March 2016

CNS Global Incidents and Trafficking Database

Tracking publicly reported incidents involving nuclear and other radioactive materials

2015 Annual Report

Produced Independently for the Nuclear Threat Initiative by the James Martin Center for Nonproliferation Studies

Contents

March 2016 | **CNS GLOBAL INCIDENTS AND TRAFFICKING DATABASE**

Acknowledgments

The 2015 Report was authored by Bryan Lee and David Schmerler with research assistance from Sarah Bidgood, Julia Diamond, Kyle Pilutti, and Ruby Russell. The authors are also grateful to Dr. George Moore and Elena Sokova for their valuable feedback on an earlier version of this text.

Executive Summary

Nuclear terrorism continues to be the single largest threat to peace and security in the United States and the world. The nuclear- weapons states are aware of that risk and have put considerable effort into securing nuclear facilities and fissile materials. Unfortunately, fissile materials are not the only radioactive materials in circulation. Radioactive isotopes are widely used in industry and in medicine. Some radioactive isotopes would be suitable for radiological terrorism, and the risk of them falling into terrorist hands remains high.

The CNS Global Incidents and Trafficking Database identified 188 publicly reported incidents from 26 countries of nuclear or other radioactive material outside of regulatory control in 2015. Only eight of these incidents involved nuclear materials (uranium, thorium, and plutonium-beryllium), and in all eight cases the material was recovered.

The bulk of the cases involving radioactive material are reports of contaminated scrap metal or other materials that may pose health hazards, but are not very well suited for use in a radiological dispersion device (RDD) or for "inhalation, injection, and immersion" attacks such as the polonium- 210 poisoning of former Russian agent Alexander Litvinenko. Nonetheless, two cases in 2015 involved materials classified by the IAEA as Category 1, which pose the greatest danger to human health. There were an additional seven incidents involving Category 2 so-called "very dangerous" materials.

Although there were few recorded incidents involving the most dangerous radioactive materials, almost half of the total reports since 2012 were for materials generally accepted as well-suited for RDD use. Clearly the danger of bad actors securing nuclear or other radioactive materials is still very much a reality.

A review of the trends in the incident data echoes the findings of previous reports.

Key Finding 1

Variable reporting. It should come as no surprise that industrialized and wealthy democracies tend to have more robust public reporting systems than other countries. What is perhaps less well known is that there are no globally accepted standards for public reporting of incidents. This makes it difficult to make accurate comparisons between reports from different countries, and also hampers public education and awareness efforts.

Policy Implication: Develop a Common Standard for Incident Reporting

Identifying standardized criteria for what characterizes an incident and what information should be reported would make it easier to assess training and assistance needs. If developed in a transparent and collaborative manner, a single minimum standard that applies to all could also reduce state concerns about reporting through a demonstration effect, i.e. countries would see that their neighbors report the same information without ill effects.

Key Finding 2

Theft, trafficking, and physical security. More than 20% of the 2015 incidents involved theft, although it remains unclear whether the thieves were targeting radioactive material or more likely, the sophisticated and expensive-looking equipment that uses the material. The intent of the smugglers in the three recorded trafficking cases was clearer: All three targeted radioactive material with the intent of earning a large profit. In one case in Moldova, the suspect openly expressed his hope that ISIS would use the material to attack U.S. citizens.

Policy Implication: Implement Basic Physical Security Measures

It continues to be the case that most thefts take place during transport. Obvious physical security improvements such as installing alarms on transport containers and vehicles, increased vehicle GPS tracking, and the rapid roll-out of prototype radio frequency identification device (RFID) technology, a wireless radio based identification and tracking system, could improve this situation at relatively low cost.

Key Finding 3

Human negligence. Over half of the incidents in the 2015 database were the result of negligence. This was especially the case with lost materials but was also a contributing factor in many of the reported thefts. In most instances, the problem does not seem to have been a lack of published standards but rather an inability to enforce the standards.

Policy Implication: Focus on Building a Security Culture

In order to improve training effectiveness, assistance programs should consider more comprehensive approaches that emphasize the development of a safety and security culture, rather than the penalties of non-compliance.

Key Finding 4

Material minimization. The majority of incidents captured in the database involve sources used for medical or industrial applications. Many of these sources fall into the highest IAEA risk categories of 1 or 2. A widely publicized 2008 report from the National Academy of Sciences concluded that non-isotopic sources exist for nearly all Category 1 and 2 radioactive source applications, yet efforts to implement the adoption of replacement sources have been limited. There is also almost no effort devoted to developing alternatives for the much more numerous Category 3 and lower sources.

Policy Implication: Sponsor Material Minimization Efforts

Cost is undoubtedly one of the key factors in the conversion effort. Policymakers should consider accelerating the replacement of dangerous sources by partnering with industry and end users to reduce the cost. This approach would be relatively inexpensive, especially in comparison to ongoing security and counterterrorism costs, as well as the projected recovery costs in the event of a terrorist attack.

Conclusion

For the third year in a row, opaque reporting, lax physical security, and human negligence are the major themes of this report. Governments concerned about the threat of radiological or nuclear terrorism could potentially receive a large benefit at reasonable cost by focusing more on end-user training and other capacity building efforts to address these key areas.

I. Introduction

According to the President of the United States, nuclear terrorism is the "single biggest threat"[1] to U.S. security. A nuclear detonation, whether on U.S. territory or anywhere else in the world, could devastate the world economy and cause global panic as states scrambled to protect themselves from similar attacks. Fortunately, the international community is aware of the danger and has expended considerable time, effort, and resources, notably through the Nuclear Security Summit process, working to secure nuclear materials globally.

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 where gaps may still exist in the security of nuclear and non-nuclear radioactive materials. It is the only database of its type that is freely available to both experts and the general public. It differs from the IAEA's Incident and Trafficking Database (ITD) in that it is generated entirely from publicly available data, does not rely solely on government agencies to supply the information, and is accessible by the general public.

The CNS database contains detailed reference information on any incident involving the loss of regulatory control over nuclear or other radioactive material requiring such control. Loss of control may refer to both unintentional acts, such as loss or misrouting, as well as to intentional acts such as theft or attempted trafficking. The information itself comes from U.S. and international government reports, as well as local language news reporting from every region of the world.

The level of detail in each entry is necessarily limited by the accuracy and comprehensiveness of the base reporting. At a minimum, researchers attempted to ascertain the date of the report, the location, the type of material, and the circumstances of the loss. In this way, trends and commonalities can be discovered that can lead to more effective security policies. The database now contains three years of data.

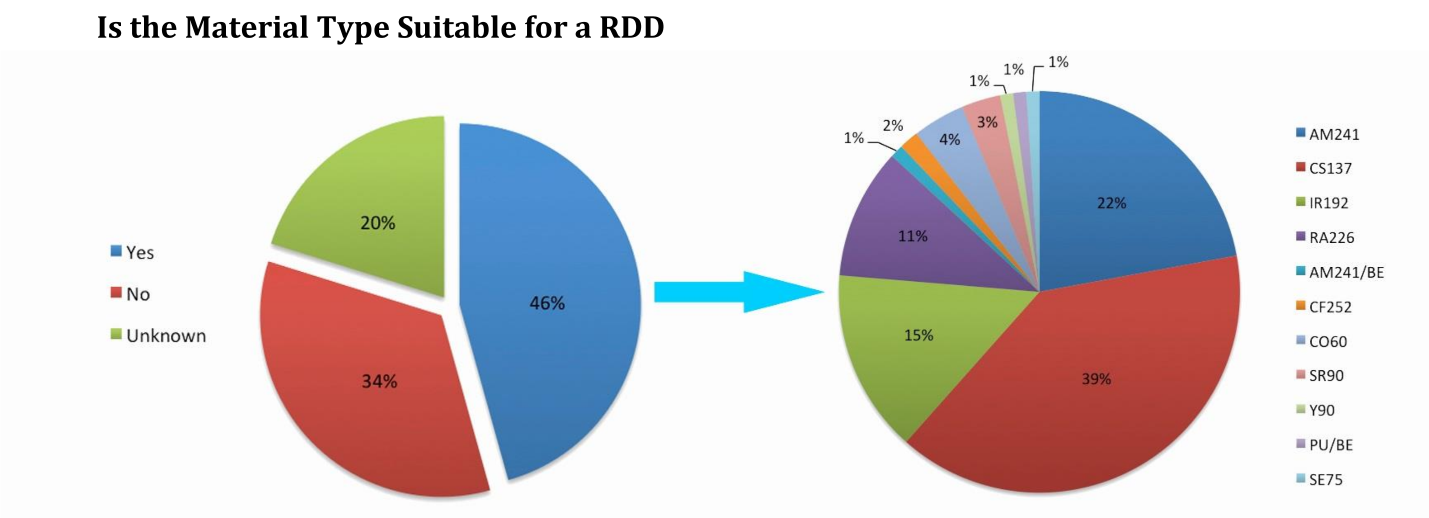
The 2015 report contains four key recommendations and builds on trends first observed in 2013, notably the large role that negligence continues to play in incidents. The report also dramatically demonstrates the need for increased vigilance. The 2015 database captures reporting on several particularly troubling trafficking incidents, one of which was conceived in the hope of transporting the material to members of the Islamic State of Iraq and Syria (ISIS). Fortunately, the overall data continue to show that genuine trafficking incidents remain rare, and that thieves targeting expensive-looking equipment remain much more common than smugglers or terrorists. The case details and policy recommendations that follow are presented in the spirit of helping governments and industry keep it that way.

[1] "Remarks by President Obama and President Zuma of South Africa before Bilateral Meeting." The White House. April 11, 2010. Accessed March 11, 2016. www.whitehouse.gov

II. Materials and Data Overview

Terrorists or criminals can only build an improvised nuclear explosive device (IND) or a radiological dispersion device (RDD) if they can acquire the necessary materials. An IND requires the acquisition of large (kilogram) quantities of fissile material, such as highly enriched uranium or separated plutonium. Whereas nuclear weapons are typically only made from uranium or plutonium, radiological weapons could employ a wide range of nuclear or non-nuclear radioactive materials and do not require fissile material. Although many types of radioactive materials exist, only about a dozen exhibit characteristics that qualify them as serious security threats, such as half-life, radioactivity, portability, dispersibility, and availability.[2]

Figure 1. Reported Incidents by Material Type



Nuclear Material

Reported cases involving nuclear material—defined as various forms, or isotopes, of uranium, plutonium, and thorium—account for 4 percent of the incidents in the 2015 database. None of the incidents captured over the past three years has involved separated plutonium.

In all of the reported cases from 2015 that involved nuclear materials, the material had been recovered at the time of discovery. The IAEA's Incident and Trafficking Database (ITDB) documented 15 confirmed cases involving unauthorized possession of HEU or plutonium for the period 1993-2012.[3] Of the cases reported over the past three years in the CNS database, the incidents involving nuclear material have been infrequent in nature and generally centralized around the Black Sea region. This was demonstrated most recently by the HEU trafficking case in Moldova in 2011 (CNS Incident #2015490). There were no reported cases involving weapons-usable nuclear material in 2015.

It is unclear whether the low number of reported cases involving weapons-usable nuclear material is attributable to overall adequate security measures for fissile materials, or if cases are going unreported. Of the nuclear material trafficking cases that have been reported over the past three years, the majority have dealt

[2] George M. Moore & Miles A. Pomper, "Permanent Risk Reduction: A Roadmap for Replacing High-risk Radioactive Sources and Materials," CNS Occasional Paper No. 23, James Martin Center for Nonproliferation Studies, July 2015, www.nonproliferation.org

[3] IAEA, "IAEA Incident and Trafficking Database (ITDB)," Fact Sheet, 2014, www.iaea.org; Lyudmila Zaitseva and Fredrich Steinhausler, "Nuclear Trafficking Issues in the Black Sea Region," EU Non-Proliferation Consortium Papers, No.39, April 2014, www.nonproliferation.eu

with depleted uranium and non-weapons-usable material, such as scrap metal taken from abandoned nuclear facilities. In Moldova, a gang was arrested for trying to sell a 1.8kg sawed-off piece of a depleted uranium cylinder, which was suspected to have come from Chernobyl (CNS Incident #2015489). Although a high degree of attention is placed on all cases concerning weapons-usable material, it continues to be difficult to accurately assess the status of global nuclear security, due to the unknown number of unreported or undetected incidents.

Other Radioactive Material

The majority of cases reported in the CNS database are those involving non-nuclear radioactive material, many of which could be employed for radiological terrorism.

In a radiological dispersion device (RDD)—colloquially but inaccurately known as a "dirty bomb"—radioactive material is dispersed using conventional explosives or other mechanisms in order to contaminate a certain area. An RDD would be unlikely to cause extensive casualties but could result in mass panic and require expensive cleanup measures.

Another often overlooked method of radiological terrorism involves what one group of experts dubbed "inhalation, injection, and immersions (I^3) attacks."[4] These attacks focus on a radioactive substance actually entering the human body to deliver a direct internal dose of radiation as opposed to external radiation. While some low-penetrating radioactive materials, or alpha-emitters such as polonium-210, do not pose a threat when outside the human body, once internalized, they are lethal even in minuscule quantities.

Figure 2. Radioactive Sources

Figure 3:
(a) Moisture Density Gauge, typically contains less than Category 3 sources of cesium-137 and americium-241, Source: NRC.gov
(b) Tritium Exit Sign, Hydrogen-3, Source: Wikimedia Commons [5]
(c) Gas Chromatograph Machine, typically contains Nickel-63, Source: Wikipedia[6]

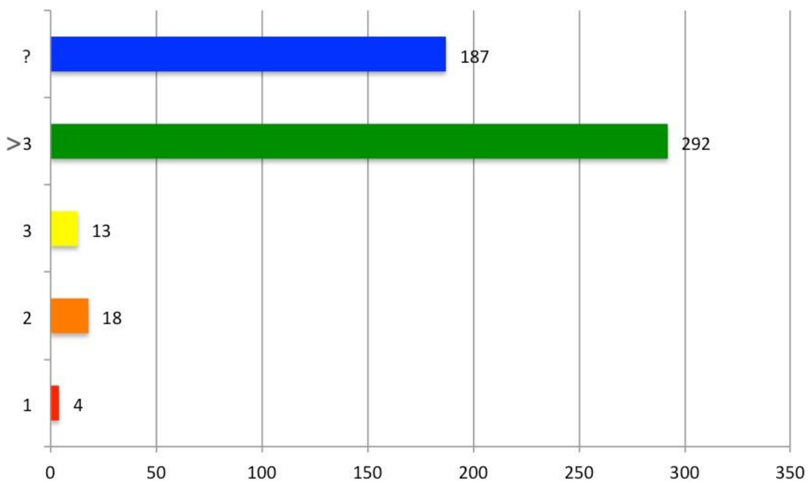
[4] Charles D. Ferguson, Tahseen Kazi, and Judith Perera , and Judith Perera, "Commercial Radioactive Sources: Surveying the Security Risks," *CNS Occasional Paper* No. 11, James Martin Center for Nonproliferation Studies, January 2003, www.hps.org

[5] Gazebo, "Tritium-exist-sign," 12 January 2014, www.wikipedia.org

[6] Polimerek, "Example of a GC-MS instrument," 16 November 2005, www.wikipedia.org

The International Atomic Energy Agency (IAEA) categorizes radioactive sources according to their safety and security risk on a scale of 1-5, as detailed in IAEA Safety Standards Series RS-G-1.9, based on their potential harm to human health. Category 1 sources present the greatest health risk (e.g., the source radiation in a Radioisotope Thermoelectric Generator), and Category 5 the lowest (e.g., the source radiation for X-ray fluorescence devices).[7] 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, a large number of cases in the CNS database do not have a listed IAEA category. Of those that were categorized, few involve the most dangerous category of radioactive sources; only three Category 1 cases were reported in 2013, none were reported in 2014, and two cases were reported in 2015.

Figure 3. All Incidents by IAEA Category (2013-2015)



The IAEA categorization system does not take into account ease-of-access to specific types of radioactive materials. Some radioactive material is very difficult to access and is encased in a device that normally remains stationary, while other devices facilitate transport. Moisture density gauges, which typically contain cesium-137 and americium-241 sources that are less than Category 3, were involved in the majority of incidents specifying a device. These gauges are widely used in a variety of industrial applications, frequently at remote or temporary locations requiring regular transport to and from job sites.

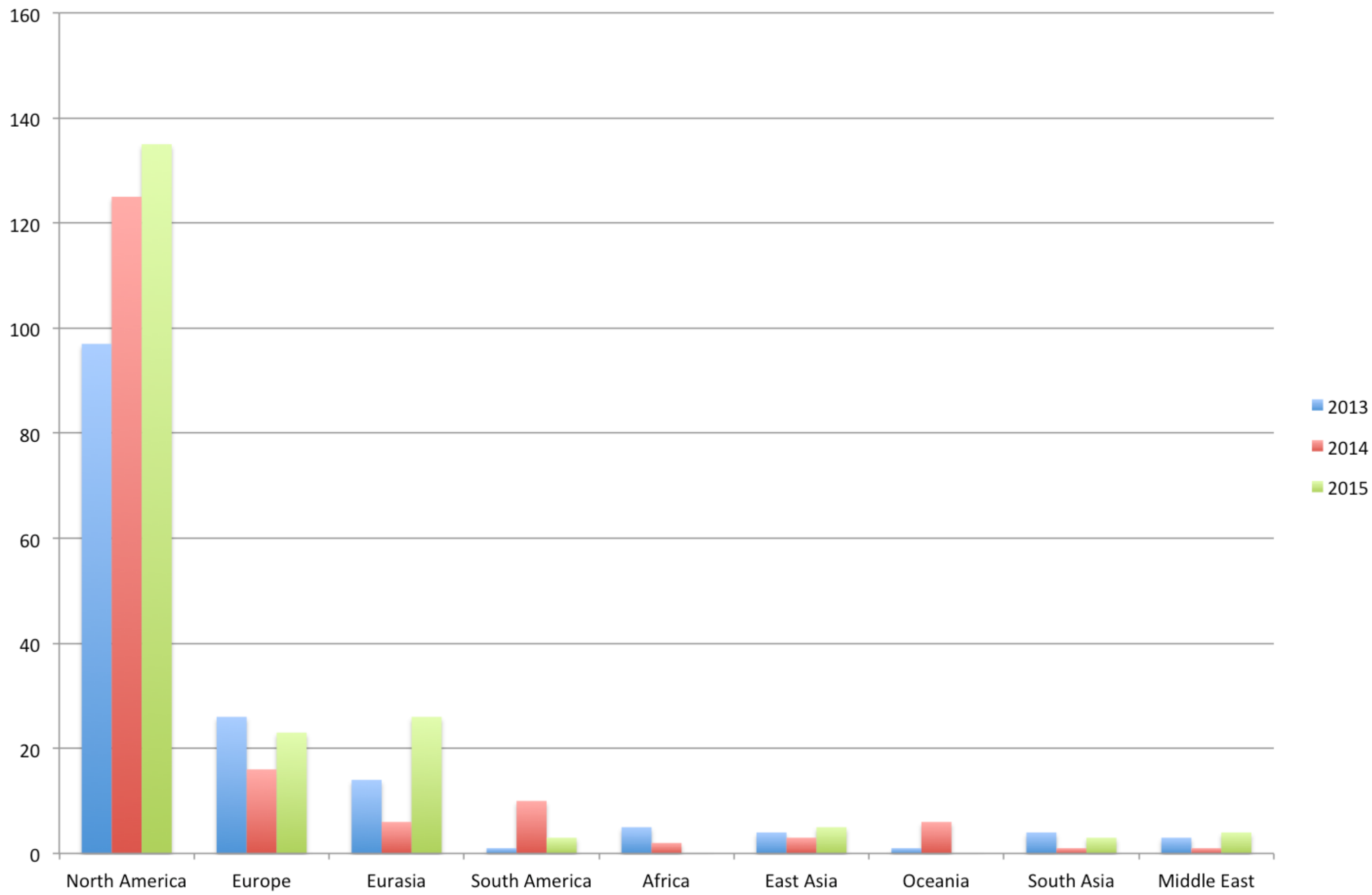
[7] "Categorization of Radioactive Sources," IAEA Safety Standards Series RS-G-1.9, International Atomic Energy Agency, Vienna, 2005, p.6, www.iaea.org

III. Key Findings and Policy Implications

Key Finding 1: Highly Variable Reporting

Over the past 3 years, CNS has recorded 514 incidents involving nuclear and other radioactive materials outside of regulatory control. Of these incidents, 188 occurred in 2015 in 26 different countries. As in past years, the majority of the cases from 2015 were reported in North America (66.3%). The United States had the highest number of reported cases (59.4%), followed by France (5.9%), Canada (5.9%), Ukraine (5.3%), and Russia (5.3%).

Figure 4. Reported Incidents by Region 2013-2015



One of the explanations for the disproportionately high number of reports from North America, as opposed to the rest of the world, is that the United States and Canada are among the five countries whose governments engage in public reporting of incidents. The level at which governments participate in public reporting varies, but the countries whose governments issue any form of report are the United States, Canada, France, Australia, and Belgium.

The level of global reporting is noticeably inconsistent and presents a generally incomplete picture. There are a variety of factors that could explain the scarcity of reports in certain regions, the simplest of which being the existence of fewer nuclear and other radioactive materials. However, governments may not always catch incidents occurring on their territories, and if they do they may choose not to publicly report on them. The majority of the cases over the past three years have consistently come out of comparatively wealthy industrialized democracies, which frequently have the most robust reporting mechanisms.

Policy Implication 1: Assistance and Standardization

Improving reporting of incidents and trafficking cases worldwide would better inform assessments of the current status of global nuclear security. The failure to report incidents could have a number of explanations. In some cases, authorities choose to withhold information from the public. In other cases relevant authorities simply do not have the resources or knowledge to effectively regulate and control radioactive materials and may be unaware of the incidents that take place.

Identifying a standardized set of criteria for what characterizes an incident would benefit the process of comparative analysis. It is evident that there are some types of cases that countries like the United States report on which other countries do not consider worth reporting. For example, while the Canadian government published a 2015 report on radioactive incidents, it did not include any cases involving contaminated material. It is unlikely that over the course of an entire year there were no instances detected of radioactive contaminated material. Instead, the Canadian Nuclear Safety Commission (CNSC) report only contains incidents of "losses and thefts of licensable sealed sources and radiation devices,"[8] a much more limited set of criteria than those guiding the United States NRC reports. If all countries were to report incidents and trafficking cases based on a single set of criteria, analysts could more thoroughly assess regional and global progress in securing the various types of nuclear and other radioactive materials.

While assistance and advisory programs for nuclear security can help to address the lack of reporting from certain countries, addressing the reluctance of some countries to report due to security and media censorship concerns is more difficult. Such countries should be encouraged to assist in global nuclear security efforts but are unlikely to change their reporting methods. Additionally, it is possible that some countries refrain from publicly reporting on radioactive incidents because they fear inciting "radiophobia"[9] among their people. This can be addressed by increased educational efforts to spread understanding of the effects of radioactive materials on the human body, as well as the measures necessary to protect human health. Greater public awareness may also result in governments applying stricter standards or better enforcing laws regarding the security of nuclear materials.

[8] "Reports on Lost or Stolen Sealed Sources and Radiation Devices." Canadian Nuclear Safety Commission. Accessed March 11, 2016. www.nuclearsafety.gc.ca

[9] The term "radiophobia" comes from Igor Khripunov (ed.), "The Human Dimension of Security for Radioactive Sources." CITS/UGA and Indonesia's National Nuclear Energy Agency, Editor. 2014, cits.uga.edu

Key Finding 2: Theft, Trafficking, and their Relationship with Transport and Physical Security Vulnerabilities

The theft and trafficking of nuclear and other radioactive material offer a primary means by which terrorists or other illicit actors might obtain the material necessary to build a radiological dispersion device (RDD). While there has been no major use of an RDD as of yet, the information gathered from the CNS database suggests potential pathways these groups could exploit in order to obtain such material.

Out of the 188 total cases that occurred in 2015, 45 cases were related to theft and trafficking. From these cases, a majority (80%) involved devices with industrial uses, less than half of which were reported recovered. All recorded trafficking cases occurred outside of the United States (in Ukraine, Colombia, and Moldova).

An examination of the circumstances surrounding the theft and trafficking of radioactive materials can shed light on existing vulnerabilities in security controls. Moreover, many of these incidents occurred while the radioactive material was in transit; therefore, improving material protection standards for devices in transit may help limit unsanctioned access to sensitive material.

Theft

Thefts accounted for just under a quarter (22%) of the incidents that occurred in 2015. Of these cases, slightly over half of the incidents involved the theft of industrial gauges or machines like moisture density gauges (17 cases; 41%), and x-ray fluorescence analyzers (8 cases; 20%). An examination of the locations and circumstances involved in these incidents provides helpful insight as to why and how the thefts occurred.

Industrial use items such as moisture density gauges (MDG) and x-ray fluorescence (XRF) analyzers are expensive tools (costing between $4,000 and $18,000 USD), and are used for many purposes, including on construction sites. Of the cases involving such equipment, 58% of the thefts occurred while the items were in transit, with 68% of thefts in transit involving vehicles which were unattended during the time of the theft.

Although perpetrators were rarely identified, the circumstances surrounding many reported thefts indicate that a majority of them were crimes of opportunity carried out by outsiders. The question remains however, as to whether there is an existing "black market" for items that contain regulated material.

One case in the Colombian capital of Bogota provides rare evidence of the potential existence of a black market for such items (CNS Incident #2015525). In this case, two men were arrested for the theft of a moisture density gauge. After their arrest it was discovered that they intended to smuggle the gauge into Brazil and sell it for "a large sum of money." If their confession is considered reliable, it would imply that these two men had arrangements in Brazil to offload the stolen gauge in a black market transaction. However, it is equally possible that these men were not being truthful or were opportunists, with only a vague understanding that they could potentially sell stolen items in another country.

Trafficking

A small number of the cases have been linked to the trafficking of radioactive materials. In 2015, there were 3 cases of trafficking, with one of them involving the intention of trafficking material to ISIS for use in a dirty bomb. All of these cases ended in arrests.

Moldova:

In February 2015, smugglers were arrested as they attempted to sell Cesium to an undercover agent posing as a buyer. After producing a vial of CS135, police arrested the three men and secured the material. One of the smugglers expressed his hope that the material would be used by ISIS for a dirty bomb against U.S. citizens[10]. These men were associated with a criminal organization and claimed to have access to CS137, which would have been more optimal for an RDD than CS135. (CNS Incident #2015417)

Ukraine:

In August 2015, four men with suspected ties to criminal organizations were arrested by the Ukrainian Security Service (SBU) after an attempt to sell what was claimed to be U238. They were apprehended trying to move across Ukraine's border with Romania. (CNS Incident #2015454)

Colombia:

In September 2015, police in the Colombian capital of Bogota arrested two men carrying stolen radioactive material. The two men confessed that the material was stolen from a laboratory in Santiago de Cali and they intended to sell it in Brazil for a large amount of money. Police evacuated the location and conducted reviews of the area. After a close examination of the video of the arrest, the material in question was identified as a moisture density gauge. (CNS Incident #2015525)

Transport and Physical Security Vulnerabilities

The cases of theft and trafficking illustrate that the physical security regulations currently implemented in many countries leave radioactive material vulnerable to illicit actors. The 2015 dataset reinforces the finding in previous reports that these materials and devices are particularly vulnerable during transport. The database draws distinctions between two categories of theft: The first specifies the location of the material, and includes "theft from fixed site" (35 incidents total since 2013; 10 in 2015); "theft from individual" (3 incidents since 2013; 1 in 2015); "theft from vehicle" (50 incidents since 2013; 12 in 2015); "theft with vehicle" (20 incidents since 2013; 10 in 2015); or "unknown" (45 incidents since 2013; 8 in 2015). The second specifies whether the material was "attended" (5 incidents since 2013; 2 in 2015) or "unattended" (64 incidents since 2013; 20 in 2015) when the theft occurred.

As in 2014, nearly half of all documented incidents in 2015 involved material in transit. Of the 133 thefts recorded in the database cumulatively, more than twice as many incidents occurred while in transit (74) as did from a fixed location (35). Further, in nearly 60 percent of thefts during transit, the material was unattended when the theft occurred. Unsurprisingly, the majority of radioactive sources stolen or lost during transit are contained within small, portable devices such as radiography cameras (typically Category 2 sources) and

[10] Kelsey Davenport, "Smugglers Arrested in Moldova", Arms Control Association, November 2015, www.armscontrol.org

moisture density gauges (typically Category 3 and below). These devices are commonly used at temporary job sites, and therefore require frequent transport by operators between designated storage locations.

Recovery Rate Data

While measures to prevent material from falling out of regulatory control are essential to any comprehensive security regime, detection and response mechanisms to re-establish control over lost or stolen materials are equally important. The IAEA notes that recovery rates for high-risk radioactive sources are typically high given concerted efforts to recover them.[11] In the CNS database, recoveries were reported in 18 of the 22 incidents involving Category 1 or 2 sources. For lower category sources, recoveries were only reported in about 29 percent of the incidents.

Recovery rates should not be taken out of context. In the absence of substantial public interest in an incident, recoveries are often not reported. In addition, although it may be mandatory in some countries to report materials that have fallen out of regulatory control, reporting on whether they are recovered is often discretionary. When reported however, recovery methods can illuminate a great deal.

While most accounts of recovery methods recorded in incident reports included information on whether licensees contacted local law enforcement to report a loss or theft, details on subsequent investigations were usually scarce. A small number of cases specified response measures such as offering a reward for the device's return, notifying local vendors, or alerting surrounding districts. In cases where details on the recovery process were provided, it appears most relied heavily on physical searches, anonymous tips, and a fair amount of luck.

In one case collected in the 2015 database, when a Category 2 IR-192 source was reported stolen from a vehicle in Cárdenas, Mexico, the source was recovered nearly ten days after Civil Protection agencies, the Ministry of Defense, the Secretary of the Navy and Federal Police were alerted to the theft (CNS Incident #2015443). The source was found abandoned under a bridge only after authorities were alerted through a phone call reporting the discovery of a suspicious looking device.[12] In another incident in the Russian Republic of Tatarstan, a metal container holding a capsule containing a radioactive Plutonium-Beryllium neutron radiation source was discovered by a local resident nearly three weeks after it went missing from the AMK "Gorizont" research and production company (CNS Incident #2015517).

In another incident widely covered by the media, a Radiography camera containing a small capsule of IR-192 was stolen from a storage facility in the city of Basra, Iraq in November 2015.[13] The proximity of the storage facility to territory held by the terrorist group ISIS, as well as the fact that prolonged exposure to IR-192 can be particularly dangerous, makes this a notable incident. The material was found nearly four months later, dumped

---

[11] International Atomic Energy Agency, "IAEA Incident and Trafficking Database (ITDB)," Fact Sheet, 2014, www.iaea.org

[12] El Pais, "México alerta de un robo de material radiactivo peligroso," April 16, 2016 ; Informador, "Recuperan material radiactivo robado en Tabasco," April 22, 2015; DW, "Stolen Radioactive Capsule Found in Mexico," April 22, 2015.

[13] Ahmed Rasheed, Aref Mohammed, and Stephen Kalin, "Exclusive: Radioactive material stolen in Iraq raises security concerns," Reuters, February 17, 2016, www.reuters.com

behind a gas station in the village of Zubair, roughly nine miles southwest of Basra.[14] Notably, the radiography camera was found intact, with the radioactive source still inside its protective container.[15]

In other cases, sources were discovered by ordinary citizens before an official recovery process was even initiated. In New Iberia, Louisiana, a radiography camera containing a Category 2 IR-192 source was recovered by a citizen who discovered it in the weeds of a parking lot before the licensee could return to search for it (CNS Incident #2015366). These unsystematic responses and inconsistent rates of recovery illustrate the shortcomings of current protocols for the recovery of radiological sources that have fallen out of regulatory control. They also reveal the ease with which someone with nefarious intentions could steal these devices without fear of immediate pursuit.

Policy Implication 2: Security and Tracking

Since the first Nuclear Security Summit (NSS) in 2010, awareness of the need to implement stronger radiological security measures has increased globally. However, while the IAEA offers guidance, states are under no obligation to follow its recommendations, and there are still no international instruments that set enforceable standards for methods to secure radioactive materials. As a result, national regulations governing the security of radioactive materials continue to vary widely.

While the importance of securing radiological sources has been recognized within the NSS context,[16] much of the focus remains on Category 1 and 2 sources. Following the 2014 NSS, for example, a group of 23 states committed to secure all IAEA Category 1 radioactive sources in their territories by 2016,[17] including through implementation of the IAEA's *Code of Conduct on the Safety and Security of Radioactive Sources*, which pertains to Categories 1-3 sources.[18] While much progress has been made to achieve this important goal,[19] international efforts to implement security measures for radiological sources designated below Category 3 remain limited.

The need to improve detection and recovery efforts for lower category radioactive sources that have fallen out of regulatory control has led to renewed efforts to track and locate these sources. Since the 2014 report, an NNSA-funded project to develop technology for tracking mobile radioactive sources has progressed to the pilot stage.[20] Using Bluetooth, Wifi, and satellite-based GPS tracking, the Mobile Source Transit Security System (MSTS) will provide tracking for portable well-logging equipment containing sealed radioactive sources including Cs-137 and Am-241 Be.[21] Notably, the MSTS employs both an "etag," which is attached directly to the source's shield and includes a "built-in tamper-detection sensor," as well as an "rtag" used to measure levels of

---

[14] "Some 'Highly Dangerous' Radioactive Material that Went Missing in Iraq has Been Found," Vice News – by Reuters News Agency, February 21, 2016, news.vice.com
[15] Ibid
[16] "Security of Radioactive Sources," Nuclear Security Summit, March 30, 2012, pgstest.files.wordpress.com
[17] "Statement on Enhancing Radiological Security," Nuclear Security Summit, March 24, 2014, pgstest.files.wordpress.com
[18] "Code of Conduct," International Atomic Energy Agency, www.iaea.org
[19] Michelle Cann, Kelsey Davenport and Jenna Parker, "The Nuclear Security Summit: Progress Report on Joint Statements," Arms Control Association and Partnership for Global Security, March 2015, pgstest.files.wordpress.com
[20] Pacific Northwest National Laboratory (PNNL),"RFID Tracks Radioactive Sources in Oil Industry," National Security Directorate: News Highlights, Last updated January 2016., www.pnnl.gov
[21] Claire Swedberg, "RFID Tracks Radioactive Materials Used by Oil Services Providers to Explore New Well Sites," *RFID Journal*, May 18, 2015; Henry Rosen, "Oil and Gas Industry Developing New Technology-Based Tracking for Radioactive Sources." Geoforce Blog, September 29, 2015, www.geoforce.com

radioactivity within the vehicle and thereby detect the source's presence.[22] A successful, commercially available MSTS system could greatly improve physical security standards for portable radioactive sources as well as recovery methods in the event of their loss or theft.

While the 2014 data highlighted a greater need for direct-source tracking rather than general GPS tracking for vehicles transporting radioactive sources, a decrease in the gap between "thefts with vehicle" (10 in 2015; 6 in 2014) and "thefts from vehicle" (12 in 2015; 27 in 2014) indicates that GPS tracking for vehicles could also be an effective recovery measure. Even so, other cases in the 2015 dataset make clear that GPS tracking on the vehicle alone is not sufficient. When a truck containing a moisture density gauge with a sealed CS-137 and AM-241 source was stolen off a construction site near San Juan, Puerto Rico, the vehicle was recovered within a day; however the source remains missing (CNS Incident #2015365). In such a case, direct source tracking would have been useful to help recover the device.

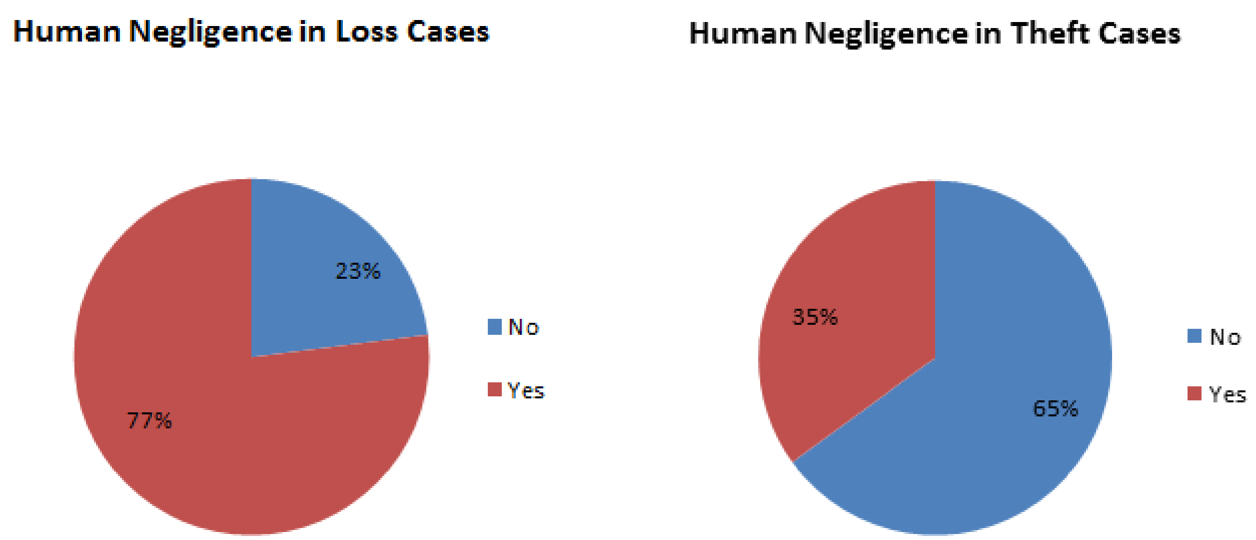
While the pairing of GPS tracking systems with radioactive sources and their transport vehicles may help improve current recovery methods, it must be noted that a nefarious actor seeking to steal these sources might have the aptitude and cognizance to disable GPS systems, and thereby evade rapid detection. Establishing appropriate security measures, improving security culture, and reducing incidents involving human negligence are therefore essential to preventing these sources from falling into the wrong hands in the first place.

[22] Claire Swedberg, "RFID Tracks Radioactive Materials Used by Oil Services Providers to Explore New Well Sites," RFID Journal, May 18, 2015., www.rfidjournal.com

Key Finding 3: Human Negligence

Over half of the incidents reported in the 2015 database occurred due to human negligence. Primarily associated with cases involving lost radioactive material, negligence also contributed to 35 percent of the cases of theft.

Figure 5. Human Negligence Loss/Theft Cases, 2015



The high percentage of incidents in which human negligence is a factor indicates the necessity for the establishment of a stronger security culture, reinforced by improved training and regulations. Indeed, nearly all of the reported loss cases could have been avoided with stricter adherence to safety and security guidelines when handling and processing radioactive materials. Negligent reporting and lax inventory controls are among the leading causes of reported loss cases. For example, in October 2015 the Andrew W. Breidenbach Environmental Research Center was asked to locate two aerosol neutralizers that had been delivered to their facility in 1977. After an extensive search, the Cincinnati office of the U.S. EPA was unable to locate the devices or identify any record of the devices after 1983 (CNS Incident #2015500).

Additionally, lack of proper storage protocols and negligent handling of sources containing radioactive elements was identified as a leading cause of loss cases in the 2015 database. In these incidents, workers failed to handle the devices with the necessary precautions required for a piece of equipment with a radioactive component. For example, in November 2015 an authorized employee of Taney Engineering Inc. reported that a moisture density gauge went missing from the back of his truck somewhere between his trip to Walmart, Buffalo Wild Wings, and a grocery store (CNS Incident #2015505).

A lack of proper storage protocols and negligent handling of radioactive devices was also a contributing factor in a large percentage of theft cases, many of which were incidents where proper storage would have prevented the theft. Frequently, the stolen radioactive material or device was left unattended or improperly secured in a worker's car, or in an unsecure location at a job site. In one example, a radiography camera containing an IR-192 source fell off the bumper of a truck in Louisiana when two employees transporting the device failed to secure it to the vehicle's rig. Environmental, health and security agencies were notified and radiation detection instruments were employed before the device was recovered (CNS Incident #2015431).

Shipping of radioactive material was also identified as an area in which human negligence has posed security concerns. Delivery failure was cited in at least 19 NRC cases in 2015. While these cases cannot be directly attributed to human negligence without greater detail on how the package was misrouted, more stringent shipping policies for radioactive materials might help reduce the number of loss cases. Understandably, shipping mistakes pose the greatest risk when involving materials with higher radioactive isotopes and in larger quantities. Of the six incidents in the 2015 database involving a radioactive material with an IAEA classification of 1 or 2 in which negligence may have played a key role, in four of these cases the error was made in the process of shipping the radioactive material. In one case reported in February 2015, three containers of Category 1 quantities of IR-192 were mistakenly shipped to Baton Rouge, LA instead of their intended destination of South Korea (CNS Incident #2015348).

Policy Implication 3: Strengthening Inventory and Security Protocols

Security systems are only as effective as the people who run them. Without proper training for employees and respect for security regulations even the most advanced security system is rendered useless. According to the former commander in chief of U.S. Strategic Command Eugene Habiger, Gen, USAF-Ret. "good security is 20 percent equipment and 80 percent culture."[23] In flagging the prominence of human negligence in incidents associated with loss or theft, the 2015 trafficking database highlights gaps in the existing security culture associated with the handling of radioactive materials and their devices.

An examination of the data since 2013 also indicates a troubling lack of accountability and improvement. Accountability is rarely reported, and the recurring nature of similar negligence cases over the past three years indicates a lack of improvement or adaptation of security protocols. The policy focus for radioactive material protocols should emphasize measures to address negligence as opposed to simply strengthening penalties. Harsher penalties might only reduce the rate of self-reporting as opposed to rectifying the problem. With stronger security guidelines it might be possible to reduce the number of opportunities for negligent acts that result in lost or stolen radioactive material.

Closely related to security policy improvement is the need for increased training for custodians of radioactive materials, both in matters of security and inventory. An increased understanding of the importance of preventing the loss or theft of radioactive materials is imperative to help curb the frequency of these incidents.

[23] "Strengthening Global Approaches to Nuclear Security." Paper presented at the International Conference on Nuclear Security: Enhancing Global Efforts - International Atomic Energy Agency, Vienna, July 1, 2013. Belfercenter.ksg.harvard.edu

Key Finding 4: Material Minimization

Over half of the total incidents captured in the CNS database involved sources used in industrial and medical applications, some of which involved high-risk radioactive sources. Nine incidents involving Category 1 or 2 sources were recorded for 2015, six of which involved sources used in industrial applications. Portable radiography cameras containing Iridium-192 accounted for all six cases involving industrial radioactive sources. Iridium-192 is among the radionuclides that have been labeled as security concerns by the U.S. government because of possible application in radiological dispersion devices (RDDs).

Of the 130 trafficking incidents that occurred in 2015 with a known IAEA category, about 93% involved sources of Category 3 and below. While an RDD built from a Category 3 or below source is unlikely to cause fatalities, it could cause significant economic disruption, including panic and property damage.[24] Further, large quantities of lower category materials may be re-classified under a higher category given the increased risk posed by a higher volume.[25] Some experts recommend including Category 3 sources in the high risk grouping, especially when a large number of such sources are combined.[26] Disposal of these lower category sources also remains a challenge, since they "exist in large quantities around the world in different forms and variations."[27] Despite this concern, little attention is being paid to technology alternatives for Category 3 and below radioactive sources.[28]

Policy Implication 4: Cost, Efficacy, and Awareness

Minimizing the civilian use of radioactive material that could be used for an RDD is among the most effective ways to reduce the likelihood of terrorists acquiring necessary materials. According to a 2008 National Academy of Sciences (NAS) report, non-isotopic replacements "exist for nearly all applications of Category 1 and 2 [radioactive] sources." Considerations should be given to the economic, technical, operational, and social feasibility of alternative technologies.

Efforts to replace high-risk radioactive sources have increased. At the 2014 Nuclear Security Summit, the United States committed to establishing "an international research effort on the feasibility of replacing high-activity radiological sources with non-isotopic replacement technologies, with the goal of producing a global alternative by 2016."[29] Towards this end, the United States has been working domestically and collaboratively with the IAEA, as well as other countries and international organizations, to explore available alternatives for high-risk radiological sources and to share best practices. Global efforts have focused on non-isotopic replacement technologies. For example, Morocco, Zimbabwe, and Malaysia are replacing cobalt-60 teletherapy units with

---

[24] George M. More and Miles A. Pomper, "Permanent Risk Reduction: A Roadmap for Replacing High-Risk Radioactive Sources and Materials," James Martin Center for Nonproliferation Studies, p. 4, footnote 9, www.nonproliferation.org

[25] U.S. Nuclear Regulatory Commission (NRC), "The 2014 Radiation Source Protection and Security Task Force Report, Report to the President and the U.S. Congress Under Public Law 109-58, The Energy Policy Act of 2005," August 14, 2014, p. 46, www.nrc.gov; Charles Ferguson, "Ensuring the Security of Radioactive Sources: National and Global Responsibilities," US-Korea Institute at SAIS, March 2012, p. 8, fas.org

[26] "IAEA Safety Standards for Protecting People and the Environment: Categorization of Radioactive Sources," IAEA Safety Standards Series No. RS-G-1.9, International Atomic Energy Agency (IAEA), p. 30, Appendix 2; George M. More and Miles A. Pomper, "Permanent Risk Reduction: A Roadmap for Replacing High-Risk Radioactive Sources and Materials," James Martin Center for Nonproliferation Studies, p. 4, footnote 9, www.nonproliferation.org; Charles Ferguson, "Ensuring the Security of Radioactive Sources: National and Global Responsibilities," US-Korea Institute at SAIS, March 2012, p. 8, fas.org

[27] Laura Gil Martínez, "IAEA Reaches Milestone in Disposal of Radioactive Sources," International Atomic Energy Agency (IAEA) Office of Public Information and Communication, January 11, 2015, www.iaea.org

[28] U.S. Nuclear Regulatory Commission (NRC), "The 2014 Radiation Source Protection and Security Task Force Report, Report to the President and the U.S. Congress Under Public Law 109-58, The Energy Policy Act of 2005," August 14, 2014, p. 46, www.nrc.gov

[29] National Progress Report United States of America, Nuclear Security Summit, The Hague, 2014, www.state.gov

linear accelerators; and France, Norway, and Japan are shifting from cesium-137 blood irradiation to x-ray technology. However, few incidents recorded in the database involved high-risk sources; on the contrary, Category 3 and below sources accounted for a majority of the cases. Many of these incidents occurred as a result of loss or theft.

As efforts to explore alternatives for high-risk radioactive materials have grown, it may be worthwhile to place increased emphasis on examining commercially viable replacements for smaller, more portable, and readily concealed sources given their greater susceptibility to loss or theft. As Category 3 and below sources have not been prioritized by the U.S. government or the international community, it may be necessary to reevaluate the priority levels for source replacement, taking into account the physical ease with which these lower category sources can be lost or stolen.

The 2014 NRC report names a "lack of awareness by users, [and] the often higher cost of new technologies and efficacy of replacement technologies" as the major reasons why alternative technologies for radionuclides are used on a case-by-case basis rather than more widely.[30] These reasons are addressed below.

Cost

As suggested in a July 2015 CNS Occasional Paper, governments can address the problem of the often high costs of non-radioactive substitutes and the training required prior to their use through economic incentives. Costs of training staff remain an impediment to the widespread use of alternatives to radiographic cameras and blood irradiators housing radioactive sources, two applications in which replacement is most demanded. Governments can provide funding support to countries or international organizations specifically for the use of alternative technologies, as well as offer current and potential users tax breaks to encourage such use where it is viable.[31] A lack of affordable liability policies for high-risk radioactive sources and materials can steer users and potential users from utilizing sources and materials. Governments can educate insurance industries on the risks of using these radioactive materials to guide them away from offering such policies.[32] International organizations and governments can provide, when possible, education and training in the use of alternative technologies to offset this element of the costs that often deters users and potential users from choosing radioactive source replacements. For developing countries, where cancer rates and the demand for radiation treatments continue to rise, activities by international organizations to offset such costs are hugely significant.[33]

Efficacy

Portable x-ray units and small accelerators can replace radiography cameras that contain a radioactive source. However, the physical size of the x-ray units can render them difficult to use in certain applications.[34] A similar situation exists for blood irradiation. X-ray technology and linear accelerators (LINACS) have proven viable replacements for Cesium-137. However, the generation of heat during radiation and difficulties of x-ray tube

[30] U.S. Nuclear Regulatory Commission (NRC), "The 2014 Radiation Source Protection and Security Task Force Report, Report to the President and the U.S. Congress Under Public Law 109-58, The Energy Policy Act of 2005," August 14, 2014, p. v, www.nrc.gov

[31] George M. More and Miles A. Pomper, "Permanent Risk Reduction: A Roadmap for Replacing High-Risk Radioactive Sources and Materials," James Martin Center for Nonproliferation Studies, p. 4, 9, 21, www.nonproliferation.org.

[32] Ibid, p. 21

[33] Ibid, p. 14

[34] George M. More and Miles A. Pomper, "Permanent Risk Reduction: A Roadmap for Replacing High-Risk Radioactive Sources and Materials," James Martin Center for Nonproliferation Studies, p. 14, www.nonproliferation.org.

maintenance remain impediments to the use of these devices.[35] As emphasized in the NRC Report, more research and development must be done to create alternative technologies for devices, particularly those containing Category 1 and 2 sealed sources.

Awareness

Social media can play a role in the international promotion of alternative technologies. Government agencies, national and international industries, and professional society groups can promote these technologies.[36] Social media, much like in the nonproliferation and disarmament fields, can serve as an effective medium through which these entities can raise levels of awareness and technical knowledge of issues associated with and dangers that can result from using radioactive sources, as well as the existence of replacement technologies.

While governments should continue to focus efforts on the minimization and replacement of high-risk radioactive sources, the immense volume of cases in the CNS database that involve lower category sources suggests that governments must expand their efforts with regard to reducing the use of lower category radioactive sources. Governments should adopt methods, such as economic incentive programs, to make the use of replacements more appealing to users and potential users. International organizations and governments can help users and potential users offset educational and training costs. These actors, as well as relevant professional society groups should utilize social media to raise global awareness of existing alternatives. International organizations and governments should continue to invest efforts in research and development programs to develop replacements in applications where feasible ones do not already exist.

[35] George M. More and Miles A. Pomper, "Permanent Risk Reduction: A Roadmap for Replacing High-Risk Radioactive Sources and Materials," James Martin Center for Nonproliferation Studies, p. 5, 8, www.nonproliferation.org.
[36] Ibid, p. 21-22

IV. Conclusion

Loss of regulatory control over dangerous nuclear or other radioactive materials is an issue of serious concern for public safety and security. Yet a review of the incidents found in this year's database and the recommended measures to prevent them illuminates distressing trends similar to those found in previous years' data. Lax government reporting and oversight, negligence, and a lack of political will and resources are common threads winding through three years of global incident data.

Most governments do not systematically gather and publicly report on incidents occurring on their territory, which obscures the extent of the problem. Low overall incident reporting also means the public may become overly alarmed when incidents are reported by journalists, who frequently do not understand the context or basic science behind the threats associated with nuclear and other radioactive materials.

Non-nuclear radioactive materials and equipment are lost, misdirected, or stolen at an alarming rate. Yet in many if not most incidents, commonsense security measures such as locking shipping containers, conducting inventories, or ensuring valuable materials are attended at all times would have prevented the loss of the items. A renewed emphasis on operator and direct supervisor training could improve this situation at a very low cost in both time and money.

The most effective way to prevent the use of nuclear and other radioactive materials in terrorist attacks is to reduce the quantities in circulation. Solutions to replace many of the most dangerous (Category 1 and 2) sources with safer alternatives exist today and can be implemented with a straightforward investment of capital and regulatory effort.

The trafficking incidents recorded in 2015 demonstrate that there are criminals who will eagerly sell nuclear or other radioactive material to the highest bidder. Last year, it was public law enforcement officials in three of the poorest and most corrupt[37] countries in the world who were responsible for stopping these crimes. If the risk of nuclear terrorism truly is the biggest security threat facing the world today, surely greater global efforts should be made to prevent nuclear and other radioactive materials from falling into the wrong hands.

[37] Beddow, Rachel, ed. "Transparency International, Global Corruption Perceptions Index 2015." *Berlin, Germany: Transparency International* (2016).

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, 2015
- CNS researchers conducted global searches in 14 major languages. Use of these languages also enabled in-depth native language searches for incidents in 91 countries.
- Researchers used a variety of information sources, including 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 subsequent subcategories are explained in the Category Definitions section of the database.

Incidents identified as linked to human negligence in Key Finding (3) are not classified as such in the database. The following guidelines were used to determine whether negligence was a contributing factor in an incident:

- Negligence 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 negligence. If insufficient details were given, the role of negligence was deemed unknown.
- All incidents classified as "loss" were deemed due to negligence 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 negligence 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 communication 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 negligence if the incident report mentioned activities that fit the definition of negligent behavior detailed above.