Queensland Injury Surveillance Unit

QISU collects and analyses data from emergency department injury presentations on behalf of Queensland Health. Participating hospitals represent urban, rural and remote areas of Queensland. QISU publications and data are available on request for research, prevention and education activities.

INJURY BULLETIN

NO. 109 **March 2010**

Injuries due to Magnets in Children: An Emerging Hazard

Dr Mohan Swaminathan, Dr Ruth Baker, Debbie Scott

Summary

- Strong magnets are becoming more accessible in the home.
- Magnetic foreign bodies in children come from toy and non-toy sources.
- Ingestion of more than one magnet can lead to serious gastrointestinal complications.
- Serious complications have been reported from fake magnetic body piercing of the nose and tongue.
- The median age of magnet related injury in Queensland children is 4 years for girls and 5 years for boys.
- Health professionals and the general community need to be alerted to the potential serious health consequences of magnet related injury.
- Whilst current Australian regulatory strategies go some way towards addressing risk associated with magnets in toys, they remain silent on non-toy sources.
- Consumers, industry, injury prevention bodies and government regulatory agencies need to collaborate to develop a workable preventive strategy to address this emerging hazard.

Introduction

Ingestion of non-food objects, inadvertently or intentionally, is common among young children but also occurs in older children and adolescents [1,2,3]. Even though objects may be large or sharp, the majority pass through the digestive system without health consequences. However, some non-food objects, such as magnets and batteries, can cause serious health problems. In Brisbane, Queensland, a case series report on three children (aged 4–11 years), describes multiple bowel perforations as a consequence of multiple magnet ingestions[4]. All three children presented with abdominal pain and vomiting and were treated for gastroenteritis, as the history of magnet ingestion was not initially apparent. Plain abdominal films were subsequently taken to exclude surgical conditions, and the diagnosis of 'foreign body ingestion' was made. In all 3 children, surgery revealed the ingested objects to be pieces from magnetic toy construction sets. The ingested magnets had adhered to each other across intervening bowel, and the pressure had resulted in bowel perforations. The cases are summarized in Table A.

The authors of this report recommended more stringent regulations on the use of magnets in toys — especially in toys for children younger than 5 years — and measures to increase public and clinician awareness of this issue[4].

HOSPITALS

• *Atherton*	• *Clermont*	• *Moranbah*	• *Proserpine*	• *Queen Elizabeth II*	• *Logan*	• *Mackay Base*	• *Mount Isa*	
• *Mareeba*	• *Sarina*	• *Mackay Mater*	• *Dysart*	• *Innisfail*	• *Robina*	• *Royal Children's*	• *Mater Children's*	
• *Bundaberg*	• *Marybourgh*	• *Warwick*	• *Collinsville*	• *Yeppoon*	• *Gatton*	• *Tully*	• *Cherbourg*	

I SSN 1442-1917 **QISU** is funded by Queensland Health with the support of the Mater Health Service, Brisbane

Table A: Details of the cases described in [Ingestion of magnets in children: a growing concern][4]

Magnet related Injuries	Case1	Case2	Case3
Age	11 yrs	4 yrs	5 yrs
Developmental status	Autism	Normal	Normal
Injury due to Magnet	Several magnets (rods, rings and balls) in loops of the small bowel resulting in 13 perforations of small bowel	A cluster of magnetic rings caused perforations in two separate areas of the bowel.	Single perforation in small bowel
Surgical Management	Operation required to remove part of damaged bowel and allow healing by placing a temporary "stomal bag" on the abdomen for 3 weeks.	Magnets were retrieved through an operation and a hole in the bowel caused by magnet was oversewn.	Gut repaired by removal of the damaged segment and re-joining the edges of the bowel.

This issue of the Injury bulletin will discuss injuries related to magnetic foreign bodies in Queensland children for the eleven year period from January 1999 to December 2009.

Methods

QISU data is collected at triage in participating emergency departments throughout Queensland. These data are representative of approximately one-quarter of emergency presentations in Queensland. Data were extracted using a keyword search for "magnet" or "magnetic" for all age groups for the 11 year period between 1 January 1999 and 31 December 2009. This method identified 120 cases. Only cases where the magnet was a foreign body (ingested, inhaled, inserted or external), were retained (105 cases). There were no adult cases (>18 years of age) of magnetic foreign body injury. Further analyses were conducted on this dataset. These analyses included a review of the narrative text contained in the 'presenting problem' field of the triage notes to provide more detailed information than the coded surveillance data supplied.

Results

There were 105 emergency presentations with foreign body related injuries due to magnets during the 11 year period. All magnetic foreign body presentations were for children aged below 18 years of age (range 0-13 years). The median of the number of annual presentations was 12 (range 1– 19). The majority of these presentations (70%) occurred between 2005 and 2009 .

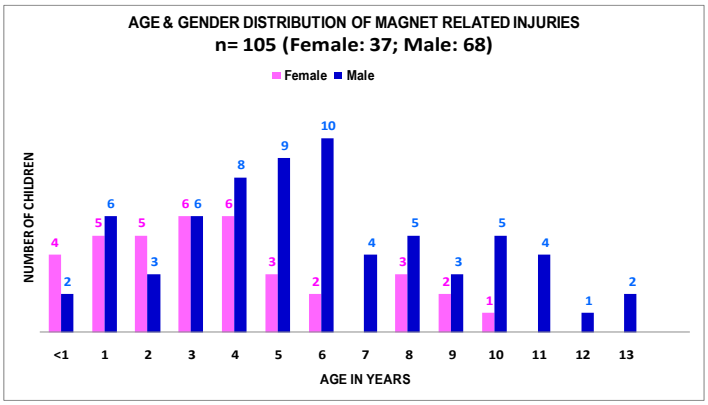
Death Data

A search of the National Coroner's Information System database (NCIS) revealed no Australian deaths associated with magnets between 2000 and 2006 (only those cases where the coronial enquiry is complete can be accessed, so this may under represent the actual number of deaths). There has been one death reported in The United States (described later in Discussion)[5].

Age & Gender

Figure 1 shows the age and gender distribution of magnetic foreign body injury in children. Of the 105 children presenting with magnetic foreign body injury there were 68 males and 37 females. The male to female ratio was 1.8: 1. The median age of presentation of magnet related injuries for girls is 4 years (Range 0-10 years). The median age of presentation of magnet related injuries for boys is 5 years (Range 0-13 years). More than 40% of magnet related injuries occur in children 6 years old and over. Only boys presented with magnetic foreign bodies after 10 years of age.

Figure 1: Age and Gender Distribution of Magnetic Foreign body related injuries in children



Source and Shape of magnetic foreign body

The magnetic object was frequently described in the triage text terms of shape (sphere, oblong, flat, round etc.) and occasionally source (toy, toy set, fridge magnet etc). Sometimes shape or source could be determined from other descriptors (magnetic marble; magnetic ball etc.).

Source

The source of the magnet was classified as follows: magnetic jewellery, fridge magnet, toy magnet, possible toy magnet and unspecified magnet. The category of "Possible toy magnet" was used for those cases where the activity at the time of injury was "playing" and the triage data text stated that the object was a magnetic ball. Table 1 shows age distribution by source of magnet and Table 2 shows the gender distribution by source of magnet. There were 13 children in whom the source of magnets was a toy and 27 children in whom the source of the magnet was a "possible toy". Thus 38% (n=40) of the foreign body injuries due to magnets in children were likely to have occurred due to magnets accessed from toys. The male: female ratio in this group was 2.2: 1. There were 57 children in whom the source of magnet was "unspecified". The male to female ratio for this group was 1.7:1. There were 7 children in whom type of magnet was "Fridge magnet". One child was injured by magnetic jewellery.

There was variation in the age of children sustaining injuries due to magnets from different sources. Only children under the age of 4 years were identified as having been injured due to fridge magnets. There were no toy magnet related presentations over the age of 9 years. All

Table 1: Source of Magnet and Age Distribution

Source of Magnet causing injury & Age in Years	<1	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
MAGNETIC JEWELLERY	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
FRIDGE MAGNET	3	2	1	1	0	0	0	0	0	0	0	0	0	0	7
TOY- MAGNET	0	2	0	2	2	2	3	1	0	1	0	0	0	0	13
POSSIBLE TOY MAGNET	0	1	3	4	6	5	6	2	0	0	0	0	0	0	27
UNSPECIFIED MAGNET	3	6	4	5	6	5	3	1	8	3	6	4	1	2	57
Total	6	11	8	12	14	12	12	4	8	5	6	4	1	2	105

presentations over the age of 9 years were due to unspecified magnets. (Table1)

Table 2: Source of Magnet and Gender Distribution

Source of Magnet & Gender Distribution	Female	Male	Total
MAGNETIC JEWELLERY	1	0	1
FRIDGE MAGNET	4	3	7
TOY- MAGNET	3	10	13
POSSIBLE TOY MAGNET	8	19	27
UNSPECIFIED MAGNET	21	36	57
Total	37	68	105

Shape

The shape of the object could be determined in 43% of cases and included 'Flat' (stickers, strips and fridge magnets), 'Sphere' (ball, marble), 'Oblong' (linket- part of fashion jewellery). The remainder were grouped as 'Unspecified' (a magnetic badge, magnetic rock and other items where the shape could not be determined). The number of cases by source and shape of magnet is presented in Table 3. After the "unspecified shape" group (n=59, 56%), most magnets were spherical (n=38, 36%). The male to female ratio (M:F ratio) for magnetic injuries due to "unspecified' shape of objects was 1.8:1 and the M:F ratio for spherical objects was 2.5:1.

Table 3: Number of cases by Source and Shape of Magnet

Source of Magnet and Shape	FLAT	OBLONG	SHAPE UNSPECIFIED	SPHERE	Total
MAGNETIC JEWELLERY	0	1	0	0	1
FRIDGE MAGNET	7	0	0	0	7
TOY- MAGNET	0	0	3	10	13
POSSIBLE TOY MAGNET	0	0	0	27	27
UNSPECIFIED MAGNET	0	0	56	1	57
Total	7	1	59	38	105

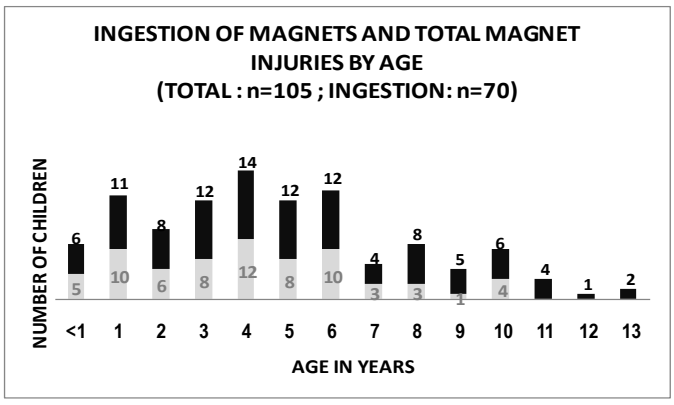
Mechanism of Injury

Where the magnets were swallowed, the mechanism of injury was classified as "Ingestion". Where the magnets were inserted in a body orifice; mouth (but not swallowed), rectum, ear, nose or penis; the mechanism of injury was classified as "Insertion". Magnets were also placed externally (eye lid, lips and penile foreskin) and in these cases the mechanism of injury was classified as "external". No magnets were identified in this series as foreign bodies within the respiratory tract. In some cases the child presented with choking due to obstruction of the posterior pharynx or larynx. The magnet in question was either successfully removed by the carer, coughed out by the child, or swallowed by the child. Although also an ingestion, the 3 cases of "choking" episodes have been described separately as they highlight the potential for both large objects to obstruct air intake in the posterior pharynx and for small objects to be directly inhaled into the trachea. Table 4 describes Mechanism of Injury and Source of Magnet by Gender.

Ingestions accounted for the majority of magnet related injuries in this series (n=70 or 67% age range 10 months - 10 years). Figure 2 depicts the age distribution of "Ingestion" of magnets as compared to the total number of all magnetic injuries. In this group, 45 were boys and 25 girls (M:F ratio 1.8:1), with 40% of cases due to "unspecified magnets"; 37% due to magnets from "Possible Toys"; 16% from "Toy Magnets" and 7% from "Fridge Magnets".

There were 28 cases where "Insertion" was the mechanism of injury, 21 boys and 7 girls. Insertion into the nose occurred in 23 children; 18 were boys and 5 were girls. All the 23 objects in the nose were "unspecified magnets". Amongst the remaining 5 children, one child had an unspecified magnet inserted into the penis; another had 2 unspecified magnetic objects inserted into the rectum. In the third child, a fridge magnet was stuck in the roof of the mouth and in the

Figure 2: Age Distribution of Ingestion of Magnets compared to total magnet injuries.



final 2 cases, a small magnet from a toy was stuck in the ear of one child by a sibling and an unspecified magnet was inserted into the ear of another.

Table 4: Mechanism of Injury and Source of Magnet by Gender.

MECHANISM OF INJURY & SOURCE OF MAGNET	Female	Male	Total
INGESTION	**25**	**45**	**70**
FRIDGE MAGNET	2	3	5
TOY- MAGNET	2	9	11
POSSIBLE TOY MAGNET	7	19	26
UNSPECIFIED MAGNET	14	14	28
INSERTION	**7**	**21**	**28**
FRIDGE MAGNET	1	0	1
TOY- MAGNET	0	1	1
UNSPECIFIED MAGNET	6	20	26
EXTERNAL	**2**	**2**	**4**
MAGNETIC JEWELLERY	1	0	1
TOY- MAGNET	1	0	1
UNSPECIFIED MAGNET	0	2	2
CHOKING	**3**	**0**	**3**
FRIDGE MAGNET	1	0	1
POSSIBLE TOY MAGNET	1	0	1
UNSPECIFIED MAGNET	1	0	1
Total	**37**	**68**	**105**

There were 4 children in whom the magnet was "External" and attached to the surface of the body. In the first two cases oblong magnets from a jewellery set and a toy magnet respectively were attached to either side of the child's top lip. In the third case, two magnets "stuck" together with the eyelid between them. The final case was a boy in whom 2 magnetic pieces were "stuck" to the foreskin of the penis and the parents were unable to remove them at home.

There were three girls in whom the mechanism of foreign body injury was "choking" on the magnetic object. Of these, a one year old choked on a fridge magnet; a 3 year old choked on a magnetic sphere (possible toy) and the third, a 5 year old choked on an "unspecified" type of magnet. All 3 children received effective first aid by their immediate care giver at the site of injury. All 3 cases subsequently presented to the hospital for further assessment.

Body Region injured

The most common body region injured was the alimentary tract (not including mouth and rectum (n=70, all ingestions). The next most common region injured was the nose (n=23, 22%). Table 5 describes the relationship between the body region injured, Source of magnet and the Mechanism of Injury.

Table 6: Triage categories for number of children with Magnet related injury

TRIAGE CATEGORIES	Number of Children with Magnet Related Injury	Percentage of Total
Emergency (10 minutes)	3	**2.9%**
Urgent (30 minutes)	13	**12.4%**
Semi urgent (60 minutes)	81	**77.1%**
Non urgent (120 minutes)	8	**7.6%**
Total	**105**	**100.0%**

Severity

The Triage category of the 105 children presenting to emergency department with magnet related injuries is shown in Table 6. There

Table 5: Mechanism of injury, Source of Magnet & Body region injured

MECHANISM OF INJURY, SOURCE OF MAGNET & BODY PART	Alimentary tract	Ear	Eye	Penis	Lips	Nose	Rectum	Upper Airway	Total
INGESTION	**70**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**70**
FRIDGE MAGNET	5	-	-	-	-	-	-	-	5
TOY- MAGNET	11	-	-	-	-	-	-	-	11
POSSIBLE TOY MAGNET	26	-	-	-	-	-	-	-	26
UNSPECIFIED MAGNET	28	-	-	-	-	-	-	-	28
INSERTION	**1**	**2**	**-**	**1**		**23**	**1**	**-**	**28**
FRIDGE MAGNET	1	-	-	-	-	-	-	-	1
TOY- MAGNET	-	1	-	-	-	-	-	-	1
UNSPECIFIED MAGNET	-	1	-	1	-	23	1	-	26
EXTERNAL	**-**	**-**	**1**	**1**	**2**	**-**	**-**	**-**	**4**
MAGNET JEWELLERY	-	-	-	-	1	-	-	-	1
TOY- MAGNET	-	-	-	-	1	-	-	-	1
UNSPECIFIED MAGNET	-	-	1	1	-	-	-	-	2
CHOKING	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**3**
FRIDGE MAGNET	-	-	-	-	-	-	-	1	1
POSSIBLE TOY MAGNET	-	-	-	-	-	-	-	1	1
UNSPECIFIED MAGNET	-	-	-	-	-	-	-	1	1
Total	**71**	**2**	**1**	**2**	**2**	**23**	**1**	**3**	**105**

were 7 cases presenting with magnet related injuries that required admission to the hospital.

Discussion

This bulletin describes the burden of injury in Queensland children related to magnetic foreign bodies over the eleven year period (1999 to 2009). The most common mechanism of magnet related injury identified was ingestion (67%) and this has the greatest potential for serious consequences. Whilst the shape and source of magnets in the QISU data has been described (where possible), the data is unable to describe the strength of the magnets involved in the injuries. Increasingly, magnets available in the home are "strong" or "rare earth magnets" (see Box A). Domestic applications for strong rare earth magnets include toys, jewellery, magnetic beads, fridge magnets, photographic displays and homeopathic aides. **The reduction in the size of the magnet relative to its strength, not only allows for novel domestic applications, but also increases the risk of inhalation, ingestion or insertion and subsequent injury**.

Box A: What are Rare Earth Magnets?

What are Rare Earth Magnets[6,7]?

- In "Rare earth" magnets, the primary metal element (neodymium or samarium) that is used to make the magnet belongs to the "rare earth elements" of the Periodic Table.
- There are two types: neodymium iron boron magnets (NIB magnets) and samarium-cobalt magnets.
- They are "strong" Permanent magnets. The term "Powerful Magnets" is also interchangeably used to describe the magnetic "flux" of "Strong Magnets".
- Magnetic "flux" is a measure of quantity of magnetism, taking into account the strength and the extent of a magnetic field. The "Strength" of the physical magnetic force inherent in a magnet decides how tightly the magnet attracts and binds to another magnet.
- Both raw materials and patent licenses were initially expensive when magnets were made using rare earth metals, so the high cost of these magnets limited their use.
- Beginning in the 1990s, NIB magnets have become steadily less expensive. Their low cost and diminishing size in proportion to strength has inspired new uses..
- The attraction between these small powerful magnets is such, that when intervening body tissue is impacted between them, the strong magnetic force of attraction causes pinching effect on the blood supply to the tissue resulting in local cell death and ultimately a perforation.

The true burden of magnet related injuries in Queensland is unlikely to be captured using QISU data for a number of reasons. QISU data collection is estimated to represent one quarter of injuries presenting throughout the state. Therefore, where QISU data identifies an average of 10 cases of magnet related injuries in children per year, an estimated 40 children per year are likely to present. In addition, many foreign body injuries in children (particularly ingestions) may go unrecognized unless the event is witnessed by a parent or symptoms develop. QISU data is collected at triage on initial presentation of the patient to the emergency department (ED). Foreign body ingestion or placement is rarely self reported by children. Younger children (under the age of 2 years) are limited by their developmental and linguistic abilities and are unlikely to tell their parents about the magnet misuse. Older children often fail to report foreign body placement or ingestion for a variety of reasons (embarrassment, concern regarding consequences). In these circumstances, the foreign body injury is not registered in the injury surveillance system, and may only come to light after admission. It is also likely that many children ingest a single magnet that may pass without event, unbeknown to the parent. Magnet ingestions, in particular, are difficult to recognise. EDs assess many patients every year that present with vomiting and abdominal pain. Most of these patients will have gastroenteritis or other self-resolving illnesses. The cases presented from Queensland[4] and other authors in the subsequent discussion, highlight the significant delays in diagnosis and magnet removal.

Despite the potential for serious injury, the admission rate in our series is only 6.7%. Again, this is an underrepresentation of the injury severity. It is likely that the cases reported from Queensland[4], were not identified in our injury surveillance system (despite being reported from two QISU collecting hospitals) as the magnet ingestion was only discovered after admission to hospital and subsequent surgery.

Toy vs. non-toy sources

QISU data demonstrates that magnetic foreign body injury in children occurs due to magnets from both toy and non-toy sources. The types of magnets that are involved in causing foreign body injury in children range from common household items like fridge magnets, magnets from jewellery items, magnetic components from toys and magnets from other "non-toy" sources. This finding is consistent with data collected by a researcher in the United States. The author primarily surveyed radiologists and researched cases of magnet ingestion in the literature (prior to 2008), documenting age and gender, numbers of magnets, nature of the magnets, reasons for swallowing, and outcome[8]. Cases from 21 countries were found. A total of 128 instances of magnet ingestion were identified, one fatal. Magnet ingestion occurred throughout childhood and continued into adulthood. Twelve of the 122 children (under 18 years of age) were known to be autistic (10%). This highlights both the propensity for children with disabilities to ingest foreign bodies, as well as challenges in obtaining a verbal history of the same. The number of swallowed magnets ranged up to 100. Considerable delay before seeking

medical assistance was frequent, with additional delays before obtaining radiographs or ultrasound imaging. Many reasons were given for ingesting magnets, and a wide range of gastrointestinal damage was encountered. **Toys were the definite source of the magnets in just over half of the cases (52%). In 48% of cases the magnets were from other sources.** Box B details the various —"non-toy" sources of the magnets found in this survey. (Personal communication with the author Oestreich AE: Jan 2010).

This report consisted of a very comprehensive review of cases of magnet related injuries in the scientific literature over the last decade but the survey (done in an attempt to find more cases of magnet related injuries (beyond those already published) was limited in that only radiologists were asked to participate. Some additional cases could have been identified by also surveying other medical groups such as general practitioners, surgeons (general, ENT), respiratory physicians and emergency physicians who may not have published their cases.

Box B: Sources of Magnets from the 128 cases reported in Reference 4

Box B: Sources of Magnets from the 128 cases reported in the worldwide survey of swallowed multiple magnets
Ref: Personal Communication : 2010 from Oestreich AE
67 cases: magnets from toys
The most frequently mentioned toys were further identified as originating from two brands of magnetic construction toys.
38 cases: did not specify source of magnets (several seemed to be from toys, but not so stated)
6 cases: devices to treat muscle or joint pain
2 each: (Total 6)
jewellery
magnetic small rocks
alphabet magnets (for example, to affix to refrigerator doors)
1 each: (Total 12)
from school bag
to fix marks on hat
to attach paper to magnetic board
Miscellaneous: swallowed to neutralise stomach contents
industrial magnets
Others: magnets to retain coins in stomach
from magnetic lights
from mother's organiser
from interactive reading book
circular pictured magnetic badges
magnetic bracelet

Age of magnet related injury

QISU data has demonstrated that foreign body injury due to magnets continues well beyond the age where foreign body risk is considered to be highest (1-3 years of age). In particular, the median age for ingestion of magnets was 4 years (Range 10 months -10 years). This is also consistent with the survey by Oestreich, in which the majority of children ingesting magnets were older than 3 years (71%)[8]. Current toy safety guidelines for small children limit loose small parts and require small parts warning labelling on toys for older children aimed at reducing the choking and ingestion risk for children under the age of 3 years[9]**.** Other authors, have reviewed case series of children who have choked on objects and recommended increasing both the small part cylinder dimensions and the upper age for small parts warning labelling from 3 years to 6 years [10,11].

Mechanism of injury

There have been several other detailed reports of serious magnet related injuries to children. The majority of reports relate to intestinal complications following ingestion of multiple magnets. Reports of injury following ingestion from Australia (NSW)[12], The United States (California[13], Minnesota[14] & Texas[15]), United Kingdom (Sheffield)[16] and Turkey[17] identified between them 14 cases of injury due to magnet ingestion aged between 3 to 15 years (9 boys and 5 girls). The number of magnetic objects swallowed per child ranged from 2 to 11.

In the New South Wales (NSW) case, a four year old boy ingested multiple magnets from a school badge resulting in two perforations in the small intestine. Diagnosis was delayed for more than 4 days after initial misdiagnosis of the presentation as gastro-enteritis. **The authors concluded that public and clinicians should be aware of the health hazard of "non-toy" sources of magnets[12]** .

Additional reports have described cases where magnets have been inserted or placed externally. A 12 year old boy from New Zealand[18] had 2 toy magnets attached to his penis, resulting in 2 circular scars extending to, but not through, deeper layers of the penile tissue. An operative procedure to remove the 2 magnets was required. In another report from Michigan[19], a 9 year old girl was described who placed magnets within the nostril in an attempt to hold an ear-ring on each side of her nose. The magnets failed to adhere to the earrings but were attracted to each other, pinching the nasal septum between them. Presentation was delayed and this accidental misuse of magnetic earrings resulted in perforation of the nasal septum several weeks after first use. In both these cases, there was delayed reporting of the event by the child causing delayed presentation to the hospital, by which time severe local tissue damage had already occurred. The QISU series also identified cases where parents presented their children to emergency departments for removal of externally placed magnets, demonstrating the strength of the magnets involved and the difficulty of removal.

Magnetic jewellery - an overlooked danger?

The Sheffield case series, reported in 2002, **described 24 cases that presented over an eight week period, where children were injured due to magnets used for fake body piercings[16].** The children were aged between 5-15 years, and all but one were injured following the use of commercially available magnetic body piercings on their nose, ears, penis, and tongue. A total of nine children ingested the magnets while attempting to use them and others sustained injury to their ears, nose, and penis. In one of the cases, a nine year old girl ingested several magnets and sustained severe injury. This was published separately as an individual case report by the attending surgical team[20]. She had accidentally ingested a series of flat magnetic objects (normally used for

industrial use) which she attempted to use to imitate tongue studs. Despite presenting with symptoms, she failed to reveal the ingestion history for several days. She sustained five bowel perforations and was admitted to intensive care[20].

Other authors have reported similar injuries as described in the Sheffield series due to insertion or external placement of magnetic jewellery. An eleven year old boy with nasal septum perforation has been reported from Miami (2003) [21]. He presented 2 days after applying the fake jewellery and required surgical removal of the magnets. Another case series of 6 children (Age Range 9 to 15 years) was reported from Newcastle upon Tyne in 2005[22] with misplaced magnets from nose jewellery. In each case the inner magnetic disks inserted within each nostril to hold the decorative metal on the nasal cartilage adhered to each other across the nasal septum. All children required removal of the magnets in a hospital. One girl developed severe damage to her nasal septum as she was too embarrassed to report the misplaced magnetic disc for 6 months. Medical attention was sought only when she had developed severe nasal obstruction and foul smelling nasal discharge[22].

An American investigative news report in 2007 warned the public that magnetic jewellery is an overlooked danger[23]. This report highlighted case reports of "non toy" sources of magnets causing serious injuries in children when used to emulate tongue, lip or nose piercings. The news report also included an expert commentary from medical specialists about the concern that "non-toy" sources of magnets "fall through the cracks" as there is no regulation to prevent the use of strong rare earth magnets in domestic products. In this report, the US CPSC *was reported to have indicated that it had not received enough reports of injuries linked to magnets in jewellery to warrant further action at that time*. Subsequently, the US CPSC Neighbourhood Safety Network released a warning to the public that *children should never use magnets to emulate tongue, lip or nose piercings*[24].

Magnetic jewellery, (in particular pieces that are intended to be worn in the mouth or nose) presents an inherent risk of injury. **This fashion accessory would not have been possible to design nor economically feasible to market, without the development of strong rare earth magnets.**

Response to the emerging threat of strong magnets in toys

United States (US)

Despite the presence of stringent regulations and standards for the safety in the manufacture and sale of toys, **magnetic components were not recognised as a potential hazard by experts involved in drafting standards until recently**.

In a summary report in 2007, US CPSC reported one death of a 20 month old boy from Seattle, Washington in 2005 (having ingested his brother's Magnetix™ toy components) and 19 other cases of injury requiring gastrointestinal surgery resulting from strong magnet ingestion during the period 2003-2006. It also reported that the injured children ranged in age from 10 months to 11 years, with the majority of them boys older than three years. All injuries led to hospital stays of between three and 19 days and in almost all cases the children had suffered intestinal perforations[5]. The reported death and injuries prompted toy recalls due to the hazard posed by loose magnetic components (Magnetix™ and Polly Pocket™)[25,26].

The magnets were not intended by the manufacturer to be loose in either the Magnetix™ or Polly Pocket™ toys, but presumably due to a combination of design and manufacturing issues, the small magnets became dislodged from the larger components over time. At the time that these toys were produced, many toy safety standards (covering products marketed for younger children) addressed the issue of small loose parts using the small parts cylinder test and duress testing, but remained silent on the issue of magnets. The recall in the United States prompted worldwide interest in the safety of magnets in toys and action in other countries; the faulty Magnetix™ products were also recalled in Australia.

In April 2007, t**he US CPSC** issued the following strong warning to parents *As the number of toys with magnets increases so does the number of serious injuries to children. The U.S. Consumer Product Safety Commission (CPSC) became aware of hundreds of complaints that magnets had fallen out of various toys and at least 33 cases where children swallowed loose magnets and required emergency surgery*[27]. **This warning also included a statement: "The CPSC cautions the public that small magnets from other "non-toy" products may pose the same hazard** [28].

In 2008, in the United States, ASTM International, originally known as the American Society for Testing and Materials (ASTM), published a new edition of the Consumer Safety Specification for Toy Safety,ASTM F963-2008[29]. This is the widely used toy safety standard in USA which includes guidelines and test methods to protect children from a wide range of potential hazards, including lead exposure, choking, and sharp edges. New requirements were developed for magnets to address the ingestion risk. This formed the basis of the amendment to the Australian Standard.

Europe

In May 2007, **The European Committee for Standardisation** (Comite European de Normalisation- CEN)[30] received a mandate to amend the then existing European Standard (EN) 71-1 on toys to include the specific risks related to small magnets in toys. A revision for amendment was recommended that contained requirements that were intended to address the hazards associated with ingestion of strong magnets. As an interim standard the European Committee urged the EU Commission to adopt the ASTM F963-07 version of the American standard which **applies to magnetic toys for children up to the age of 8 years and provides not only for a warning, but also covers technical specifications to cater for reasonable foreseeable use or abuse of such toys.** The revised European Standard was published on 8th April 2009 and **sets limits as to the strength (flux less than *50kg²mm²*) of small magnets (capable of fitting into the small parts cylinder) allowed in toys.**

Australia

Australia has adopted the International Standards Organisation (ISO)[31] standard for toys as the benchmark for this country; **AS/NZS ISO 8124.1:2002** Safety of toys - Safety aspects related to mechanical and physical properties (ISO 8124.1:2000, MOD)[32] The Standard specifies safety and performance requirements for toys for all age groups.

In recognition of the hazards associated with strong magnets an amendment was made to the Australian Standard in 2009 to cover 'hazardous magnets'. Although the standard is currently limited to the provisions of warnings about hazardous magnets it is recognised as an interim measure until more thorough requirements are developed to cater for specific normal use and foreseeable abuse.

Following the publication of a regulatory impact statement, the Australian Competition & Consumer Commission (ACCC) proposed a regulation with an aim to address the hazard associated with small, strong magnets in toys that might be ingested by children based around the amendment to the Australian Standard in 2009[33]. On 10th **February 2010**, the Australian Federal Minister for Competition Policy and Consumer Affairs released —"The Consumer Product Safety Standard for Children's Toys Containing Magnets"[34]. This document details the definition of children's toys and scope of the revised standard[35]. This standard requires a warning label to be affixed to the toy packaging that states:

Warning! The product contains small magnet(s). Swallowed magnets can stick together across intestines causing serious infections and death. Seek immediate medical attention if magnet(s) are swallowed or inhaled[35].

The new requirements apply to all toys used by all age groups and are intended as an interim measure to partially address ingestion hazards associated with any toys containing magnets and will take effect on 1 July 2010.

A "hazardous magnet" is defined as *a magnet with a flux index greater than 50kg^{2}mm^{2}and which is in any of the shapes and sizes that can pass through a small parts test fixture*[35]. The mandatory safety standard also requires that toys that contain hazardous magnets should not release the magnet when subjected to a number of use and abuse tests contained in the Australian Standard.

Section E.40 of the Australian Standard states further requirements will be added in the future once testing procedures addressing specific normal use and reasonable foreseeable abuse for toys containing hazardous magnets are developed[35].

The definition of hazardous magnets as being those with a magnetic flux greater than 50kg^{2}mm^2 is arbitrary and more work needs to be done globally to accurately define the minimum strength (flux) of magnet that is likely to cause injury and limit the strength of magnets used for toy (and other domestic) applications accordingly. Currently, the ACCC is relying on warning labels to inform parents at point of purchase and act accordingly to protect children. Warnings of this nature have potentially little impact because once the toy is removed from the packaging the warning is no longer apparent. Whilst parents may read a warning message at point of purchase, there is little to suggest that this will translate into preventative behaviour once the product is in the home. Parents with children of different ages may purchase the product for an older child, but not consider that their younger child could access the toy and ingest it or misuse it. QISU and other data also demonstrate that magnet misuse occurs in older children, a risk parents are unlikely to consider when purchasing a product. Whilst there is some grassroots consumer awareness being created through internet warnings to parents[36], this combined with regulators efforts is unlikely to compete with well financed toy marketing.

The warning covers those magnets that are: "loose as received hazardous magnets" but fails to address the risk encountered with the Magnetix™ and Polly Pocket™ recalls where magnets fell out of larger toy components over time and were subsequently ingested. This could be addressed through **development of a toy design framework that could inform and influence the toy industry to design** and manufacture toys with inherent safety in design, where safety is a fundamental part of design at a very early stage rather than an afterthought. Designers need to think about the total environment, about how and where a product is used and not just rely on the current standards and methods of testing individual design components limited to normal use settings. In the case of Magnetix™, it may have been possible to design the toy such that small magnets would not have been able to fall out of the larger components.

The ACCC response to this hazard confines consideration of magnet related injury to toys alone and fails to address the issue of injury due to magnets from non-toy sources. Risk posed by non-toy sources of strong magnets in the home could be addressed by similarly limiting the strength of magnets used in all domestic applications.

Warnings have been issued from time to time by Australian state regulatory authorities and the issue was subject to an enquiry by the NSW Product Safety Committee[37]. The Committee recommended that a mandatory safety standard be introduced based around the Australian Standard. This took effect on 1 March 2010.

Product Safety and Surveillance

There is currently no systematic collection of data on product related injury in Australia. Current Australian systems rely on individual networks and smaller, state based injury surveillance. Without a standardized national surveillance system many instances of product related injury are likely to continue to be unreported. Currently the Queensland Office of Fair Trading through its Product Safety Unit registers complaints about product related injury and liaises with industry, community and safety experts in order to develop appropriate responses, such as recommending regulation changes, undertaking further research or developing education campaigns.

The introduction of a new product safety system on 1 January 2011 includes, amongst other reforms, a mandatory requirement for manufacturers, importers and retailers to report to the Commonwealth government when one of their products has been involved in a serious injury or death. This will still not address the fundamental issue of the lack of a standardised, national surveillance system that would allow

for the early identification of emerging issues and have the potential to measure the magnitude of product related injury in a more systematic manner.

The Australian Productivity Commission was critical of the way product related injuries were reported. In a report released by the Australian Productivity Council in 2006[38], the key recommendation (9.1) was that:

The Ministerial Council on Consumer Affairs should initiate the development of a broadly-based hazard identification system, based on a clearinghouse approach, to gather a range of information and analysis on consumer product incidents (largely from existing sources) and disseminate it to all jurisdictions. Sources should include information from hospital emergency departments and admissions, business notifications (including recalls), international product warnings, mortality data and linked consumer complaints information. This system should be coordinated by the Australian Competition and Consumer Commission[38].

This recommendation is currently being progressed by the ACCC in conjunction with the States and Territories and while it is a step in the right direction, it still does not address the issue of standardisation of data definitions and collection systems to ensure comparability and completeness of the collection. True progress on this issue will require cross-sectoral engagement across areas of industry, product safety and health.

Recommendations

1. **The ACCC consider broadening their current focus to address risk of injury due to non-toy magnets as well as toy magnets.**
2. **Consideration be given to limiting the availability of strong magnets in all products likely to be used in a domestic setting.**
3. **Warning labels for ingestion of small parts be revised to include children 5 years and under.**
4. **Industry, consumers and clinicians be educated regarding the risk of magnet related injury**
5. **Development of a national reporting and standardised data collection system for product related injury to enable accurate understanding of risk factors, incidence and prevalence of product related injury.**
6. **Consumers, clinicians and industry be encouraged to report an injury or incident associated with a consumer product to the relevant product safety unit in their state or territory or the ACCC.**

Whilst our system of identifying product safety issues lags, new products are being designed, developed and marketed. An internet search reveals a plethora of magnetic products, both toy and non-toy, marketed for children and adults and many of them, inexpensive. Action to address this is urgently required.

Conclusion

Ingestion of more than one magnet may cause serious intestinal injury. In many instances, the ingestion is not disclosed at the time of presentation to health services and may go unrecognised whilst the patient is being treated for other conditions (i.e. viral gastroenteritis). Other serious injuries due to magnets have also been described.

Injury due to magnetic foreign bodies is likely to increase as small strong magnets are increasingly found in a variety of household applications. Efforts to reduce the risk of magnet related injuries need to focus both on toy and non-toy sources.

Links

Australian Competition and Consumer Commission (ACCC):
Website: http://www.accc.gov.au
ACCC Infocentre on 1300 302 502.

Office of fair trading:
Website: http://www.fairtrading.qld.gov.au
Email: safety@deedi.qld.gov.au Phone: 131304 and ask put through to the Product Safety Unit from the Office of Fair Trading

Kidasfe QLD: Website: http://www.kidsafeqld.com.au
Email: qld@kidsafeqld.com.au Phone: (07) 3854 1829

References

1. CDC. Non-fatal choking-related episodes among children—United States, 2001. MMWR 2002; 51:945–8.
2. Kay M, Wyllie R. Pediatric foreign bodies and their management. Curr Gastroenterol Rep 2005; 7:212–8.
3. Uyemura MC. Foreign body ingestion in children. Am Fam Physician 2005; 72:287–91.
4. Siddaiah-Subramanya MB, Borzi P. Ingestion of Magnets in Children: a growing concern. Medical Journal of Australia (MJA) (Letter): 2009; 190(2):98
5. Centers for Disease Control and Prevention (2006) Gastrointestinal injuries from magnet ingestion in children – United States, 2003–2006. MMWR Morb Mortal Wkly Rep 55:1296–1300
6. Cullity, B. D.; Graham C.D (2008). Introduction to Magnetic Materials. Second Edition: Wiley-IEEE. pp. 489. ISBN 0471477419
7. Furlani EP. Permanent Magnet and Electromechanical Devices: Materials, Analysis and Applications", Academic Press Series in Electromagnetism (2001) ISBN 0-12-269951-3
8. Worldwide survey of damage from swallowing multiple magnets. Oestreich AE. Pediatr Radiol (2009) 39:142–147.
9. U.S. CONSUMER PRODUCT SAFETY COMMISSION: Office of Compliance: Small Parts Regulations(1): Toys and Products Intended for Use By Children Under 3 Years Old:16 C.F.R. Part 1501 and 1500.50-53. Accessed March 2010 at: http://www.cpsc.gov/businfo/regsumsmallparts.pdf
10. Characteristics of Objects that cause Choking in Children. Rimell FL et al. JAMA 1995; 274: 1763-1766.
11. Size/ Shape Analysis of Aero-digestive Foreign Bodies in Children: A Multi-institutional study. Reilly JS et al. American Journal of Otolaryngology, Vol 16, No 3 (May-June), 1995: pp 190-193.
12. Ingested magnets and gastrointestinal complications. Alzahem AM, Soundappan SV, Jefferies H, Cass DT. Journal of Paediatrics and Child Health 43 (2007) 497–498
13. Multiple Magnet Ingestion as a Source of Severe

Gastrointestinal Complications Requiring Surgical Intervention. Sanjeev Dutta,; Ario Barzin. Arch Pediatr Adolesc Med. 2008;162(2):123-125;
14. Toy Magnet Ingestion in Children: Revising the Algorithm. Butterworth J, Feltis B. Journal of Pediatric Surgery (2007) 42, E3–E5
15. Magnet Ingestion: Schierling S, Snyder SK, Custer M. J Pediatr 2008;152:294
16. Children and mini-magnets: an almost fatal attraction. S McCormick, P Brennan, J Yassa, R Shawis. Emerg Med J 2002;19:71–73
17. Intestinal Volvulus and Perforation Caused by Multiple Magnet Ingestion: Report of a Case. Zekeriya İ'lçe, Hakan Samsum, Emil Mammadov, and Sinan Celayir. Surg Today (2007) 37:50–52.
18. A Case of Penile Trauma Caused by Magnets. Al-Sameraaii A, Bowkett B. UroToday Int J 2009 Aug;2(4). doi:10.3834/uij.1944 -5784.2009.08.10
19. Pediatric nasal septal perforation secondary to magnet misuse: A case Report. Shermetaro C, Charnesky M. ENT Journal.2007: 86:(11); p675-676
20. Cauchi JA. Shawis RN. Multiple magnet ingeslion and gastrointestinal morbidity. Arch Dis Child 2002:87(6):539-40.
21. Karkos PD. Karagame YG, Manivasagam A. El Badawey MR. Magnetic nasal foreign hodies: A result of fashion mania. Int J Pediatr Olorhinolaryngol 2003:67(12):1343-5.
22. Lehman DA. Roy S. Septal perforation caused by nasal magnetic foreign bodies. Ear Nose Throat J 2005:84(5):266-7.
23. Magnetic Jewellery- an overlooked danger. An Investigative Report. The Chicago Tribune. December 20, 2007 Reporter: Possley M. Accessed March 2010 at: http://www.pulitzer.org/archives/7772
24. Neighbourhood Safety Network. The Hidden Dangers of Magnets. Accessed March 2010 at: http://www.cpsc.gov/nsn/child.html
25. Consumer Product Safety Commission. Child's death prompts replacement program of magnetic building sets. Release 06-127. Washington, DC: Consumer Product Safety Commission; March 31, 2006. Accessed March 2010 at: Available at http://www.cpsc.gov/cpscpub/prerel/prhtml06/06127.html
26. Consumer Product Safety Commission. Serious injuries prompt recall of Mattel's Polly Pocket magnetic play sets. Release 07-039. Washington, DC: Consumer Product Safety Commission; November 21, 2006. Accessed March 2010 at: Available at http://www.cpsc.gov/cpscpub/prerel/prhtml07/07039.html
27. US CPSC Release #07-163: Small Magnets Are Injuring Children; CPSC Releases Stronger Warning to Parents: April 19, 2007 Accessed March 2010 at: http://www.cpsc.gov/cpscpub/prerel/prhtml07/07163.html
28. US CPSC document: Ingested Magnets Can Cause Serious Intestinal Injuries Accessed March 2010 at: http://www.cpsc.gov/cpscpub/pubs/magnet.pdf
29. Official website of ASTM International (Standards Worldwide) - ASTM F963 – 08:Standard Consumer Safety Specification for Toy Safety: Accessed March 2010 at: http://www.astm.org/Standards/F963.htm
30. Official website of the Comite Europeen de Normalisation- CEN: Accessed March 2010 at: http://www.cen.eu/cen/News/PressReleases/Pages/magnet_toys.aspx
31. Safety of toys: International Organization for Standardization: Published Standards: ISO 8124-1: series: Accessed March 2010 at: http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm
32. AS/NZS ISO 8124.1:2002: Safety of toys - Safety aspects related to mechanical and physical properties (ISO 8124.1:2000, MOD): Available for viewing for those with registered access: Accessed March 2010 at: http://www.saiglobal.com
33. Official site of Australian Competition & Consumer Commission: Accessed March 2010 at: http://www.accc.gov.au
34. Consumer Protection Notice No.5 of 2010; registered on the Federal Register of Legislative Instruments (FRLI) on 16 February 201: FRLI registration No. F2010L00195 Accessed March 2010 at:
35. AS/NZS ISO 8124.1:2002/Amdt 2:2009. Available for viewing for those with registered access: Accessed March 2010 at: http://www.saiglobal.com
36. http://magnetscankill.spaces.live.com Accessed- March 2010
37. NSW Fair Trading Amendment (Magnetic Toys) Regulation 2009 : No 531; Accessed March 2010 at: http://www.legislation.nsw.gov.au/sessionalview/sessional/subordleg/2009-531.pdf
38. Official website of The Australian Productivity Commission Report released in 2006: Accessed March 2010 at: http://www.pc.gov.au/data/assets/pdf file/0008/9998/productsafety.pdf

QISU CONTACT DETAILS:

Mater Health Services
Level 1 Whitty Building
Raymond Terrace,
South Brisbane QLD 4101
Phone: 07 3163 8569
Facsimile: 07 3163 1684
Website: www.qisu.org.au
Email: mail@qisu.org.au