Toppled television sets and head injuries in the pediatric population: a framework for prevention

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Injuries to children caused by falling televisions have become more frequent during the last decade. These injuries can be severe and even fatal and are likely to become even more common in the future as TVs increase in size and become more affordable.

To formulate guidelines for the prevention of these injuries, the authors systematically reviewed the literature on injuries related to toppling televisions. The authors searched MEDLINE, PubMed, Embase, Scopus, CINAHL (Cumulative Index to Nursing and Allied Health Literature), Cochrane Library, and Google Scholar according to the Cochrane guidelines for all studies involving children 0–18 years of age who were injured by toppled TVs. Factors contributing to injury were categorized using Haddon's Matrix, and the public health approach was used as a framework for developing strategies to prevent these injuries.

The vast majority (84%) of the injuries occurred in homes and more than three-fourths were unwitnessed by adult caregivers. The TVs were most commonly large and elevated off the ground. Dressers and other furniture not designed to support TVs were commonly involved in the TV-toppling incident. The case fatality rate varies widely, but almost all deaths reported (96%) were due to brain injuries. Toddlers between the ages of 1 and 3 years most frequently suffer injuries to the head and neck, and they are most likely to suffer severe injuries. Many of these injuries require brain imaging and neurosurgical intervention. Prevention of these injuries will require changes in TV design and legislation as well as increases in public education and awareness. Television-toppling injuries can be easily prevented; however, the rates of injury do not reflect a sufficient level of awareness, nor do they reflect an acceptable effort from an injury prevention perspective.

<http://thejns.org/doi/abs/10.3171/2015.2.PEDS14472>

KEY WORDS television toppling; pediatrics; head injury; traumatic brain injury; review; systematic review; trauma

TELEVISIONS can be dangerous to children and especially to toddlers between the ages of 1 and 3 years.¹⁵ These devices are present in 99% of American and 95% of Canadian homes and have become larger over time.^{33,34} Newer televisions, such as wide-screen plasma TVs, are heavy and are often not well fixed to a stable base. A typical 36-inch-wide TV falling just 1 m creates the momentum equivalent to a 1-year-old child weighing 10 kg falling from 10 stories.⁴ Small children injured by falling TVs usually suffer head and neck injuries such as fractures and intracranial hemorrhages,

which can be fatal.^{4,38,54} Such injuries are not rare events in developed countries where TVs are commonplace: TV toppling is ranked third in the top 5 hidden home hazards in the US,^{8,37} and the US Consumer Product Safety Commission (CPSC) reported 19,200 injuries between 2008 and 2010, up from 16,500 from 2006 to 2008.^{18,19} Over the last decade TV-related injuries have become more common, a trend that is likely to continue as TVs increase in size and more households globally are able to afford a TV.^{33,35,42,47}

Although literature exists on injuries related to the

ABBREVIATIONS ASTM = American Society for Testing Materials; CPSC = Consumer Product Safety Commission; CRT = cathode ray tube; FDTV = flat-panel television; PHA = public health approach; UK = United Kingdom; UL = Underwriters Laboratory.

ACCOMPANYING EDITORIAL See pp 1–2. DOI: 10.3171/2015.2.PEDS1582.

SUBMITTED September 8, 2014. **ACCEPTED** February 4, 2015.

INCLUDE WHEN CITING Published online September 29, 2015; DOI: 10.3171/2015.2.PEDS14472.

toppling of televisions, it is primarily epidemiological or clinical in nature, without a focus on prevention. Despite annual warnings on the US CPSC website about TV tipover and Health Canada website warnings of TV tipping accidents, the rate of injury remains high and appears to be increasing.^{9,11,12,18,19,24,25} The goal of this study was to systematically review the literature on injuries related to toppling TVs and to formulate a framework for the prevention of these injuries.

Methods

Using the Cochrane guidelines for systematic review, we searched Medline, PubMed, Embase, Scopus, CINAHL (Cumulative Index to Nursing and Allied Health Literature), the Cochrane Library, and Google Scholar using the following terms: “head injury,” “neck injury,” “cranial injury,” “skull fracture,” “brain injury,” “cerebral contusion,” “cerebral laceration,” “subdural hematoma,” “subarachnoid hemorrhage,” “epidural hematoma,” “diffuse axonal injury,” “traumatic brain injury,” “TBI,” “crush and static head injuries,” “TV,” “television,” “infant,” “child,” and “youth.” We also searched the US CPSC and Health Canada websites using the same key words. Hand searches of the journals *Injury Prevention*, *Journal of Neurosurgery: Pediatrics*, and the *Journal of Pediatric and Child Health* were performed, starting with publications from 1988 (the initiation of the first study of injuries related to falling TVs, by DiScala et al.,¹⁵ which was published in 2001) through December 28, 2014.

We included all studies involving children 0–18 years of age who were injured by toppled TVs. Studies investigating household furniture injuries including televisions as furniture were also included in the literature review. Studies with no mention of head injuries inflicted by toppled televisions were excluded. Studies with injuries inflicted by television components in the absence of a toppling event were also excluded. A combined total of 4163 article titles and abstracts were read and screened according to the aforementioned criteria. Thirty-three articles met these criteria and were selected for full manuscript review. Of those 33 articles, 29 studies met the criteria fully and were selected for inclusion in the literature review. Four articles were excluded after full manuscript review because the reported injuries were inflicted by televisions but did not result from a tipover, or they were studies using the same group of injured individuals. The diagram of the systematic search and review is found in Fig. 1.

Factors contributing to injury were categorized using Haddon’s Matrix and the public health approach (PHA) as the framework for developing a strategy for the prevention of these injuries. Haddon’s Matrix has a systematic setup for identifying risk factors, whereas the PHA outlines a method for developing a plan of action to prevent injuries.³⁰ The PHA has 4 levels: surveillance, identification of risk and protective factors, implementation, and development and evaluation of interventions. The data in the Haddon’s Matrix are divided into 3 phases: pre-event, event, and post-event. Columns labeled “host,” “agent,” and “environment” are used to organize the factors based on the injured party, the vehicle causing the injury, and the social

FIG. 1. Search protocol flowchart. This flowchart depicts the steps taken to systematically review the literature. Reasons for not including articles that received full manuscript review are also provided. Of 4163 articles initially found using the search terms, 29 met the criteria for inclusion in this review.

and physical situation surrounding the incident. In the case of TV-toppling injuries the hosts are children, particularly toddlers (children between the ages of 1 and 3 years); the agent is the television set; and the environment includes both the physical surroundings, such as the TV support furniture, and the social environment, such as caregiver supervision. From the factors presented in Haddon’s Matrix and the PHA, we systematically derived a set of strategies for the prevention of these injuries. Gray literature from conference abstracts and presentations, public alerts, articles, and blogs, was also considered in the construction of prevention strategies. Screening of these articles was subject to the same inclusion criteria mentioned above and any pertinent information on the mechanism of injury and prevention was collected and considered. Discussion of prevention is subdivided into 4 categories: engineering and design; legislation and enforcement; education; and systems.

Results

Twenty-nine studies from 7 countries met the selection criteria. Information on head and neck injuries from the articles reviewed is summarized in Table 1. According to the data from these studies, of all age groups involved in TV-toppling incidents, toddlers most frequently suffer injuries to the head and neck, and their injuries are most likely to be severe, with an Injury Severity Score > 15.²² The case fatality rate varies widely, but almost all deaths in these series (96%) were due to brain injuries. Murray et al. used only population-based estimates in their review of the National Electronic Injury Surveillance System, which surveys approximately 100 US hospitals.³⁵ These investi-

TABLE 1. Summary of head and neck injuries from toppled televisions as reported in the literature*

Authors & Year	Country	No. of Hospitals	Study Duration	Patient Age	ISS	Total No. of TV-Related Injuries Reported	Fraction of Total Injuries Presenting in Head & Neck (%)	Deaths Due to TV Topping (% of total injuries)	Fraction of Total Deaths Due to Head & Neck Injury (% of total deaths)
DiScala et al., 2001	US	78	1988–1999	76% 1–4 yrs	69.4% <10, 28.4% ≥10 (4 cases NR)	183	125/183 (68.3%)	5 (2.73%)	5/5 (100%)
Scheidler et al., 2002	US	All trauma hospitals in PA	1989–1999	56% 0–3 yrs	30.2% >15	43	25/43 (58.1%)	5 (11.6%)	NR
Bernard et al., 1998	US	169	1990–1997	Mean 36 mos	NR	73	NR	28 (38.4%)	13/14 (92.9%)†
Bernard et al., 1998*	US	1	1995–1997	Mean 20 mos	NR	5	4/5 (80%)	1 (20%)	1/1 (100%)
Doichin & Gordon, 2007	Canada	1	1990–2002	65% 0–4 yrs	NR	104	49/104 (47.1%)	NR	NR
Gottesman et al., 2009	US	~100	1990–2007	75% 0–6 yrs	NR	4031	1991/4031 (49.4%)	NR	NR
De Roo et al., 2013	US	~100	1990–2011	Median 3 yrs	NR	12,227	7641/12,227 (63%)	6 (4.9 x 10 ⁻² %)	NR
Jea et al., 2003	US	~100	1992–2001	Range 0–18 yrs	NR	732‡	732/732 (100%)	NR	NR
Jea et al., 2003*	US	1	1995–2002	Mean 22 mos	NR	7‡	7/7 (100%)	0	0
Yahya et al., 2005	Canada	1	1992–2003	Mean 44 mos	NR	18‡	18/18 (100%)	0	0
Sikron et al., 2007	Israel	10	1997–2003	70% 1–3 yrs	61% ISS 1–8, 18% ISS 16+	116	85/116 (73.3%)	4 (3.45%)	4/4 (100%)
Mills et al., 2012	Canada	1	1997–2011	81% 0–5 yrs	NR	179	136/179 (76%)	0	0
Murray et al., 2009	US	~100	1998–2007	69.5% 1–9 yrs	NR	§	§	NR	NR
Rutkowski et al., 2011	US	1	1999–2009	Mean 36 mos	Mean 8.3 (range 1–25)	52	43/52 (82.7%)	1 (1.92%)	1/1 (100%)
Cho et al., 2009	Australia	2	2000–2003	Median 2.5 yrs	Mean 1 (range 1–25)	52	22/52 (42.3%)	1 (1.92%)	1/1 (100%)
Cho et al., 2009*	Australia	NSW coroner	2000–2002	Range 1 mo–4 yrs	NR	2	2/2	2 (100%)¶	2/2 (100%)
Güloğlu et al., 2012	Turkey	1	2001–2010	65% 1–3 yrs	NR	42	24/42 (57.1%)	5 (11.9%)	5/5 (100%)
Ota et al., 2006	US	1	2003–2004	Median 40 mos	Mean 2.5 (range 1–20)	26	14/26 (53.8%)	0	0
Marnewick et al., 2011	Australia	1	2006–2008	Mean 51 mos	Mean 15	13	9/13 (69.2%)	1 (7.69%)	1/1 (100%)
Platt & Stanley, 2011	US	NR	2006–2008	Range 11 mos–3 yrs	NR	3	3/3 (100%)	3 (100%)¶	3/3 (100%)
Platt & Stanley, 2011*	US	1	2006–2008	NA	NR	28	NR	0	0
Suresh et al., 2010	India	1	2007–2008	Range 6 mos–5 yrs	NR	11	9/11 (81.8%)	0	0
Gokhan et al., 2010	Turkey	1	2008–2009	Mean 40 mos	NR	71	49/71 (69%)	4 (5.63%)	4/4 (100%)
Befeler et al., 2014	US	1	2009–2013	Mean 3.3 yrs	NR	26	20/26 (77%)	0	0
Braff et al., 2004	US	1	NR	5 yrs	NR	1	1/1‡ (100%)	0	0
Deisch et al., 2011	US	NR	NR	13 mos & 32 mos	NR	2	2/2 (100%)	2 (100%)¶	2/2 (100%)
Farooqui et al., 2013	Pakistan	1	NR	Mean 3.8 yrs	NR	20	20/20 (100%)	0	0
Gupta et al., 2010	India	1	NR	6 yrs	NR	1	1/1‡ (100%)	0	0

(continued)

TABLE 1. Summary of head and neck injuries from toppled televisions as reported in the literature* (continued)

Authors & Year	Country	No. of Hospitals	Study Duration	Patient Age	ISS	Total No. of TV-Related Injuries Reported	Fraction of Total Injuries Presenting in Head & Neck (%)	Deaths Due to TV Toppling (% of total injuries)	Fraction of Total Deaths Due to Head & Neck Injury (% of total deaths)
Kodikara & Pollanen, 2012	Canada	1	NR	2 yrs	NR	1	1/1† (100%)	1 (100%)¶	1/1 (100%)
Lam & Place, 2008	US	1	NR	1 yr	NR	1	1/1 (100%)	0	0
Muñiz, 2012	US	1	NR	Range 1–5 yrs	NR	3	3/3 (100%)	0	0
Samson et al., 2010	India	1	NR	Mean 12 mos	NR	8	8/8 (100%)	1 (12.5%)	1/1 (100%)
Wolf & Harding, 2011	US	NR	NR	Range 3–6 yrs	NR	4	3/4 (75%)	4 (100%)¶	3/4 (75%)
Summary††	7 countries	Median 1	Range 1988–2013	Median 3 yrs	Range 1–25	Total 143,315	Total 91,497/143,315 (63.84%)	Total 216 (0.15% of total injuries)	Total 47/49** (95.9%)

ISS = Injury Severity Score; NA = not applicable; NR = not reported; NSW = New South Wales; ~100 = US hospitals surveyed by the National Electronic Injury Surveillance System (NEISS).

* The second row of data is included for studies with 2 separate sources of TV-toppling injury information. The secondary source (indicated by an asterisk) may differ from the primary source in hospital involvement, data collection dates, ages of participants, ISS, or morbidity or mortality rates (including those affecting the head and neck).

† Only 14 of the 28 deaths were investigated to determine the cause.

‡ Statistically derived national values (not included in table; see text).

¶ Only head injuries were accounted for in the study.

‡ Only fatal cases were included.

** Cause of death was stated in only 49 of the 210 deaths reported.

†† Summary row does not include statistically derived national data.

gators reported a nationally estimated 42,122 TV-toppling injuries between 1998 and 2007, 44% of which were head injuries. National estimates of TV-toppling injuries reported by Gottesman et al. included 125,280 injuries between 1990 and 2007, and De Roo et al. reported 380,385 between 1990 and 2011.^{12,21}

Data from multiple studies regarding the characteristics of the events that led to TV-toppling injuries are summarized in Table 2. Most (84%) of the injuries occur at home and more than three-fourths are unwitnessed by caregivers. The TVs are most commonly large (median size 27 inches) and elevated off the ground 1–5 feet. Dressers and other furniture not designed to support televisions were commonly involved in the TV-toppling injury. The most commonly reported event leading to television toppling was a child climbing onto often unstable furniture to reach the TV or an object on top of the TV, although many studies did not report the number of incidents. There were also frequent reports of children pulling the TV onto themselves or colliding with the TV stand and thus causing the TV to topple.

A total of 160 TV-toppling cases had a specific mechanism of injury stated. Of those 160 cases, collision of the child with the stand was most common cause precipitating injury from a falling TV (Table 2). However, in the majority of studies (19/29), climbing was identified as the most significant cause of injury, but many reports did not state the number of injuries related to this mechanism. Thus, the values reported in Table 2 for events leading to TV tipover may be skewed by the few studies (n = 9) for which the number of cases for each mechanism of injury was reported. In some cases the events leading to injury were vaguely described (e.g., TV/stand tipping), resulting in their exclusion from analysis. Toddlers were reported to have higher rates of climbing injuries than older children (> 4 years old), who were more likely to collide with the TV stand.^{21,35,46}

The wide variety of cranial pathologies caused by toppling TVs is summarized in Table 3. Superficial injuries included contusions, ear/nose/throat bleeds, abrasions, lacerations, ecchymosis, and other nonintracranial injuries. Neurological deficits included any temporary or permanent cranial nerve palsies as well as cognitive and memory deficits. These injuries can clearly be devastating or fatal.

Discussion

Haddon's Matrix (Table 4) was used to organize the factors associated with toppling injury during 3 time periods: pre-event, event, and post-event. This matrix was derived from the results of our review, and factors are discussed in order of host, agent, and environment. From these factors prevention methods were devised.

Analysis of Host Factors

The "host" in Haddon's Matrix refers to the typical victim of a particular injury.⁴¹ In the case of TV-toppling injuries, young children—specifically toddlers—are at the highest risk of injury. Factors in the host occurring before, during, and after the event contribute to the risk of injury in this group.

TABLE 2. Factors associated with injury across the studies

Factor	Data Summary From Included Studies*
Injury at a private home	84% (n = 21,197)
Unwitnessed or witnessed by another child (<18 yrs)	77% (n = 165)
Height of TV stand from ground	Range 1–5 ft
Size of TV	Median 27 in
Reported events resulting in tipover	1) Colliding with TV stand, 75.6% (n = 121) 2) Climbing, 13.1% (n = 21) 3) Pulling on TV component, 6.9% (n = 11) 4) Another person applying the tipping force, 4.4% (n = 7)

* The n value represents the total number of injuries in the studies that were included. Only 160 cases had a clear mechanism of injury provided and were included in the analysis.

Pre-Event Host Factors

There are 3 major factors preinjury that make toddlers more susceptible to television-toppling injuries. First, young children lack the perception and awareness of many risks.²⁰ At such a young age, toddlers' cognitive ability to recognize and avoid danger has not fully developed, leaving them much more vulnerable to injury. Studies confirm that climbing television support furniture is a common activity leading to injury.^{4,35,45} Second, uncoordinated infants and toddlers can unintentionally collide with unstable stands while playing in the vicinity of the TV, causing toppling accidents.^{22,33} Third, these children are exposed to the risk of television tipovers for extended periods of time every day. Not only are televisions becoming more ubiquitous, it is estimated that children 2–5 years old spend more than 32 hours per week watching TV.³² The combination of a susceptible host with significant exposure to risk provides opportunity for preventive approaches.

Event Host Factors

At the time of the television toppling, the factor contributing to head injury is the television toppling onto an unprotected head. Because a toddler's height is shorter than most TV stands, the head is most often the first point of contact from a TV-toppling event. Protecting the head may prevent or reduce the severity of injury. However, head protection may not be the most suitable means of prevention for this injury mechanism. Although head in-

juries cause the most deaths from toppling TVs, multiple injuries sustained in different body regions also increase injury severity. A study by Güloğlu et al. found that toddlers 1–3 years old were more likely to sustain injuries to multiple body regions than any other age group.²² Small children may sustain secondary brain injuries or death caused by mechanical asphyxia because of their small size in relation to the television.

Post-Event Host Factors

Small children often have a limited ability to verbalize symptoms. In the case of mild head or neck injuries the child may underplay the severity of the damage, and the injured child or other children who were present may not inform a caregiver who has not witnessed the event. This can be dangerous and allow minimal damage to progress into a more serious condition. The case report by Lam and Place shows how injuries that are seemingly minor initially can progress to severe symptoms: a 12-month-old child initially presenting with mild symptoms experienced rapid deterioration and cranial nerve deficits in a short time.²⁹ Table 3 shows the range of head injuries that can occur and that many of those injuries require neurosurgical intervention.

Analysis of Agent Factors

The agent factors refer to energy that is transmitted to the host through a vehicle.⁴¹ The agent in this case is the television and the physical energy it transmits to the child, causing the injury. Recent changes in TV style and stability have not reflected awareness of child safety but instead have contributed to the increasing numbers of injuries caused by TVs (Table 1).

Pre-Event Agent Factors

Over the years the physical composition of the TV set has changed. The once popular bulky cathode ray tube (CRT) TV has given way to the less space-consuming flat-panel TVs (FPTVs). The base to which the TV is attached has also changed dramatically over the last couple of decades. Gone are furniture-style CRTs inserted into a rectangular wooden box with 4 short and stable legs providing 4 points of contact with the floor and a center of gravity that is largely in the center of the furniture. Newer CRT TVs have forward-shifted centers of gravity, increasing the chance of tipping,³⁶ and also in fashion are large, poorly supported FPTVs that are frequently mounted above toddler head height.

FPTVs are thin, wide, and tall, with fairly central centers of gravity; however, even if properly secured, FPTVs

TABLE 3. Types of head injuries acquired from TV-toppling accidents

Type of Head Injury	No. of Studies Reporting	No. of Reported Head Injuries*	% of Reported Cases
Superficial injuries	17	14,568 (n = 30,447)	47.8%
Skull fractures	19	136 (n = 360)	37.7%
Intracranial bleeding	20	60 (n = 457)	13.1%
Neurological deficits	8	50 (n = 249)	20.1%

* The n value represents the total number of injuries in the studies that were included.

TABLE 4. Haddon's Matrix for factors associated with head injuries caused by toppled TVs

Time Period	Factor		
	Host	Agent	Environment
Pre-Event	Child's insufficient perception & awareness of risk. Lack of coordination. Increased risk exposure.	Lack of hazard warnings on TV & regulations on securing TVs in home & institutions. Improper securing of TV. Forward-shifted center of gravity.	Caregiver lack of supervision/restriction, awareness & perception. Placement of toys & other objects desirable to children on top of the TV. Unstable/climbing-permissible TV support furniture.
Event	No protection of head. Other injured body regions. Mechanical asphyxia.	Heavy weight of the TV. Pointed TV edges.	Height of TV support furniture.
Post-Event	Neglect to report "mild" injuries.	Lack of prompt & proper removal of TV off of the child's body. Lack of proper removal of penetrating TV components from the child's body.	Length of time before medical attention is sought (if at all). Speed & availability of first responders.

have a considerable chance of toppling over.^{3,34,44} Very minimal force is required to tip the television forward. In one study, Dotchin and Gordon found that 31 of the 49 televisions within their Nova Scotia pediatric hospital were not secured in any way. In fact, 90% of all the TVs in this medical facility could be tipped over by children 4 years or younger.¹⁶

Consumers could be made aware of the hazard through warnings on televisions or the packaging in which they are sold, but in North America such warnings are not enforced, and the only mandatory labels on electronics (including TVs) are fire hazard warnings.⁵¹

Event Agent Factors

Several agent factors contribute to injury at the time of toppling. The sheer mass of television sets can cause a lot of damage to a child's head. TVs are now flatter and lighter than in the past, but they can still weigh more than 40 kg, which is nearly 3 times the size of the average 3-year-old child (14 kg).^{14,33,35} In addition, the pointed corners of the television set can cause penetrating injuries, leading to lacerations of the face or scalp, and more severe blunt-force skull fractures. Changes to the design of TV sets can be made to help make them safer and prevent injury.

Post-Event Agent Factors

After a television has fallen onto a child, further crushing damage to the head or asphyxiation may occur if the object is not promptly removed. In older television sets, antennae are another possible source of penetrating injuries. A case report by Al-Sebeih et al. described a penetrating oral-facial injury caused by a TV antenna, which fortunately didn't cause severe damage.¹ Glass TV screens can shatter, depending on the force of impact, causing lacerations and penetrating injuries.

Analysis of Environmental Factors

Environmental factors can be physical or social. These are the objects, people, and social concepts associated with the vehicle and host. In cases of TV-toppling injuries, the role of parents and caregivers who create the environment

around TVs and must respond when injuries occur is chief among these factors.

Pre-Event Environmental Factors

Several environmental factors play key roles in TV-toppling injuries. Chief among these is the role of parents and caregivers who create the environment around TVs and who may be unaware of the high risk posed to toddlers from falling TVs. The resulting lack of safety precautions and inadequate supervision of small children are critical concerns, given that 77% of TV-toppling injuries are unwitnessed by adult caregivers.

Another risk factor is the placement of desirable objects on top of the TV, which can entice children to climb the support furniture. Stands with drawers or other components easily climbed by toddlers are more likely to lead to toppling injuries. Kodikara and Pollanen describe a case in which a 2-year-old girl attempting to climb a stand to reach the TV controls suffered a fatal toppling accident, and there are many more children who have met the same fate.²⁸

Event Environmental Factors

The higher the stand, the more velocity the TV picks up before impact with the child's head. Thus, lower stands and those bolted to walls are safer.² Unfortunately, far too many households have not taken these factors into consideration when making decisions about TV placement.

Post-Event Environmental Factors

Many studies show that time to medical attention after a head injury influences outcome from that head injury.^{46,55} Many people from low- and middle-income countries are now buying televisions, but these countries rarely have well-developed first response systems that service all areas.³⁹ This lack of timely medical attention may lead to delays in treating primary and secondary effects of head injuries in these toddlers.

Prevention

With the factors associated with TV-toppling injuries

clearly outlined by Haddon's Matrix, the next step in prevention, as the PHA suggests, is devising a plan of action. In this section we discuss prevention methods being used currently, ways in which these methods can be improved, and additional prevention methods not currently in practice. The topic of prevention of TV-toppling injuries in the pediatric population has been organized into 4 categories: engineering and design; legislation and enforcement; education; and systems. A list of methods of prevention is provided in Table 5.

Engineering and Design

Throughout the literature, comments about the engineering of newer generations of CRT televisions have emphasized the problem with their forward-shifted center of gravity.^{28,31,33} This engineering issue causes major instability in CRT TVs. The FPTVs have a more balanced center of gravity and are much lighter than CRT TVs of equivalent screen size.^{12,31} The thin, light design of FPTVs, however, make them more susceptible to tipping with less force applied, and much easier for children to grasp. Also, FPTVs can still weigh upward of 40 kg, with the possibility of inflicting significant damage on children. Recent studies have reported tipover injuries caused by FPTVs leading to pediatric head injuries.^{3,12} Efforts should be made to design lighter TVs with evenly distributed weight and built-in anchoring systems.

Another design and engineering concern around TV-toppling events is the support furniture on which televisions are placed. The decrease in popularity of CRT TVs is not actually reducing the amount of injury.¹² This may be due in part to TV owners placing older CRT TVs in less supervised rooms and on furniture that was not built to withstand the weight of the TV, thus increasing the risk of toppling events. Dressers, armoires, and bureaus are reported as the most common furniture involved in TV-toppling accidents.^{12,19,22,31,33,54} Although regulations are in place for testing of dressers and other household furniture, they are not tested to withstand the weight of TV sets be-

cause that is not their primary use.^{2,51} The CPSC, along with the American Society for Testing Materials (ASTM) and the Underwriters Laboratory (UL), have regulations on the manufacturing and testing of furniture often used to support televisions. Because consumers do not always place their TV sets on the manufacturer's recommended stands, there is a greater risk of tipping. To address this issue of TV support furniture from an engineering and design point of view would be only half the battle, and so this issue is also discussed in the *Legislation and Enforcement* section. Ultimately, lower, wide-based stands will reduce the risk associated with toppling because a TV falling from a lower height obtains lower velocity before impact, and increased stability will decrease the risk of toppling from collisions with the stand. As climbing support furniture is reported as a major contributor to toppling events (Table 2), designing stands with fewer knobs and drawers will reduce the potential for children to climb, thus reducing toppling rates.

Legislation and Enforcement

Currently there are regulations on the stability of TV stands as well as testing of TV stability. Testing of stands is routinely done postmanufacturing.⁵¹ However, as previously mentioned, many other pieces of household furniture are used to support televisions. In light of the increased tipping accidents, ASTM revised the ASTM F2057 standards for dressers, chests, and door chests, implementing 2 new tests for stability of these furniture pieces.² The US CPSC has regulations on the testing and safety of "Children's Products," which include television sets.¹⁰ Health Canada Consumer Product Safety and the government of the United Kingdom (UK) also have general regulations for household electronics.^{6,40,52} The UL is a global company contracted to test the safety of manufactured products. The UL has its own safety regulations in conjunction with regulations set by the country distributing the product. Regulations on TVs and stands are in place, but the incidence of injuries is still high. Therefore,

TABLE 5. Prevention methods for pediatric TV-toppling events

Factor	Prevention Method
Host	1. Educate children about in-home hazards including TV toppling. 2. Restricted play in rooms containing a TV.
Vector	3. Place safety warnings on televisions & instructions on how to safely secure the TV. 4. Improve the design of TVs to evenly distribute the weight & make them less easily tippable. 5. Place TV back away from the edge of the stand.
Environment	6. Educate the public, including parents, teachers, medical professionals, children, & other caregivers. 7. Set regulations on the support furniture & wall mounts used for particular TV makes & sizes. Dressers should not be used to support TVs. 8. Regulations for anchoring TVs to the ground or wall using brackets or some other apparatus. 9. Manufacture shorter, more stable TV stands that can withstand the dynamic force caused by climbing children. 10. Objects desirable to children, such as toys or remotes, should not be placed on top of TVs. 11. Caregivers should increase supervision of children around the home. 12. Caregivers should refrain from removing objects that deeply penetrate the head & wait for medical professionals to assess the injury. 13. Have parents/caregivers learn cardiopulmonary resuscitation. 14. Increase the number or speed of first responders, thus shortening the time between injury & treatment.

improvements in these regulations and better enforcement is needed.

There are areas in which legislation on TVs and TV stands is lacking and improvements could potentially serve to reduce toppling accidents. Current legislation regarding warnings placed on TVs focuses on fire hazard labels.^{6,51} Implementing legislation requiring that mandatory warning labels for tipping be placed on televisions could be beneficial. Mandatory provision of proper anchoring brackets and TV straps at the point of sale should also be implemented. Along with anchoring devices there should be clear instructions on how to properly anchor TVs and stands. Another option is to sell TV-specific stands in conjunction with the television. This would increase the chances of televisions being placed on the proper support furniture; however, accomplishing this without other consumer costs would be important.

Education

Improved public education is important for the prevention of TV toppling. Parents, caregivers, teachers, and medical professionals should be educated on the strategies that can be used to reduce the risk of television injuries. These strategies include increasing and improving supervision of children within the home, restricting play around TV sets, anchoring of TVs and TV stands, never placing televisions on dressers and other household furniture, selecting stands that are short with wide bases, placing TVs as far back from the edge of the stand as possible, and never placing desirable objects for children on top of the TV. Once a toppling event has occurred, an injured child's outcome can be greatly improved by parents and caregivers previously educated to speedily remove a fallen TV from the child's body, to administer first aid such as cardiopulmonary resuscitation tactics, not to remove any deep penetrating objects, and to seek medical attention immediately.

Efforts to educate the general public through national campaigns can be improved. The US CPSC and Health Canada issue annual warnings. The UK's Home Accident Surveillance System (HASS; <http://www.hassandlass.org.uk>) was terminated in 2002, but this system previously reported TV toppling as a large contributor to pediatric head injury.⁴⁰ The Royal Society for Prevention of Accidents in the UK also warns the public about TV-toppling accidents.

Increasing awareness and prevention are occurring but are failing to reach a large audience. As Ota et al. reported, 85% of caregivers were unaware of TV toppling as a potential hazard.³⁶ Placing warnings on more high-traffic websites should increase the number of people exposed to the warnings. Another option is to distribute educational pamphlets at the point of sale. Also, simply placing labels warning of toppling on TV sets increases awareness, as addressed in the *Legislation and Enforcement* section.

Systems—First Responders

Although TV-toppling injuries may not be severe in all cases (Tables 1 and 4), seeking medical care for head injuries is important. Even with seemingly mild injuries, progression into more severe conditions may be avoided if medical care is sought.^{29,46,55} Thus, caregivers should

take an injured child to the nearest emergency department or call for emergency assistance. Cases that need emergency medical attention would benefit from fast, organized, emergency response systems. However, in many developing countries, and even in rural areas of developed countries, emergency first response is nonexistent or is not timely.³⁹ Adding to the issue is the affordability of CRT TVs in developing countries.^{17,47} Families of lower socioeconomic status in these countries are more likely to buy unstable heavy TVs, and in the unfortunate event of a toppling accident they may not have the benefits of an emergency medical care system. Although these system factors have larger implications than timely care of TV-toppling injuries, they are worth mentioning in the prevention of this mechanism of injury.

Limitations of the Study

Our review of the literature was systematic and thorough; however, all of the papers that we identified were case series or case reports. The papers reviewed provided little focus on the prevention of head injuries. The US CPSC and Health Canada warnings have never been evaluated for their impact, and it is unclear how many consumers actually read these websites. Properly designed studies from different jurisdictions that address the effectiveness of the types of interventions that we have suggested are required.

Conclusions

Television-toppling injuries can be easily prevented; however, the rates of injury do not reflect a sufficient level of awareness, nor do they reflect an acceptable effort from an injury prevention perspective. Amendments to current legislation and implementation of additional regulations are suggested to reduce injury rates. Improvements in the design of television sets and stands as well as better tactics to educate the public are recommended. Also, the effort to prevent these injuries would benefit from prospective studies to better understand the injury mechanism. Future implementation of the aforementioned prevention recommendations would go a long way toward reducing head and neck injuries from TV-toppling events.

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Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: both authors. Acquisition of data: Parker. Analysis and interpretation of data: Parker. Drafting the article: both authors. Critically revising the article: both authors. Reviewed submitted version of manuscript: both authors. Approved the final version of the manuscript on behalf of both authors: Parker. Study supervision: Cusimano.

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