



Australian Government

Australian Radiation Protection and Nuclear Safety Agency

ARPANSA

Protecting people and the environment
from the harmful effects of radiation

AUSTRALIAN RADIATION INCIDENT REGISTER



**Summary of Radiation Incidents
1 January 2014 to 31 December 2014**



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1 January 2014 to 31 December 2014

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1. Introduction

The Australian Radiation Incident Register (ARIR) is a repository of radiation incident information from Commonwealth, State and Territory radiation regulators. It is intended to raise awareness of radiation safety across Australia.

Schedule 13 of [Radiation Protection Series No.6 \(RPS6\), National Directory for Radiation Protection \(NDRP\)](#) specifies the types of incidents that must be reported to ARPANSA for compilation in the ARIR. Reporting arrangements are agreed by the ARPANSA Radiation Health Committee (RHC) which includes representatives from radiation regulators of each Australian jurisdiction. ARPANSA has no control over the depth of information included in incident reports outside of the Commonwealth jurisdiction.

Further information on the ARIR can be found on the [ARPANSA website](#).

2. Purpose and Scope

This report is a summary and analysis of data submitted to the ARIR for incidents which occurred in 2014.

The purpose of this report is to assist in the identification of topical areas in which safety effort may be focussed and practices to improve radiation protection. Therefore, the focus of this report is the causes of incidents.

Geographical or personal data that may lead to the identification of individuals or organisations is not included in an incident report and does not form part of this analysis.

3. Overall Statistics

The total number of reports the ARIR received in 2014 was 285. These reports were distributed amongst 16 of the 32 groups used to categorise incidents. The table below provides the number of incidents from each group together with numbers from the previous four years for comparison.

Table 1: Overall ARIR statistics for 2014 and the prior four years. Note percentages rounded.

Incident Category	2014		2013		2012		2011		2010		Average 2010-14	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Diagnostic Radiology	167	59%	112	55%	65	58%	57	48%	57	49%	92	55%
Nuclear Medicine	73	26%	52	25%	28	25%	33	28%	28	24%	43	26%
Radiotherapy	14	5%	9	4%	6	5%	10	8%	11	9%	10	6%
Borehole Logging	5	2%	6	3%	1	1%	4	3%	5	4%	4	3%
Industrial Radiography	5	2%	1	0%	0	0%	2	2%	1	1%	2	1%
Contamination	3	1%	3	1%	2	2%	0	0%	0	0%	2	1%
Dental	3	1%	2	1%	1	1%	0	0%	0	0%	1	1%
External Exposure (non-medical)	3	1%	4	2%	2	2%	0	0%	0	0%	2	1%

Incident Category	2014		2013		2012		2011		2010		Average 2010-14	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
High Recorded Dose	2	1%	1	0%	0	0%	1	1%	2	2%	1	1%
Laboratory	2	1%	2	1%	1	1%	0	0%	1	1%	1	1%
Radiation Gauge	2	1%	1	0%	0	0%	1	1%	2	2%	1	1%
Theft of Sources	2	1%	1	0%	0	0%	1	1%	0	0%	1	0%
Laser	1	0%	1	0%	2	2%	1	1%	0	0%	1	1%
Mining	1	0%	1	0%	0	0%	0	0%	0	0%	0	0%
Portable Density/ Moisture Gauge	1	0%	2	1%	0	0%	3	3%	1	1%	1	1%
Transport	1	0%	3	1%	1	1%	1	1%	1	1%	1	1%
Cabinet X-Ray	0	0%	0	0%	0	0%	1	1%	1	1%	0	0%
Consumer Products	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Deliberate or Malevolent Act	0	0%	0	0%	0	0%	0	0%	2	2%	0	0%
Industrial Linac	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Irradiator	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Luminising/ Luminous Device	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Nuclear Safety	0	0%	1	0%	0	0%	0	0%	0	0%	0	0%
Radiofrequency	0	0%	0	0%	0	0%	1	1%	0	0%	0	0%
Sources Found	0	0%	1	0%	0	0%	0	0%	0	0%	0	0%
Sources Lost	0	0%	0	0%	1	1%	2	2%	3	3%	1	1%
Static Eliminators	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Ultraviolet	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Unauthorised Disposal of Source	0	0%	1	0%	2	2%	0	0%	1	1%	1	0%
Unauthorised Possession of Source	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
X-Ray Analysis	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
XRF Source	0	0%	0	0%	1	1%	0	0%	0	0%	0	0%
TOTALS	285		204		113		118		116		167	

The number of incidents reported to the register in 2014 was significantly higher than in previous years. Improved reporting, promoted by proactive communication and requests from ARPANSA, is considered the most likely reason for the increase rather than an actual increase in the number of incidents that have occurred.

Uncertainty over reporting practices and the often limited information contained within the ARIR reports makes it problematic to draw definitive conclusions on trends without additional information that is not available to the ARIR (e.g. levels of actual reporting or number of medical procedures undertaken). ARPANSA has no evidence that the actual number of incidents has increased.

The uncertainties referred to above, two trends appear to be discernible and consistent over the past four years (Table 1 and Figure 2).

- Diagnostic radiology incidents have gradually increased.
- Radiotherapy incidents have gradually decreased as a proportion of overall incidents.

Nuclear Medicine incidents have remained relatively stable.

Overall, medical radiation incidents continue to dominate and accounted for 92% of all incidents reported to the ARIR in 2014. Data from Figure 1 shows that the proportion of medical incidents reported to the ARIR has remained within the range of about 83% to 92% over the past five years.

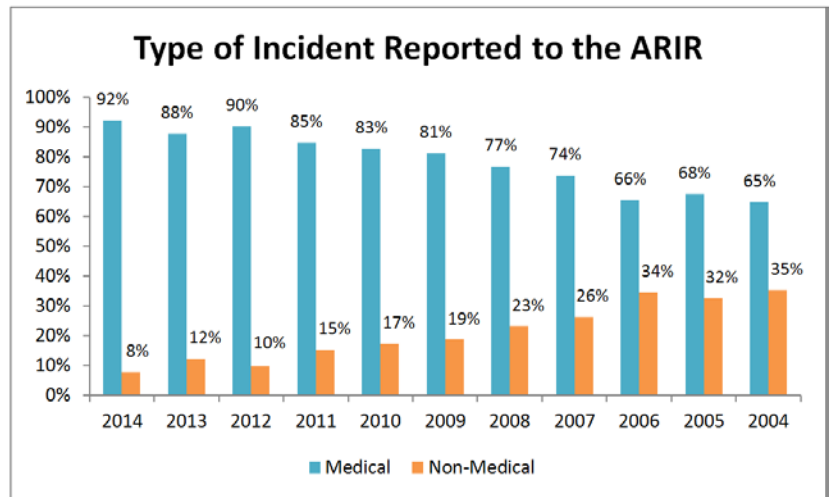


Figure 1 Types of incidents reported to the ARIR since 2004 as a percentage of total incidents for the year.

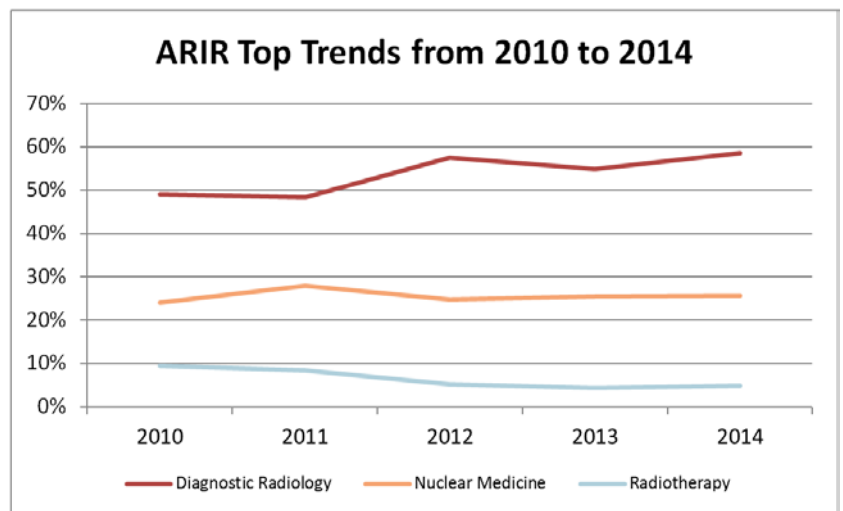


Figure 2: Trends for the period 2010 to 2014. All values are a percentage of the total number of incidents in the year.

4. Causes of Incidents and their Preventions

The largest primary cause of all reported incidents was human error accounting for 211 (74%) incidents. The primary cause of a further 27 (9%) incidents was not identified in the report, but there is a high likelihood that these would also be related to human error. This compares with 16% of incidents where the cause was not identified in 2013.

The full spread of primary causes for all 2014 incidents is:

- Human Error: 211 (74%) incidents
- Unclear: 27 (9%) incidents
- Patient error or factors beyond control: 16 (6%) incidents

- Equipment malfunction: 19 (7%) incidents
- Complicated medical procedure or complications: 7 (2%) incidents
- Equipment deficiency: 5 (2%) incidents

Note: "Patient errors" include incorrect information provided by patients or patients not consenting to the complete treatment plan. Examples include incorrect pregnancy status or patients that will not complete a procedure once it has started. There is no clinical error associated with patient error.

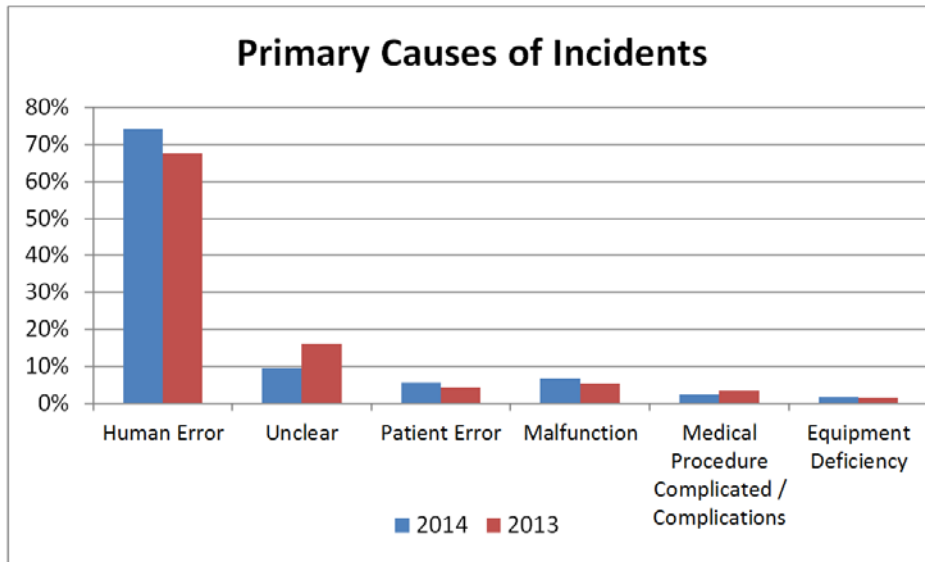


Figure 3: Primary causes of incidents in 2013 and 2014 as a percentage of the total number of incidents in each year.

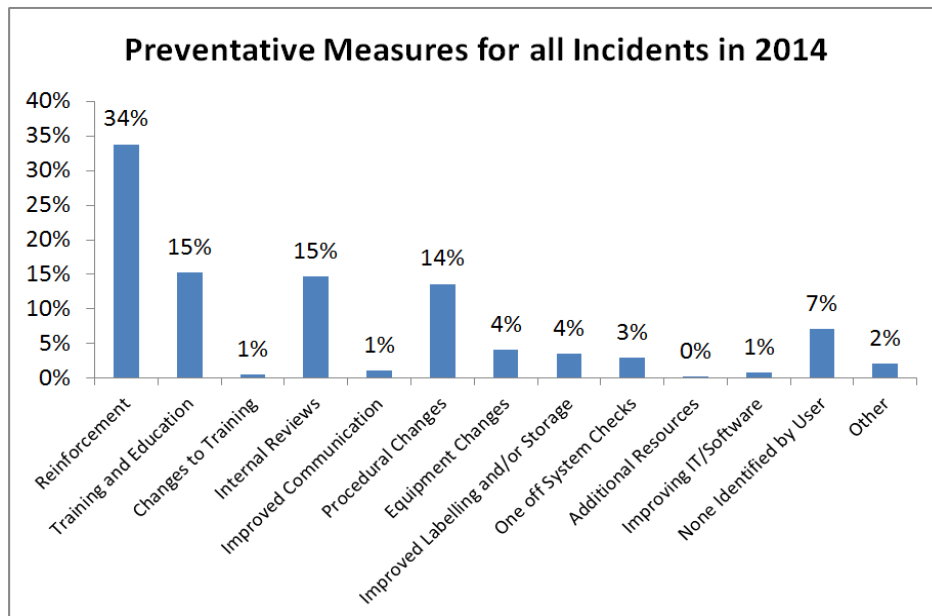


Figure 4: Preventative measures used by an operator/user for all incidents during 2014. All values are expressed as a percentage of the total number of preventative measures in the year.

The primary causes of incidents over the past two years remains similar. There has been a noticeable, 6%, increase in human error and a 7% decrease for “unclear” from 2013 to 2014 as seen in Figure 4. This may be a function of improved reporting. The prevalence of human error as the primary cause was comparable for both medical and non-medical incidents (74% and 77% respectively). However, when the proportion of incidents in which the primary cause is unclear is added to the human error incidents the prevalence of non-medical incidents exceeds medical incidents as seen in Figures 5 and 6 (i.e. 95% for non-medical incidents and 83% for medical incidents).

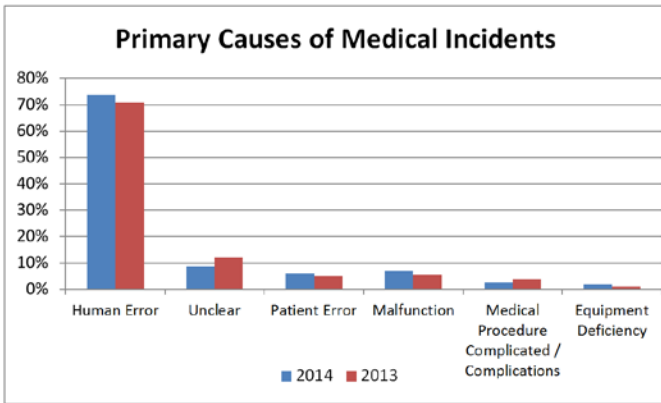


Figure 5: Primary causes of medical incidents as a percentage of all medical incidents in each year

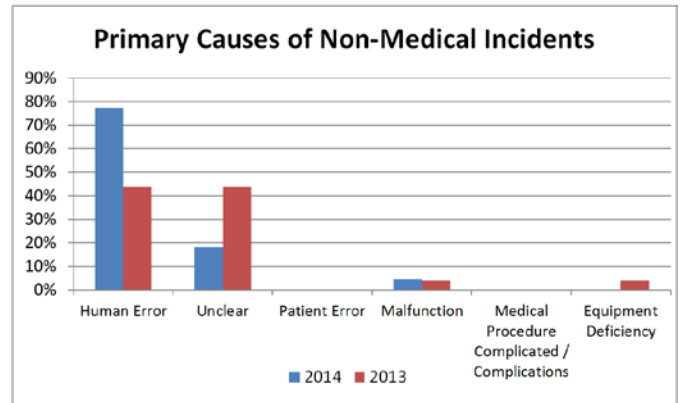


Figure 6: Primary causes of non-medical incidents in as a percentage of all non-medical incidents in each year

Incidents are usually triggered by a specific error, action or failure; the primary cause. However, the incident only occurs when there are underlying weaknesses or failed controls that align so that the consequence of the primary cause is not mitigated; these are contributing causes. Identification of the contributing causes is very important to determine the effectiveness of any safety controls and for the identification of improvements to prevent similar failures in the future. For the 2014 incident reports, the main contributing causes of the incident, as well as the preventive measures actioned by the user/operator, can be seen below in Figures 7 and 8. In addition, these figures show that many ARIR reports don’t describe any contributing causes or preventive measures; for example, contributing causes of non-medical incidents. This is an area where reporting practices should be improved.

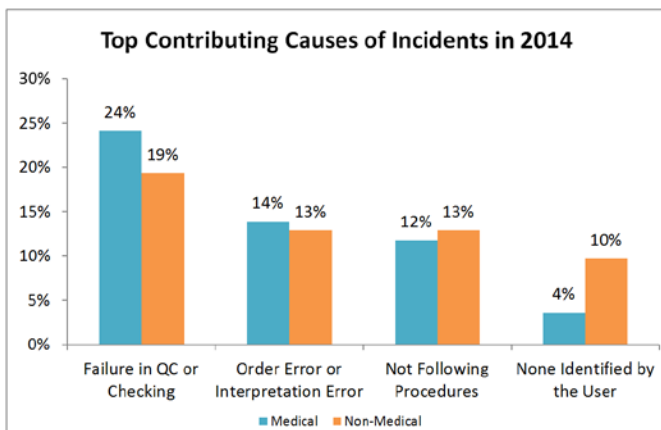


Figure 8: Significant contributing causes of incidents in 2014 as a percentage of all medical or non-medical contributing causes in the year.

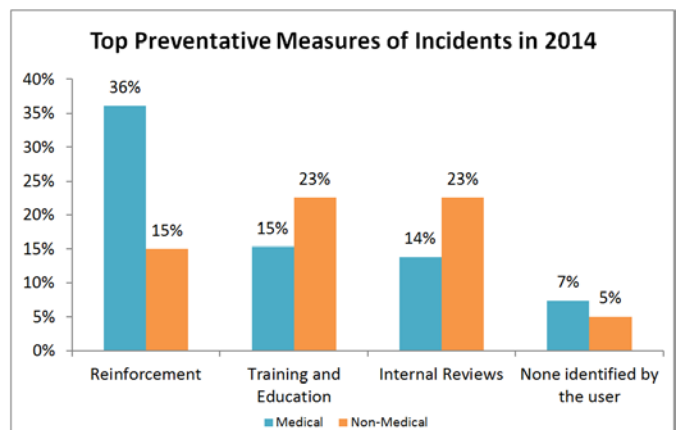


Figure 7: Significant preventative measures of incidents in 2014 as a percentage of all medical or non-medical preventative measures in the year.

The three yearly comparison of preventative measures in Figure 9 indicates that the use of reinforcement or reminders of good practice to staff and internal reviews has trended up somewhat, while decreases occurred in the use of procedural changes and training and education. The causes of these decreases are not able to be determined from the data. Procedural changes, training and education, when implemented effectively, have wider and longer lasting benefit to process safety which will reduce the prevalence of incident and their severity. Procedural changes, training and education are tools used to correct the 'latent' risks highlighted by the incident to a wider worker group than those directly involved.

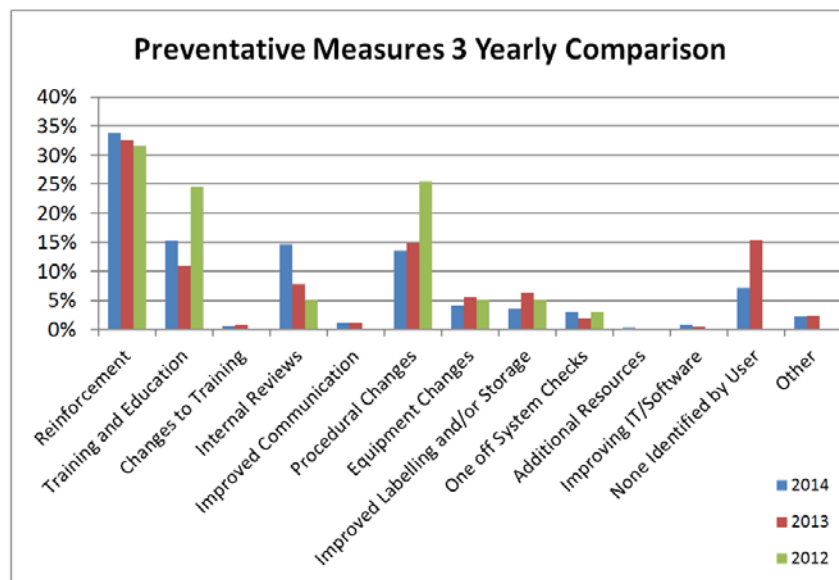


Figure 9: Three yearly comparison of preventative measures. All values are expressed as a percentage of the total number of preventative measures in each year.

4.1. Primary Causes

4.1.1. Human Error

Incident reports stated human error as the primary cause in 74% of all the 2014 incidents. The cause of a further 9% of all incidents was not specified in the incident report but it is possible that the majority of these were also caused by human error.

Analysis of the reports does not always permit the determination of contributing factors that led to the human error. However, only 5% of all the incident reports did not contain sufficient information to determine a contributing cause, an improvement from 2013 where a contributing cause could not be identified in 11% of the reports. The most common identified contributing causes were a failure in quality checks and quality control (23%), errors in orders or in the interpretation of order instructions (13%), not following procedures (12%), patient or equipment labelling errors (6%) (for medical incidents) and unknown pregnancy (6%) (for medical incidents). As a sub-group the contributing causes of non-medical incidents is somewhat different; limitations with IT or equipment (19%); deficiencies with procedures (13%), and; not following procedures (13%). This sub-group has little effect on the overall findings as non-medical incidents only amount to 9% of all incidents that identified human error as the primary cause.

In nearly all (95%) of the incidents that provided some insight on contributing causes, it is apparent that there were multiple failures associated with the incident. In these cases it is quite possible that the incident may not have occurred if some of the contributing causes had been prevented by more effective controls.

A review of the 211 incidents where human error was the primary cause indicates that preventative measures are directed at reinforcement or reminders of good practice to staff (39%), training and education (17%), internal reviews (14%), procedural changes (14%) and equipment changes (3%). Of these preventative measures, the vast majority related to medical incidents which accounted for between 70% and 96%. In a few cases reinforcement/reminders were escalated and formal warnings were issued. One medical incident resulted in the staff member being released and one non-medical incident resulted in ongoing prosecution of the company and staff member (see section 5.4).

Human factors improvements were implemented after some incidents. Many of these were relatively simple to implement. Examples include; improved labelling; rationalised storage of sources, and improvements in communications protocols and procedures.

Only 3% of all preventative measures where human error was the primary cause there was no preventative measures indicated to prevent repeat incidents. Of these, 75% related to medical incidents.

4.1.2. Unclear

There was insufficient data contained in 27 (9%) incident reports received by the ARIR to determine a primary cause of the incident. Information provided to the ARIR is processed beforehand by the Commonwealth, State and Territory regulators to remove any identifying information. An inability to determine the cause from the ARIR data does not imply that an incident has not been properly investigated within its own Commonwealth, State or Territory jurisdiction.

ARPANSA is currently reviewing reporting requirements with the aim of capturing better information through an electronic reporting system. This system will be used to encourage improved reporting and analysis of incidents that can be used to aid learning.

4.1.3. Patient Error or Factors Beyond Control

There were 20 instances reported of medical procedures to patients who were unknowingly pregnant at the time. From information provided in the reports there was no clinical error made in performing 18 of the procedures. In two of these incidents the patient was not asked if she was pregnant.

An example of a patient error incident occurred when a patient and their carer, both with limited English, incorrectly responded to another patient's name and incorrectly received a bilateral feet x-ray. Following this incident the need to understand and communication was emphasised to the carer to prevent such occurrences.

Another incident involved a nuclear medicine patient that was administered with 410 MBq of technetium-99m (Tc-99m) but refused to be imaged with the gamma camera. While the patient was in the imaging room they complained of discomfort lying on the imaging bed. Medical staff offered the patient extra pillows, an oxygen mask and a sedative while reiterating the importance of the imaging scan for their diagnosis. The effective radiation dose from the radiopharmaceutical administration was 3.2 milli-Sieverts (mSv). The operator considered that the medical staff behaved appropriately and therefore did not initiate any preventative measures.

4.1.4. Equipment Malfunction

The reported incidence of equipment malfunction leading to a radiation incident was low at 7% of all incidents in 2014. Equipment in non-medical sectors usually fails safe with no exposure to people whereas equipment failure in the medical sector is often associated with an unnecessary dose to the patient. This is because the medical procedure has often been started when the failure occurs and therefore needs to be repeated.

95% of reported incidents where there was a malfunction related to medical incidents. No common failure of equipment was identified in the data submitted to the ARIR.

A total of nine incidents were attributed to computer tomography (CT) malfunction. It was difficult to conduct any trend analysis over the past two years, due to the low incidence and spread of different types of CT malfunctions. An example of one incident was where a positron emission tomography CT scanner failed to operate after three patients had been injected with 250 to 300 MBq of Fluorine-18 fluorodeoxyglucose (FDG). This was due to a failure of the hard drives on the computer that stored the raw data produced by the CT scanner. Repairs to the hard drives of the CT scanner could not be completed in time to scan the patients.

For the x-ray system related failures, the most common type of malfunction was related to software (two incidents). X-ray system malfunctions have remained constant for the past two years at five incidents.

Outside of the medical industry there was one incident where an iridium-192 industrial radiography camera malfunctioned and unnecessarily exposed the workers. Specifically, the malfunction occurred when a worn control cable (winding gear) connection end allowed the worker to rotate the locking mechanism from 'connect' to 'operate' positions without connecting the control cable to the isotope pigtail. As a consequence the isotope was pushed from the source projector and was unable to be retracted. Workers were exposed to radiation when they recovered the source by placing it in a lead pot. The maximum radiation dose received by one of the seven workers was 24.1 mSv. Following the incident, the operating company removed the failed equipment from service, tested all other similar equipment (including misconnection tests). The company also reviewed the maintenance of equipment to ensure procedures are followed, distributed a safety alert to all workers and conducted refresher training for workers.

4.1.5. Medical Procedure was Complicated or Complications

During 2014 there were seven medical incidents (or 3% of all medical incidents) where the primary cause was attributed to the medical procedure being complicated or there were clinical complications during the procedure. Each resulted in the patient receiving a higher than expected skin dose in the range of 7.1 mGy to 10 Gy (Gray). Of these incidents, one mentioned that acute skin effects were observed which resulted in radiation induced epilation (loss of hair). Erythema (local abnormal redness of the skin) was not observed or not described in six of the incident reports. Two incident reports described the use of preventative measures training and education and an internal review. No preventative measures were described for five incidents.

4.1.6. Equipment Deficiency

Of the five incidents (or 2% of all incidents) where the primary cause was attributed to equipment deficiency, all were related to nuclear medicine medical incidents.

Of these incidents, four were caused by failed/defective batches of radiopharmaceuticals. The supplier was contacted in three of these incidents to investigate these failures. Problems with the suppliers' quality control were reported to have been a contributing cause in two incidents. However the incident reports didn't include detailed information on the findings of the supplier for these cases. The estimated effective doses received as a result of these incidents ranged from 1 mSv to 10.5 mSv. Following these incidents, the most common preventative measures actioned were internal reviews, procedural changes and equipment changes.

5. Incidents by Category

This section reviews category specific data for incidents reported in 2014. Most incidents reported were medical incidents with causes associated with a range of medical practice that are not specific to radiation incidents. Descriptions of incidents within the various sub-categories are described if the radiation exposure or lessons learnt are considered significant.

5.1. Diagnostic Radiology: 167 Incidents

Of the 167 reported incidents in diagnostic radiology, 59% involved CT scans, 36% involved x-ray scans and fewer than 5% involved surgical procedures with x-ray. The average effective doses of non-surgical CT and x-ray scans were about 6.9 mSv and 0.73 mSv respectively. The highest individual absorbed dose was a 10 Gy skin dose received due to a complicated interventional neurology procedure. Comparisons between sub-categorisations of diagnostic radiology incidents over the past two years are shown in Figure 10.

In regard to Figure 10, all sub-categories are typical of general clinical environments, i.e. they are causes which can be seen across many medical practices and are not restricted to medical procedures involving radiation. The 'Other' sub-category primarily included incidents during surgical procedures with x-rays.

Some examples regarding non-surgical CT and x-ray incidents that resulted in the largest individual doses are described below.

A female hospital patient had a CT scan of the chest abdomen and pelvis. Prior to the procedure, the patient was asked if she was pregnant, which she replied no and signed the referral form stating this. Five weeks after the procedure the patient was confirmed to be pregnant following a pregnancy scan. At the time of the CT scan the gestational age of the foetus was approximately 4 weeks. The foetal dose was estimated to be 33 mSv. The patient's unknown pregnancy was considered a contributing cause of this incident. The incident report did not describe any preventative measures.

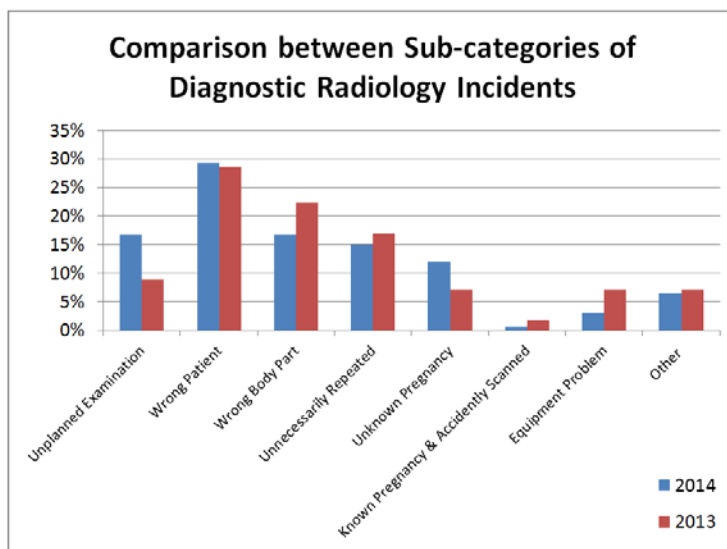


Figure 10: Comparison between sub-categorisation of Diagnostic Radiology incidents in 2013 and 2014. Values expressed as a percentage of the total number of Diagnostic Radiology incidents in the year.

At a hospital, a mini C-arm mobile image intensifier was used by an unlicensed theatre technician, who operated the unit to image a colleague's hand and produce a paper based print of the image. The radiation dose involved was less than 10 mSv. The staff members involved have been stood down by the hospital. The incident report did not describe any preventative measures.

5.2. Nuclear Medicine: 51 Incidents

The average effective dose received by patients in reported incidents involving nuclear medicine was approximately 4.85 mSv. The reported primary cause in the majority of incidents was human error (43 incidents). Where identified the largest contributing causes was a failure of quality control or checking (17 incidents) and the largest preventative measure was reinforcement (17 incidents). Incidents within different sub-categories are shown in Figure 11.

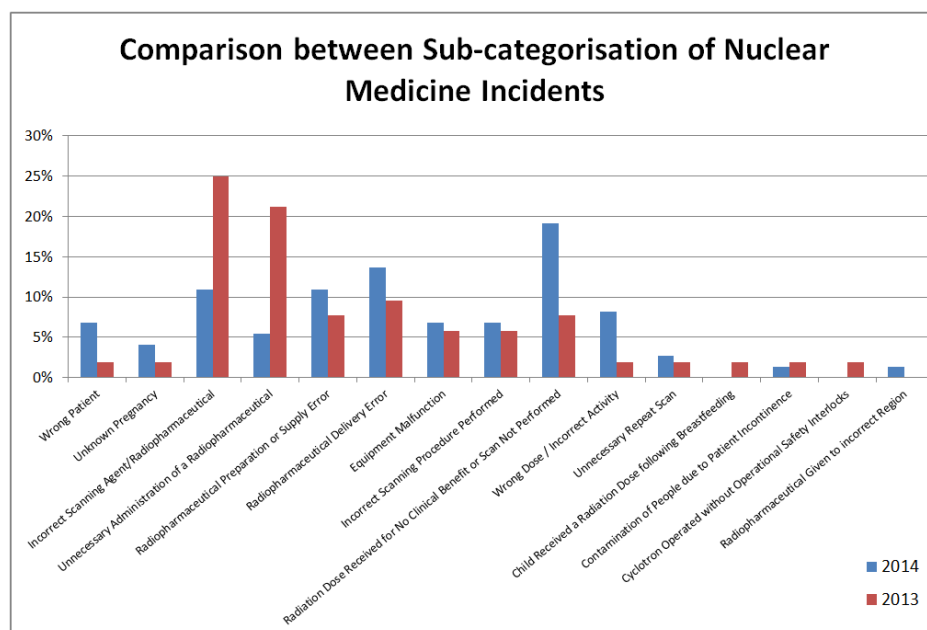


Figure 11: Comparison between sub-categorisation of Nuclear Medicine incidents in 2013 and 2014. Values expressed as a percentage of the total number of Nuclear Medicine incidents in the year.

Some examples of nuclear medicine incidents are:

- Two incidents occurred when patients had been administered Tc-99m however the injection of the radiopharmaceutical was not correctly performed. Therefore the procedure had to be repeated. These patients received an estimated effective dose of 5.6 mSv and 7.3 mSv. These incidents resulted in medical staff being re-educated in the correct procedures and operation of equipment. In one case the injection system was replaced.
- An incident occurred when a patient's condition deteriorated and was deemed too unwell to proceed with the rest of the scan following the injection of the gallium-67 (Ga-67) radiopharmaceutical. The scan was later cancelled by the patient's medical team who felt they had sufficient clinical information. The patient therefore received a radiation dose (effective dose 15 mSv) with no clinical benefit as the scan was not required to aid diagnosis. The incident occurred due to the failure by the patient's medical team to cancel the requested scan. New hospital policies to quickly move patients from the emergency department resulted in multiple tests being simultaneously requested in the early stages of

a patient's admission. This led to pressures which were listed as a contributing cause of the incident. An internal review has commenced but the outcome has not been reported to the ARIR.

- A patient under general anaesthesia was positioned for a PET Scan after administration of 370 MBq Fluorine-18 fluorodeoxyglucose (F-18 FDG) when the emergency stop button was accidentally pressed. The scanner was not able to be reset causing the patient's examination to be cancelled and rescheduled for a later date. The patient is estimated to have received an effective dose of 7 mSv.

5.3. Radiotherapy: 14 Incidents

There were fourteen incidents reported for radiotherapy. The primary cause of twelve of these was human error. One incident was unclear due to insufficient information in the report and one was due to malfunction of the door interlock switch for a medical linear accelerator.

Comparisons between the sub-categories of radiotherapy incidents for the past three years are shown in Figure 12. Over the past three years the ARIR data shows that the frequency of incidents due to incorrect doses prescribed has trended.

Some examples of radiotherapy incidents are:

- A patient received a 30 Gy dose caused through a human error by the oncologist when the wrong region was selected for treatment. Following this incident the operator updated and standardised their procedures.
- A patient receiving the fraction of a prescribed dose intended for another patient. This resulted in the patient incorrectly receiving 2 Gy to their right breast. The patient was not identified immediately before treatment as the radiation therapist knew the patient from a previous treatment. The patient was set up in one bunker but a transfer to the second machine meant that two people were preparing for treatment in the same bunker at almost the same time. This contributed to misidentification at a critical time during treatment. The radiation therapists received a reminder on the correct patient identification protocol.
- A breast cancer patient had a lumpectomy and then later axillary lymph nodes removed and investigated by pathology. The patient received radiation treatment, including irradiation of the lymph nodes, before the pathology results for the lymph glands was available. It was later noticed that there was no pathology in the lymph nodes and so the radiation oncologist decided that the irradiation was not necessary and stopped the radiation treatment to the lymph nodes. The cause of this incident was due to the radiation oncologist not reviewing the patient's pathology report prior to treatment and was therefore unaware that the result had come back as negative. The patient received a dose of 18 Gy. No preventative measures were identified in the report.

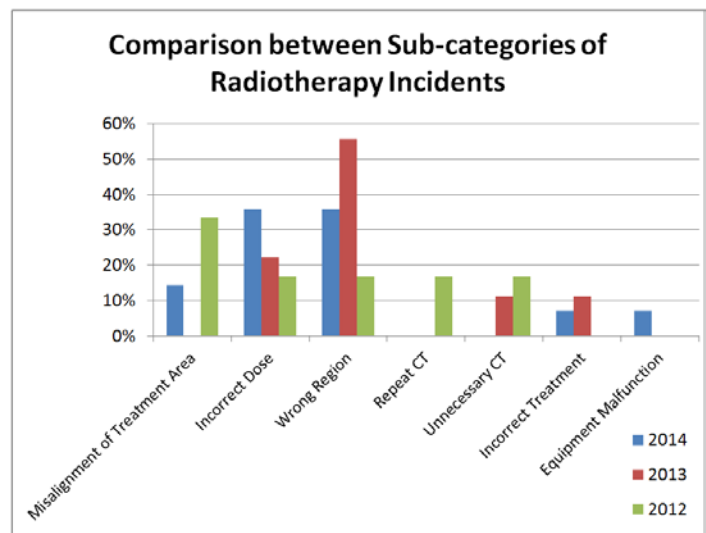


Figure 12: Comparison between sub-categories of Radiotherapy incidents for the past three years. Values for each sub-category are expressed as a percentage of the total number of Radiotherapy incidents in the year.

5.4. Borehole Logging: 5 Incidents

Two of the five incidents involved workers being unnecessarily exposed to radiation when transferring radioactive sources from the borehole back into the transport shielded container.

Two incidents occurred when borehole logging tools containing sources became stuck down the borehole. The first incident was due to the drill string becoming stuck. However, the sources were successfully recovered the following day. The second incident was due to the sources getting stuck in mud or dirt midway into the attachment process. Unfortunately the sources could not be retrieved. The contributing causes for all of these incidents were failure in quality control or checking, production pressure, limitation of equipment and deficiencies of procedures. Following these incidents the preventative measures actioned included reinforcement of correct work practices and additional resources to complete the work properly and safely.

The most serious incident involved workers unnecessarily exposed to radiation when transferring caesium-137 (Cs-137) and americium-241/beryllium radioactive sources from the borehole back into the transport shielded container. Unknowingly a 54 GBq Cs-137 source was left on the platform where work continued for a short period before it was found and examined by workers before it was properly identified. No radiation survey had been completed and area barriers and warnings had been removed.

Three personnel were admitted to hospital for monitoring, which included taking regular blood tests. After three days, they were released from hospital but, under medical advice, returned to their local clinic every two days for blood tests for the remainder of that month; with the results sent to the case physician and the borehole logging company's medical advisor. Whilst two of the operators had no observable effects, about seven days after being exposed to the radioactive source one operator noticed hair loss on their lower left leg which later developed to a rash and then a painful ulceration. Notes provided by the medical specialist treating the operator say that the clinical signs are typical for radiation injury and suggest that this worker received a leg dose of about 15 to 20 Gy to the skin and nearby tissue with up to 25 Gy in the central part of the injury. Forty days after radiation exposure the ulceration was healing well.

Based on the information in the ARIR report, the primary cause of this incident was human error in not properly placing the source inside its shielded container. The identified contributing causes include a failure in quality control or checking and deficiencies with existing procedures.

This incident was classified by ARPANSA as an INES level 3 (or serious) incident on the International Atomic Energy Agency's (IAEA) International Nuclear and Radiological Events Scale ([INES](#))¹ and subsequently reported to the IAEA. A radiation incident for a person with an INES level 3 classification is considered by the IAEA as having a likely occurrence for non-lethal deterministic effects. It is the most serious incident reported to the INES register by Australia.

Following this incident, the responsible company and one worker are subject to an ongoing prosecution. The local regulatory authority conducted an investigation and is involved with the court proceedings.

¹ Further information about INES can be found on the [IAEA website](#).

5.5. Industrial Radiography: 5 Incidents

An incident occurred at a field site when the wear of the control cable (winding gear) connection allowed a technician to rotate the locking mechanism from 'connect' to the 'operate' position without connecting the control cable to the isotope pigtail. This caused a misconnection to occur. As a consequence the iridium-192 (Ir-192) source was pushed from the source projector and was unable to be retracted. Eventually technicians were able to recover the source and placed it in a lead pot overnight. The next morning the source was placed back into the camera. The recovery of the source required seven technicians to be unnecessarily exposed to an unshielded source for an approximate duration of one hour. As a result these technicians received radiation doses ranging from 0.09 mSv to 24.1 mSv. The company investigated this incident and identified that the primary cause was malfunction of the equipment due to the worn connector on the winding cable. Following this incident the company performed the following corrective actions: all equipment involved was tested to the manufacturer's requirements, failed equipment was removed from service, similar industrial radiography equipment at other sites will undergo a misconnection test in accordance with the operating and maintenance manuals, arrangements to ensure equipment is maintained to the manufacturer's requirements were improved and records kept, a safety alert was distributed throughout the company highlighting required misconnect tests and servicing requirements, and refresher training on how to conduct a misconnection test will be provided to all technicians involved with industrial radiography.

Another incident at a field site occurred when a loosely attached guide tube became disconnected after several uses, preventing retraction of the Ir-192 source. Bags of lead shot were initially used to shield the source before it was properly retracted, a process that was delayed by a cable kink caused by the initial disconnection. The operator performing the reconnection received an estimated effective dose of 6.75 mSv during this time. The second person remained at the barrier to ensure no members of the public could access the area and did not receive a reportable dose. The company and local regulator investigated this incident and the primary cause was found to be human error since there was a failure to properly inspect the guide tube prior to use. The preventative measure actioned was for the company to remind staff to follow the operating procedures.

5.6. Dental: 3 Incidents

An incident occurred while a panoramic radiograph was performed on a dental patient. The machine x-rayed normally and the small preview image appeared normal. However, the acquisition image failed to appear on the screen and an error message displayed. The image which appeared as a perfectly acceptable image on preview could not be retrieved. The radiographic procedure had to be repeated and so the patient was irradiated a second time which resulted in the patient receiving an unnecessary dose of 24 micro-Sieverts (μ Sv). While this is a low dose, it should be noted that this was not the first time that this type of incident had happened and, unfortunately, the radiographers involved had not reported it since by shutting down the computer system, the problem disappeared. The fault in the system occurred randomly. Previous tolerance of software or computer system errors could indicate a safety culture issue. Following this incident the company strengthened work practices by requiring radiographers to always report all x-ray equipment software errors to their supervisor. The local regulator undertook to make enquiries with other medical practices with similar panoramic x-ray equipment to determine whether they experience similar problems.

5.7. External Exposure (non-medical): 3 Incidents

During the planned maintenance shutdown at a slurry handling plant, a job was scheduled to replace a walkway that had a Cs-137 radiation density gauge attached to it.

On the morning of day one, a radiation trained and badged electrician (E1) from slurry handling was requested to arrange for an electrical isolation to the radiation source detector, so that boilermakers could safely remove the structure. A discussion took place with the job supervisor, E1 and the boilermakers highlighting that the E1 had to isolate the radiation source before the boilermakers could start work on removing the structure. E1 returned later that day and disconnected the electrical systems to the gauge before unsuccessfully trying to contact the site radiation safety officer (RSO) to arrange for confirmation of shutter closure and discuss the safe removal of the source from the gauge. The RSO missed the phone call so the E1 left a message, requesting confirmation of the shutter closure early the next day. After E1 then left for another job the maintenance supervisor walked past the structure and concluded that the radiation gauge was safe to work on as it was electrically isolated.

The following day the Maintenance Supervisor instructed another electrician, (E2) to attend the area, confirm the job was safe and proceed in the removal task. E2 was not trained in radiation and the RSO was off site. E2 concluded incorrectly that the electrical isolation made the gauge safe and gave the all clear to work on the removal.

When E1 became aware of the work being completed he immediately closed and locked the shutter and relocated the structure to an area with restricted access before the source was removed. Any radiation exposure was minimal.

Contributing factors in the incident included:

- Lack of hazard awareness by the maintenance staff.
- Poor worker communication.
- Production pressures; the job was scheduled in the middle of a major maintenance shutdown
- Lack of radiation worker trained maintenance workers.
- Inadequate procedures concerning the handling of radiation sources.

Following this incident the preventative measures taken included:

- Radiation awareness training for all maintenance workers and their supervisors.
- Improved induction training.
- Future staffing for maintenance will ensure there are adequate trained and badged persons to work with radiation sources.
- Update the existing procedure for handling radiation sources.
- A site wide email will be sent to share with the maintenance teams to inform them of the findings of the incident investigation.

5.8. Laboratory: 2 Incidents

An incident occurred at a radiopharmaceutical laboratory when an operator, in order to complete work on an urgent research paper, manually overrode a hot cell interlock to recover a vial of radioactive liquid which had rolled into an inaccessible location. Whilst the operator received only a small dose (2 μ Sv), they neglected to follow proper procedures. The interlock override key was provided by a manager following a very brief discussion which did not properly examine the reasons for the request. Production pressure played a part in this incident which took place prior to the weekend and a work social activity.

The operator conducted an investigation that identified the incident root cause as access to the interlock override key by the operator without any independent assessment. Contributing causes included: limitations of the hot cell manipulators, no definition of what constituted an “emergency” scenario (and specifically when it was appropriate to invoke a vial recovery procedure), and perceived production pressure.

The operator improved a number of engineered and organisational safety controls, such as a person independent from production to be responsible for the interlock override key, changes to risk assessments, physical access and procedures to prevent unauthorised access to the interlocks, reinforcement to staff the importance of complying with safety systems and procedures, data recording for the interlock use. In the longer term hot cell manipulators are to be improved so they can reach areas within the hot cell that are currently inaccessible. The regulator found the operating company to have breached the conditions of their licence.

6. Comments and Conclusions

The number of incidents reported in 2014 increased substantially, by about 39%, from the previous year. ARPANSA has actively promoted the benefits of reporting all incidents, including low level and near-miss events. Recent increases are considered to be most likely due to an increase in reporting rates rather than an increase in incidents. Based on varying reporting rates between jurisdictions, it is likely that further increases in report numbers is possible in subsequent years as reporting practice continues to improve.

Analysis of incident causes indicates that many had multiple contributing causes and it is quite possible that the incidents would not have occurred if one of the contributing causes had been prevented. This is the basis for the James Reason ‘Swiss Cheese’ model of safety (Figure 13), where an incident or accident occurs only where there is an alignment of vulnerabilities. Shoring up vulnerabilities or adding additional controls can block a pathway leading to the incident and often small changes to operating environments can bring about a meaningful reduction in the number of incidents and accidents that occur.

As with the analysis of last years’ incidents, the majority of reported incidents in 2014 cite human error as the primary cause. Analysis of contributing causes and preventative measures suggests that there is high reliance on actions taken by individuals rather than other passive or active systems (e.g. processes,

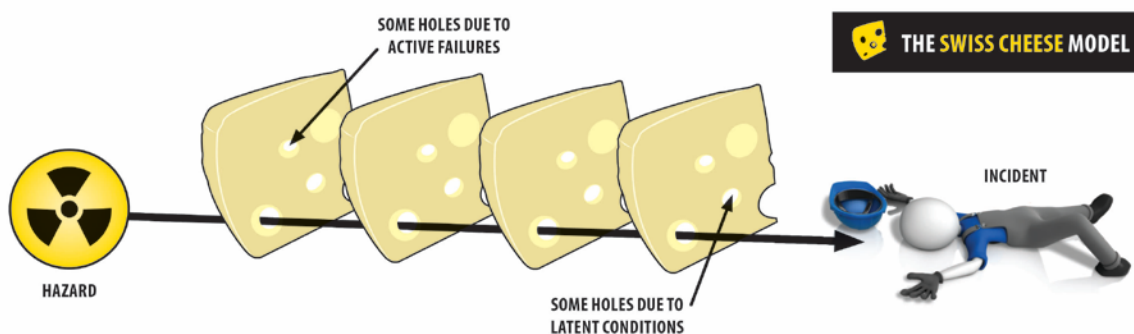


Figure 13: The Swiss Cheese Model.

procedures, physical or engineered barriers). Whilst this is to be expected in many applications of radiation use, the information in incident reports suggests that many of the contributing causes could be identified beforehand. In the majority of occurrences, similar incidents have been reported previously to the ARIR. Examples include failures in quality control processes, particularly cross checking of information, problems with procedure adherence, problems with labelling and ordering systems and more general communication issues. Many of these contributing causes are associated with skill and rule based human performance.

Reinforcement of correct processes or practices, training and education, and conducting internal reviews were the most common three preventative measures in the 2014 incident reports. Task analysis can assist in matching processes and instructions to the strengths and weaknesses in skill and rule based human performance and may lead to long lasting improvements. The data shows that work practices may have improved, where human error was the primary cause, since internal reviews were reported to have been conducted in 9% and 14% of the incidents in 2013 and 2014 respectively. It is encouraging to see that more organisations have gained deeper knowledge on the root cause and contributing causes of an incident following an internal review and therefore can implement improvements that directly aid in preventing similar occurrences.