitals—means fewer opportunities for losses, accidents, or thefts.

News headlines in 2017 highlighted the risks of the continued use of radioactive materials in civilian settings. In July 2017, after the Iraqi military and outside partners liberated the city of Mosul from Islamic State (IS) control, the Washington Post reported that two high-activity cobalt-60 sources had not been evacuated from the University of Mosul at the time of IS takeover in 2014, and remained in a storage room for the duration of the IS occupation. Government officials found the sources to be intact and undisturbed after the campus had been liberated. IS militants had access to the material for three years, and could have diverted it for use in a radiological dispersal device (RDD) at any time. This suggests IS militants either did not realize what they had and its possible applications, or were stymied by the difficulty of safely removing the material, as these cobalt-60 sources are materials of “principal concern” for radiological terrorism.

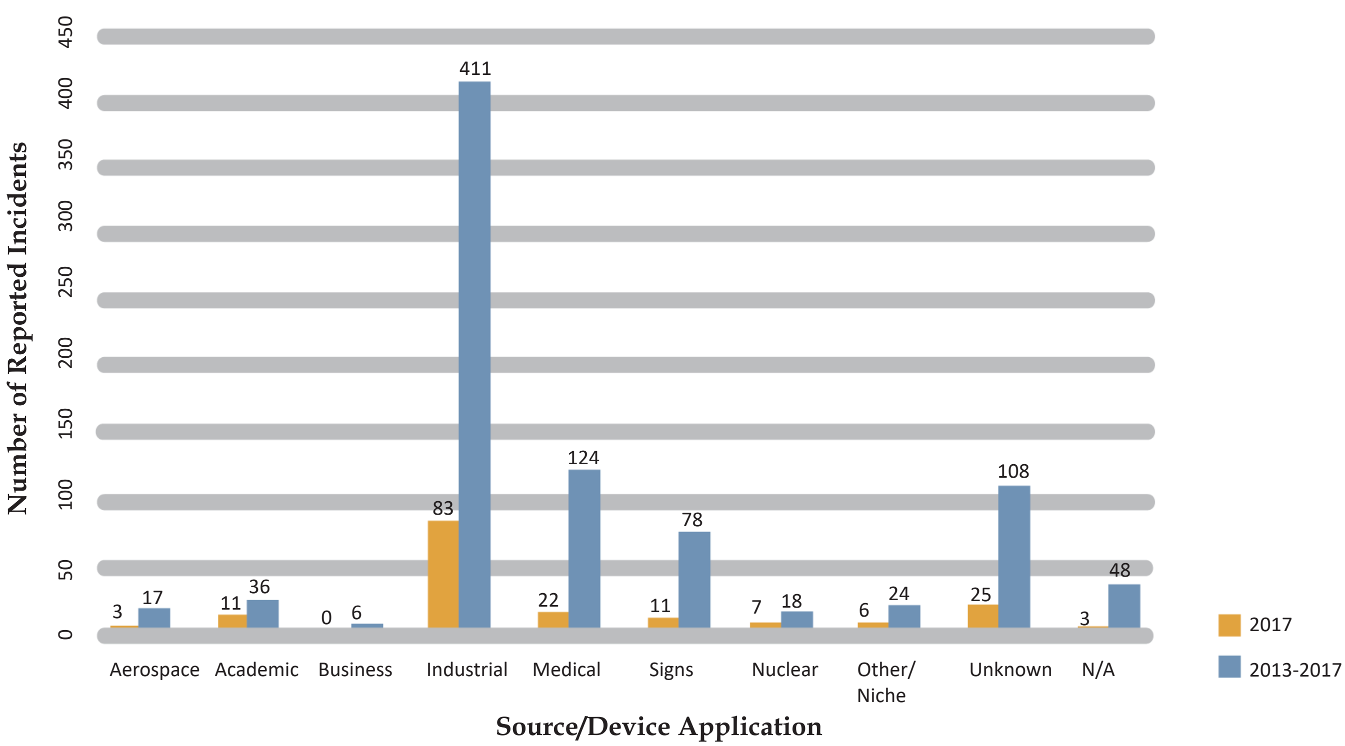
In nearly all medical and industrial applications, equivalent technologies exist that do not involve the use of radioactive materials. According to a 2008 National Academy of Sciences (NAS) report, as well as subsequent reports by the U.S. Nuclear Regulatory Commission Task Force on Radiation Source Protection and Security in 2010 and 2014, non-isotopic replacements exist for the most common medical applications of Category 1 and 2 sources, radiotherapy and blood irradiation.”[34] In many parts of the world, cobalt-60 radiotherapy machines, the devices that caused experts such concern while Mosul, Iraq was in Islamic State hands, have been almost entirely phased out in favor of clinical linear accelerators (LINACS), which permanently remove the risk. As of July 2018, there are just over 2,000 radionuclide teletherapy units remaining worldwide (most using cobalt-60), compared to nearly 12,000 clinical accelerators. However, the majority of remaining cobalt-60 machines are in lower and middle-income countries, where materials replacement efforts most commonly encounter barriers to implementation such as cost, feasibility, and perceived importance.[35] Similarly, cesium-137 is often used in blood irradiators and some radiation therapy machines. LINACs are a technologically viable replacement technology to devices containing cesium-137, but face similar conversion challenges to devices using cobalt-60.

The most recent high-level international discussion of this issue was at the 2016 Nuclear Security Summit, when the United States, along with 27 other nations and INTERPOL, released a joint statement on Strengthening the Security of High Activity Sealed Radioactive Sources (HASS). The statement reiterated that specific medical and industrial applications of dangerous sources may be replaced with “technologies based on sources of lower activity and, in some specific cases, no radioactive sealed sources at all.”[36]

There has been some progress on meeting this goal and replacing these devices. Most wealthy countries have replaced, or are working to replace, old cobalt-60 radiation therapy machines with LINACs. Similarly, there has been significant progress in replacing cesium-137 blood irradiators with alternatives, since their approval for use by the U.S. Food and Drug Administration (FDA) in 2005.[37] The Nuclear Threat Initiative is promoting the phase-out of all cesium-137 blood irradiators in the United States, and has worked with public health officials, hospital administrators, blood banks, and medical researchers in several cities around the country to identify safe and effective alternatives to continue to care for patients and advance scientific research. For example, with DOE assistance New York City has committed to replacing its cesium-137 blood and research irradiators by 2020.[38] The state of California has pledged to phase out 11 of the state's 100 cesium blood irradiators, most of which are in the University of California system.[39] Other countries have made similar commitments and met key milestones in 2017. In October 2017, Japan announced it had replaced 80 percent of its cesium-137 blood irradiators with alternatives.[40] Norway and France also finished replacing all of their cesium blood irradiators in 2017.[41]

Widespread adoption of these technologies has been hindered by capital investment costs to purchase the new non-gamma technology, concerns among users about the effectiveness of replacements, and a lack of awareness.[42] However, progress continues in each of these areas.

Figure 7: Source or Device Application



Cost

Cost remains the most significant hindrance to the widespread adoption of these technologies: LINACs can often cost several million dollars, and are more expensive to maintain than cobalt-60 units.[43] A July 2015 CNS Occasional Paper outlined different methods for addressing cost concerns. These include direct government funding for the adoption of alternative technologies, tax breaks where it is viable, government subsidies to encourage the shift to alternatives, and adjustment of liability rates to reflect the danger of accidents or misuse involving radioactive sources and materials.[44]

In addition to the up-front costs, many of these machines require several hundred thousand dollars a year in regular maintenance to function effectively. In low-income countries, these costs can be even higher due to power fluctuations and outages, and the relative difficulty in travelling to them. A U.S. company called Varian has been working to reduce these costs by developing a cheaper version of its LINAC models. In 2017, Varian released a model intended for use in countries with such difficulties.[45] While the cost is only slightly lower than traditional LINACs, Varian designed the device to require much less frequent maintenance, which would lower long-term costs.[46]

A 2016 paper titled, *Treatment, Not Terror,* by Miles Pomper, Ferenc Dalnoki-Veress, and George Moore, examined other strategies available to low-income countries. The paper suggests a combination of approaches such as donor support, developing cheaper LINACs, selling refurbished LINACs at a lower cost, and encouraging regional bodies/states to buy in bulk.[47] While progress on this front continues, addressing the high costs of these machines will likely remain an issue for the near future.

Over the last several years, terrorist and insurgent groups have taken advantage of poor governance and political instability to seize territory around the world. Given the instability in many parts of the world, the international community should prioritize (and where needed, help fund) the replacement of the most dangerous sources and devices with non-radioactive alternatives in potential conflict zones.

Efficacy

While non-radioactive technologies for radiation therapy and blood irradiation are well established, there are some concerns among end-users about their efficacy. In the United States, the FDA is still working to approve non-radioactive alternatives for all cesium sources. Some research labs are hesitant to switch over to new technologies due to concerns that subtle differences in output could make comparing data between studies undertaken by the two different types of machines difficult.[48]

This problem is even worse in well logging, a technique vital to the oil and gas industry that employs Category 2 and 3 sources, for which similar alternatives exist or are in development. In order to be used effectively, well logging analysis "relies on a large body of data that has been accumulated...using Am-Be [radioactive] sources."[49] In general, material replacement of devices with industrial applications, such as well logging tools and moisture density gauges, has not received as much attention as material replacement for medical applications. More data on the efficacy of non-isotopic replacements is needed.

Awareness

Governments should continue to promote these technologies and inform users about their advantages. In many cases, governments already know who the operators of these devices are (or at least, they should). The IAEA can assist in these efforts by promoting alternative technologies to member states. Continued outreach efforts are essential to informing these users of alternative technologies and to encourage them to adopt them.[50]

IV. Conclusion

With the release of the CNS trafficking database's fifth annual report, consistent trends have emerged, reinforced by the 2017 incident data. Despite some progress made in improving nuclear and other radioactive materials security, annual incident counts remain high. Moreover, the end of the Nuclear Security Summits has removed an important global spotlight on improving nuclear and radiological security.

Reflecting these consistent trends, the policy recommendations of the CNS Global Incidents and Trafficking report echo those in previous editions of the report:

- More systematic and transparent global reporting
- Using technology to enhance physical security
- Improving organizational security culture
- Replacing radioactive materials with less dangerous alternatives, where possible

These measures will help communities around the world to enjoy the benefits of nuclear and other radioactive materials, while reducing the risk of safety and security incidents, and especially nuclear or radiological terrorism.

V. Methodology

For a complete methodology and dataset, please refer to the full database at www.nti.org/trafficking.

- The database includes incidents reported January 1, 2013 through December 31, 2017

- CNS researchers conducted global searches in 14 major languages, and used machine-assisted translation to conduct searches in additional languages.

- Researchers used a variety of sources, including reports from countries' regulatory agencies, national and local news reports, and country-specific search engines.

- The database includes twenty categories describing each incident. The categories and their subcategories are explained in the Category Definitions section of the database.

Where possible, CNS researchers relied on incident reports to determine what category (ranging from 1 to 5) a source or device fell into. In cases where reports did not provide a category, CNS researches used the methodology provided in section 2 of *IAEA Safety Standards: Categorization of Radioactive Sources RS-G-1.9,* along with information in the incident report(s), to categorize the source or device. In some cases, reports lacked the information required to make a determination, and the incident category is therefore marked as unknown.

Because the database relies on open-source media reports, it may be skewed more heavily toward thefts than other databases, such as the ITDB, that rely on government reports. Thefts are more liable to be the subject of media reports than, say, seizures of material outside of regulatory control at border checkpoints.

Some previous editions of the database identified "human negligence" as a cause for many incidents. Because "negligence" carries specific, albeit different, meanings in civil and criminal law, CNS has elected to replace "negligence" with the term "human failure," as defined below. Incidents identified as linked to human failure are not classified as such in the database itself. Incidents are examined prior to writing this report to see if they are linked to human failure.

The following guidelines were used to determine whether human failure was a contributing factor in an incident.

- Human failure was defined as a lack of reasonable care or attention to maintaining control over radioactive materials, including any failure to follow relevant regulations or company procedures governing the use, storage, shipment, receipt, or disposal of radioactive materials.

- The circumstances surrounding how material fell out of regulatory control had to be described in the incident report in order to link an incident to human failure. If insufficient details were given, the role of human failure was deemed unknown.

- All incidents classified as “loss” were deemed due to human failure unless the circumstances surrounding loss of control involved a natural disaster or other events outside the control of the individual(s) responsible (such as a health event).

- Incidents classified as “delivery failure/misrouting” were deemed due to human failure if a shipment was delivered to the wrong address or location; was labeled improperly; contained more or less material than was specified in the invoice; was the result of a communications breakdown; or relevant individuals did not otherwise follow the proper procedures for shipping, receiving, or opening radioactive materials.

- In cases classified as “theft/stolen material,” the incident report had to specifically mention whether the user failed to follow relevant regulations or company protocols at the time the theft occurred.

- Cases falling into all other categories listed under “Type of Incident” were linked to human failure if the incident report mentioned activities that fit the type of behavior detailed above.

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