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.

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

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

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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. 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. 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. 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 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. 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. These investi-

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

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>Country</th>
<th>No. of Hospitals</th>
<th>Study Duration</th>
<th>Patient Age</th>
<th>ISS</th>
<th>Total No. of TV-Related Injuries Reported</th>
<th>Fraction of Total Injuries Presenting in Head &amp; Neck (%)</th>
<th>Deaths Due to TV Toppling (% of total injuries)</th>
<th>Fraction of Total Deaths Due to Head &amp; Neck Injury (% of total deaths)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DiScala et al., 2001</td>
<td>US</td>
<td>78</td>
<td>1988–1999</td>
<td>76% 1–4 yrs</td>
<td>69.4% &lt;10, 28.4% ≥10 (4 cases NR)</td>
<td>183</td>
<td>125/183 (68.3%)</td>
<td>5 (2.73%)</td>
<td>5/5 (100%)</td>
</tr>
<tr>
<td>Scheidler et al., 2002</td>
<td>US</td>
<td>All trauma hospitals in PA</td>
<td>1989–1999</td>
<td>56% 0–3 yrs</td>
<td>30.2% &gt;15</td>
<td>43</td>
<td>25/43 (58.1%)</td>
<td>5 (11.6%)</td>
<td>NR</td>
</tr>
<tr>
<td>Bernard et al., 1998</td>
<td>US</td>
<td>169</td>
<td>1990–1997</td>
<td>Mean 36 mos</td>
<td>NR</td>
<td>73</td>
<td>NR</td>
<td>28 (38.4%)</td>
<td>13/14 (92.9%)</td>
</tr>
<tr>
<td>Bernard et al., 1998*</td>
<td>US</td>
<td>1</td>
<td>1995–1997</td>
<td>Mean 20 mos</td>
<td>NR</td>
<td>5</td>
<td>4/5 (80%)</td>
<td>1 (20%)</td>
<td>1/1 (100%)</td>
</tr>
<tr>
<td>Dotchin &amp; Gordon, 2007</td>
<td>Canada</td>
<td>1</td>
<td>1990–2002</td>
<td>65% 0–4 yrs</td>
<td>NR</td>
<td>104</td>
<td>49/104 (47.1%)</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Gottesman et al., 2009</td>
<td>US</td>
<td>~100</td>
<td>1990–2007</td>
<td>75% 0–6 yrs</td>
<td>NR</td>
<td>4031</td>
<td>1519/4031 (49.4%)</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>De Roo et al., 2013</td>
<td>US</td>
<td>~100</td>
<td>1990–2011</td>
<td>Median 3 yrs</td>
<td>NR</td>
<td>12,227</td>
<td>7641/12,227 (63%)</td>
<td>6 (4.9 x 10^2%)</td>
<td>NR</td>
</tr>
<tr>
<td>Jea et al., 2003</td>
<td>US</td>
<td>~100</td>
<td>1992–2001</td>
<td>Range 0–18 yrs</td>
<td>NR</td>
<td>732†</td>
<td>732/732 (100%)</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Jea et al., 2003*</td>
<td>US</td>
<td>1</td>
<td>1995–2002</td>
<td>Mean 22 mos</td>
<td>NR</td>
<td>7†</td>
<td>7/7 (100%)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Yahya et al., 2005</td>
<td>Canada</td>
<td>1</td>
<td>1992–2003</td>
<td>Mean 44 mos</td>
<td>NR</td>
<td>18†</td>
<td>18/18 (100%)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sikron et al., 2007</td>
<td>Israel</td>
<td>10</td>
<td>1997–2003</td>
<td>70% 1–3 yrs</td>
<td>61% ISS 1–8, 18% ISS 16+</td>
<td>116</td>
<td>85/116 (73.3%)</td>
<td>4 (3.45%)</td>
<td>4/4 (100%)</td>
</tr>
<tr>
<td>Mills et al., 2012</td>
<td>Canada</td>
<td>1</td>
<td>1997–2011</td>
<td>81% 0–5 yrs</td>
<td>NR</td>
<td>179</td>
<td>136/179 (76%)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Murray et al., 2009</td>
<td>US</td>
<td>~100</td>
<td>1998–2007</td>
<td>69.5% 1–9 yrs</td>
<td>NR</td>
<td>§</td>
<td>§</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Rutkoski et al., 2011</td>
<td>US</td>
<td>1</td>
<td>1999–2009</td>
<td>Mean 36 mos</td>
<td>Mean 8.3 (range 1–25)</td>
<td>52</td>
<td>43/52 (82.7%)</td>
<td>1 (1.92%)</td>
<td>1/1 (100%)</td>
</tr>
<tr>
<td>Cho et al., 2009</td>
<td>Australia</td>
<td>2</td>
<td>2000–2003</td>
<td>Median 2.5 yrs</td>
<td>Mean 1 (range 1–25)</td>
<td>52</td>
<td>22/52 (42.3%)</td>
<td>1 (1.92%)</td>
<td>1/1 (100%)</td>
</tr>
<tr>
<td>Cho et al., 2009*</td>
<td>Australia</td>
<td>NSW coroner</td>
<td>2000–2002</td>
<td>Range 1 mo–4 yrs</td>
<td>NR</td>
<td>2</td>
<td>2/2 (100%)†</td>
<td>2/2 (100%)</td>
<td></td>
</tr>
<tr>
<td>Güloğlu et al., 2012</td>
<td>Turkey</td>
<td>1</td>
<td>2001–2010</td>
<td>65% 1–3 yrs</td>
<td>NR</td>
<td>42</td>
<td>24/42 (57.1%)</td>
<td>5 (11.9%)</td>
<td>5/5 (100%)</td>
</tr>
<tr>
<td>Ota et al., 2006</td>
<td>US</td>
<td>1</td>
<td>2003–2004</td>
<td>Mean 40 mos</td>
<td>Mean 2.5 (range 1–20)</td>
<td>26</td>
<td>14/26 (53.8%)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Marnewick et al., 2011</td>
<td>Australia</td>
<td>1</td>
<td>2006–2008</td>
<td>Mean 51 mos</td>
<td>Mean 15</td>
<td>13</td>
<td>9/13 (69.2%)</td>
<td>1 (7.69%)</td>
<td>1/1 (100%)</td>
</tr>
<tr>
<td>Platt &amp; Stanley, 2011</td>
<td>US</td>
<td>NR</td>
<td>2006–2008</td>
<td>Range 11 mos–3 yrs</td>
<td>NR</td>
<td>3</td>
<td>3 (100%)</td>
<td>3 (100%)†</td>
<td>3/3 (100%)</td>
</tr>
<tr>
<td>Platt &amp; Stanley, 2011*</td>
<td>US</td>
<td>1</td>
<td>2006–2008</td>
<td>NA</td>
<td>NR</td>
<td>28</td>
<td>NR</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Suresh et al., 2010</td>
<td>India</td>
<td>1</td>
<td>2007–2008</td>
<td>Range 6 mos–5 yrs</td>
<td>NR</td>
<td>11</td>
<td>9/11 (81.8%)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Gokhan et al., 2010</td>
<td>Turkey</td>
<td>1</td>
<td>2008–2009</td>
<td>Mean 40 mos</td>
<td>NR</td>
<td>71</td>
<td>49/71 (69%)</td>
<td>4 (5.63%)</td>
<td>4/4 (100%)</td>
</tr>
<tr>
<td>Befeler et al., 2014</td>
<td>US</td>
<td>1</td>
<td>2009–2013</td>
<td>Mean 3.3 yrs</td>
<td>NR</td>
<td>26</td>
<td>20/26 (77%)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Braff et al., 2004</td>
<td>US</td>
<td>1</td>
<td>NR</td>
<td>5 yrs</td>
<td>NR</td>
<td>1</td>
<td>1/1 (100%)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Deisch et al., 2011</td>
<td>US</td>
<td>NR</td>
<td>13 mos &amp; 32 mos</td>
<td>NR</td>
<td>2</td>
<td>2/2 (100%)†</td>
<td>2/2 (100%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farooqui et al., 2013</td>
<td>Pakistan</td>
<td>1</td>
<td>NR</td>
<td>Mean 3.8 yrs</td>
<td>NR</td>
<td>20</td>
<td>20/20 (100%)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Gupta et al., 2010</td>
<td>India</td>
<td>1</td>
<td>NR</td>
<td>6 yrs</td>
<td>NR</td>
<td>1</td>
<td>1/1 (100%)</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Discussion

Haddon’s Matrix (Table 4) was used to organize the factors associated with TV-toppling injuries during 3 time periods: pre-event, event, and post-event. This matrix was derived in order from host, agent, and environment. Factors are discussed in this order: host, agent, and environment.

Analysis of Host Factors

The “host” in Haddon’s Matrix refers to the typical victim of a particular injury. 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.

TV Toppling: A Multifactorial Event

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

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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.

‡ Only fatal cases were included.

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

¶ Only head injuries were accounted for in the study.

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

†† Summary row does not include statistically derived national data.
risks. 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. 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 injuries 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.20

### Table 2. Factors associated with injury across the studies

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

* 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.

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

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

* 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

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

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.15

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, antennas 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 un-witnessed 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 because 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.⁵,⁴⁰,⁵² 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>
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<th>TABLE 5. Prevention methods for pediatric TV-toppling events</th>
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<td><strong>Factor</strong></td>
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| 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. 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. 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. 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. 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. Adding to the issue is the affordability of CRT TVs in developing countries. 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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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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