Prevention of Home Injuries: A Public Health Approach

Wendy Anne Conlan Shields

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Preventie van letsels door ongevallen in huis: een benadering vanuit het perspectief van de volksgezondheid

Thesis

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Chapter 1

General Introduction

BACKGROUND

Unintentional injuries are the 4th leading cause of death in the United States accounting for 146,571 deaths in 2015. (1) They are the leading cause of death in the United States in ages 2-44. (2). Unintentional injuries are also significant causes of morbidity and account for 39 million medically attended visits in 2017. (3) Cost for the treatment of injuries is an additional concern and was estimated at $821billion in 2015. (3) It has been long documented that injuries disproportionately affect minority groups, particularly low-income children (4-7) In 2000, Faelker et all reported socioeconomic disparities for pediatric injuries by using emergency department data in Ontario, Canada. This study recommended that injury prevention efforts should be targeted to economically disadvantaged populations and called for further work to determine the optimal approach for this targeted education. (5) Hippisley-Cox et al concurred with this conclusion in an examination of hospital admission data by demonstrating an association between socioeconomic gradients; with low gradient children being at higher risk for and injury incidence and severity for children <15 in 2002.(4) Durkin et all further concurred with the recommendation that injury prevention interventions be targeted to low-income neighborhoods after examining injury differences by neighborhood level census variables.(7)

The United States mirrors other countries with its injury burden. Deaths from unintentional injury are estimated at 3.9 million worldwide annually. (8) A comprehensive examination of the childhood injury burden in Europe by Polinder et al examined disability, mortality and injury burden. (9) The study reported that the lowest burden of childhood injuries was found in the Netherlands and the UK and the highest burden was found in Latvia. The study demonstrated large disparities between western and eastern Europe. These finding are consistent with other reports which examined the burden Internationally and found that injury rates are higher, nearly double, in lower and middle-income countries as compared to high income countries (9).

The Burden of Home Injuries

In the United States a substantial portion of unintentional injury deaths occur in the home each year, accounting for an estimated 74,600 deaths (3). For every home injury death, many more non-fatal home injuries occur. There were 20.7 million medically attended visits resulting from home injuries in the United States in 2015, at an estimated cost of 255 billion dollars. (3) The young and old experience home injuries at increased rates. (3,5).

Like adults, children are more likely to be injured in the home than at other locations. (10,11). In the US, injuries sustained at home accounted for an average of 4 million pediatric emergency department (PED) visits annually,

representing approximately 40% of PED visits for unintentional injury (11). Home injuries disproportionately affect socioeconomically disadvantaged children (4-7) Durkin et all demonstrated this increased risk for falls and burns in a small area analysis in Manhattan NY (7). Hippisley-Cox et all demonstrated disparities for burn injuries and poisonings in a study of hospital admission in the UK (4).

Fire and Burns

Fire and burns are a leading cause of home injuries. Fire and burns are among the top three causes of home injuries fatalities. (11-15) In 2016, there were approximately 371,500 home fires in the United States, resulting in 10,750 civilian injuries and 2,735 civilian deaths. (16) The great majority (81%) of fire deaths occur in the home. (16) Children and seniors over 60 are at an increased risk of death from fire compared to the overall US population. (17) Reduction of residential fire deaths is a long-term objective of the Healthy People National Objectives promoted by the US Department of Health and Human Services. (18)

Hot tap water scald burns pose a serious injury risk –causing about one quarter of all scald burns in the United States– and are associated with more deaths and hospitalizations in children than any other hot liquid.(19-21) On average, 34 individuals died each year from tap water scald burns between 1999-2015.(22) Every year, more than 1,300 children under 3 years old suffer from tap water scald burns that require medical care.(23) Like children, seniors experience scald burns at rates greater than that of general population. (24) Skin exposure to water at 49°C/120°F will result in a serious burn in 10 minutes, whereas skin exposure to water at 140°F can result in a serious burn in as little as 3 seconds. (25)

Injury Countermeasures

Fortunately, many of these home injuries are preventable through the use of injury prevention measures. An evidence base has been developed and shows promise for decreasing injury risks in the home (26-29) Research and practice have led to an extensive body of evidence about effective home safety modifications. Previous research on modification to low-income housing has demonstrated that home modification interventions can reduce injury. (26-28) A widely cited example of successfully modifying housing conditions to reduce child injury is New York City's "Children Can't Fly" program, (30) which installed window guards on high-rise apartments and is credited with significant reductions in morbidity and mortality due to falls from windows. The success of the program resulted in legislative change that required landlords to provide window guards and further reductions in falls from windows.

One of the strongest examples of an evidence-based intervention to reduce home injury deaths are smoke alarms. (31,32) Smoke alarms are one of the most effective interventions to prevent residential fire deaths. (31) Functional smoke

alarms reduce the risk of dying in home fires by at least half. (32) Smoke alarms provide an early warning of a fire, giving people in a home time to escape. Low-income families are less likely to have safety devices such as smoke alarms installed in their homes. (32) Home visits have been demonstrated to improve home safety practices generally. In particular, these home visits have demonstrated improvements in the presence of working smoke alarms. (33-34) Smoke alarm home visiting programs have contributed to increases in the presence of functioning smoke alarms, (33-34) reduction of injuries,(35,36) and fatalities(37)

Housing Policy: A Potential Tool to Reduce Home Injuries

Disparities in housing quality and a child's home environment may contribute to an increased risk of injury in low-income families. (38) Low housing quality itself can be a barrier to child safety (38-40). The Centers for Disease Control and Prevention has noted the link between substandard housing including injuries, asthma, lead, and poisoning. (41). Housing Policy can be used as a tool to improve access to quality housing via programs like the Housing Choice Voucher Program in the United States, and socialized housing in the UK. (42,43) These housing programs provide low-income families with assistance to pay for housing that meets minimum quality standards and is subject to regulations to insure quality. (43) To date, there has been little research of the extent to which housing policies could be used as a tool to prevent injuries in children. A better understanding of child injury risk in the home could serve as the basis for improving housing policy.

THE PUBLIC HEALTH APPROCH

The World Health Organization defines the public health approach as a conceptual model which focuses on preventing health problems in a way that extends better care and safety to entire populations rather than to individuals (44). The public health approach is a four-step systematic process grounded in the scientific method. (45) The public health approach has been utilized to improve health outcomes across a range of topics including mental health (46), HIV, violence prevention (47), and suicide (48). The public health approach is characterized by four steps: 1) define the problem, 2) identify risk and protective factors, 3) develop and test prevention strategies, and 4) assure widespread adoption of effective injury prevention principles and strategies.

The World Health Organization and the Centers for Disease Control and Prevention recognize the utility of the public health approach for addressing injuries. (44,45) The principles of the public health approach provide a useful framework for investigating and understanding the causes and consequences of

unintentional home injuries and for preventing these injuries from occurring through primary prevention programs, policy interventions, and advocacy.

Applying the public health approach, the burden of injuries allows us to understand and monitor the burden in order to recognize spikes, or to evaluate decreases, which may result from a prevention program. In addition to basic epidemiology, it is helpful to understand the circumstances of the injury events in order understand how the most dangerous injuries might be prevented. The process of tracking the burden of injuries over time is often called surveillance. (49)

The second step of the public approach asks public health professionals to examine risk and protective factors in order to understand what puts certain individuals at increased risk, and what protects certain individuals, leading to decreased risk. A full exploration of risk and protective factors requires public health professionals to extrapolate recommendations for decreasing risk by decreasing the identified risk factors or by expanding the utilization or exposure to the protective factors.

The third step of the public health approach aims to utilize what has been learned in steps one and two to inform the development and testing of an intervention strategy.

The final step of the public health approach aims to share the knowledge learned through steps one-three with the broad audience in order to assure the adoption of the findings beyond the immediate community that was used to develop and test the interventions.

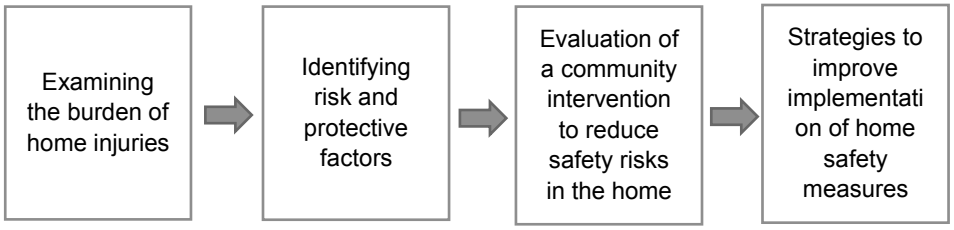


Figure 1. Application of Public Health Approach to Address Home Injuries

Research questions addressed in this thesis

This thesis aims to demonstrate the relevance of the public health approach for addressing the burden of home injuries. This thesis aims to enhance our understanding of the burden of injuries, risk and protective factors associated with home injuries. This thesis additionally reports on the evaluation of the Johns Hopkins Home Safety Project; community intervention trial aimed at reducing safety risks in the homes. Finally, this these provides strategies to improve the implementation of home safety measures. In four subsequent parts, the following research questions are studied:

For part 1: Examining the burden of home Injuries

1. What is the burden of home injuries from scalds and housing elements in the USA? (Chapter 2-3)

For part 2: Risk and protective factors regarding safety in the home

2. What are the main risk and protective factors for burn injuries and from housing elements in the homes of low-income families? (Chapter 4-7)

For part 3: Evaluation of a community Intervention to reduce safety risks in the home

3. How effective was the Johns Hopkins Home Safety Project at increasing home safety practices? (Chapter 8-9)

For part 4: Strategies to improve the implementation of home safety measures

4. Which strategies can be used to improve adoption of home safety measures? (Chapter 10-11)

Outline of the studies presented in this thesis

In this thesis nine studies are presented. Table 1 provides an overview of studies presented in this thesis. The research presented in these studies are divided into four overreaching methods for addressing injuries modeled after the public health approach. Combined these methods prove a frame work for addressing injuries in the home.

Part one of this thesis utilizes the first step of the public health approach: defining the problem by examining the burden of home injuries. **Chapter 2** describes the burden of scald injuries to children under three**. Chapter 3** describes the burden of injuries to children from housing elements.

In **part two**, we employ the second step of the public health approach via the utilization of four data collection efforts which were employed to identify risk and protective factors for home safety. **Chapter** 4 reports on an effort to improve the

accuracy of reporting of smoke alarms in the home. **Chapter 5** explored injury risks in the homes of urban children via observations of injury risks and known injury counter measures. **Chapter 6** expands our understanding of risks and protective factors for tap water scalds in urban homes via observational home visits to collect data about family structure and water heater characteristics. **Chapter 7** reports on qualitative interviews with parents about changes made to the home environment post injury to prevent reoccurrence.

Part three of this thesis utilizes the third step of the public health approach: develop and test prevention strategies. Reports on the results of a community intervention trail aimed at reducing burn risks in urban homes. In **chapter 8** results of an evaluation of a Fire Department smoke alarm installation program are presented. In **chapter 9** results of community intervention trail aimed at improving knowledge and reducing unsafe water temperatures are presented.

Part four of this thesis utilizes the fourth step of the public health approach to provide strategies for improving the implementation of home safety measures**. Chapter 10** broadly explores the epidemiology of home injuries and presents the current evidence base for reducing injuries. **Chapter 11** provides a tool targeted to providers working in the homes of children to identify and remediate injury risks. The measures on the tool aid with risk identification and provide guidance about remediation of injury risks.

STUDIES AND DATA USED

The NEISS system

In part one of this thesis, we utilize the NEISS system to explore the burden of injuries from scald burn and housing elements. (Chapters 2-3)

The primary tool for injury surveillance of consumer products in the United States is the National Electronic Injury Surveillance System (NEISS) of the Consumer Product Safety Commission (CPSC). CPSC is an agency of the US government which is charged with protecting the public from unreasonable risks of injury or death associated with the use of the thousands of types of consumer products under the agency's jurisdiction. NEISS provides data from a probability sample of US emergency departments that can be used to estimate the number of injuries due to consumer products that are treated in emergency rooms across the country.(50) NEISS data include information about year of injury, product involved in the injury, sex and age of the injured patient, diagnosis, disposition, location and mechanism of injury, and body part injured, and narrative text about the circumstances of the injury. NEISS data additionally include narrative text, which describes the circumstances of injury. Analysis of these injury patterns allows for a more comprehensive understanding of the circumstances.

The Safety in Seconds Project

The first chapter in part two of this thesis reports on a sub-analysis of smoke alarm self-reported data from the Safety in Seconds Project. The Safety in Seconds Project was a randomized trial of a smart phone application aimed at improving car seat (intervention) or smoke alarm (control) safety behaviors. (51) Parents of children 4-7 years old were recruited during a visit to the Pediatric Emergency Department (PED) at the Johns Hopkins Hospital in Baltimore MD, USA or the Arkansas Children's Hospital in Little Rock Arkansas AR, USA. Parents were randomized to receive a tailored educational intervention to improve either fire safety or child passenger safety behaviors. Tailored education was delivered via a smartphone app that was downloaded for free by study participants. Upon downloading the app, respondents completed a baseline assessment of their study group's behavior and related beliefs. Based on their responses, a personalized feedback report with tailored education was immediately delivered in the app. Chapter 4 reports on a sub analysis from the control group of this study which examined the benefit of an extended questionnaire to improve self-report of smoke alarm behaviors.

The Johns Hopkins Home Safety Project

Part three of this thesis presents the results of the Johns Hopkins Home Safety Project in Chapters 8 and 9. The Johns Hopkins Home Safety Project was a community intervention trial aimed at reducing risk from fire and burn in the homes of urban families in Baltimore. The trial was a partnership between the Baltimore City Fire Department, the Johns Hopkins Center for Injury Research and Policy, and various communities in Baltimore City. The projected area included a geographic area covering approximately 10,000 homes. The Johns Hopkins Home Safety Project was largely modeled after the Community Risk Reduction approach to fire prevention which was originally developed in the United Kingdom (52) and has since become widely utilized by the fire service in the United States. Community Risk Reduction (CRR) is a process of identifying and prioritizing risks. (52) One step of community risk involves identifying neighborhoods at increased risk for fire, and providing home safety visits to distribute smoke alarms, which have been demonstrated to reduce the risk of death. The Johns Hopkins Home Safety Project developed and tested the CRR approach with an emphasis on increasing the acceptance of fire department installation visits by enhancing the fire departments with community health workers. The Johns Hopkins Home Safety Project additionally tested an enhancement of adding in-home education about scald prevention to the Fire Department Home visit.

All studies presented in this thesis and the National Electronic Injury Surveillance System draw from populations in the United States limiting the generalizability to populations beyond the United States. The literature cited in this thesis draws from injury literature based in the European Union, United Kingdom, Canada and Australia to more broadly reflect the evidence base on the prevention of home injuries internationally.

Table 1. An overview of the studies presented in this thesis.

Chapter	Population or Data Source	Focus of the Study
Part 1 – Examining the burden of home Injuries		
2	NEISS Data US National Representative Sample (N=2,104)	The burden of scald injuries in children under three
3	NEISS Data US National Representative Sample (N=24,793)	The burden of Injuries from structural housing elements
Part 2: Risk and protective factors regarding safety in the home		
4	Parents of children in Baltimore City N=554	Parent self-report of smoke alarm coverage in their homes
5	Home of children in Baltimore City N=246	Injuries risk from structural housing element in homes of urban children
6	Homes in Baltimore City N=976	Observed water temperature and water heater characteristics in a sample of urban homes
7	Families in Baltimore City N=103	Parent report of changes to homes after a medically-attended injury to prevent reoccurrence
Part 3 – Evaluation of a community Intervention to reduce safety risks in the home		
8	Homes in Baltimore City N=8080	The results of an evaluation of a Fire Department smoke alarm installation program
9	Home in Baltimore City N=708	The results of a scald prevention intervention in community intervention trial
Part 4 – Strategies to improve the implementation of home safety measures		
10	Guidance for injury community broadly	Utilizing the evidence base to guide the prevention of unintentional home injuries across the life span
11	Guidance for individuals working in the homes of children	Presentation of the results of a case control study in the form of a tool to be utilized by practitioners working in the homes of children

REFERENCES

1. https://www.cdc.gov/nchs/fastats/deaths.htm
2. Centers for Disease Control and Prevention, National Center for Injury Prevention and Control. Web-based Injury Statistics Query and Reporting System (WISQARS) Fatal Injury Data. 2016
3. National Safety Council. *Injury Facts®, 2015 Edition*. Itasca, IL: Author. Library of Congress Catalog Card Number: 99-74142. 215.
4. Hippisley-Cox J, Groom L, Kendrick D, Coupland C, Webber E, Savelyich B. Cross sectional survey of socioeconomic variations in severity and mechanism of childhood injuries in Trent 1992–7. BMJ. 2002;324:1132.
5. Faelker T, Pickett W, Brison RJ. Socioeconomic differences in childhood injury: A population based epidemiologic study in Ontario, Canada. Inj Prev. 2000;6:203–8
6. Engstrom K, Diderichsen F, Laflamme L. Socioeconomic differences in injury risks in childhood and adolescence: A nation-wide study of intentional and unintentional injuries in Sweden. Inj Prev. 2002;8:137–42.
7. Durkin MS, Davidson LL, Kuhn L, O'Connor P, Barlow B. Low-income neighborhoods and the risk of severe pediatric injury: A small-area analysis in northern Manhattan. Am J Public Health. 1994;84:587–92.
8. Chandran, Hyder A, Peek-Asa C. The Global Burden of Unintentional Injuries and an Agenda for Progress. [online] oup.com. Available at: https://academic.oup.com/epirev/article/32/1/110/500312. 2010.
9. Polinder S, Haagsma JA, Toet H, Brugmans MJ, van Beeck EF: Burden of injury in childhood and adolescence in 8 european countries. *BMC public health* 2010, 10:45.
10. Runyan CW, Casteel C, Perkis D, et al. Unintentional injuries in the home in the United States Part I: mortality. *Am J Prev Med.* Jan 2005;28(1):73-79.
11. Runyan CW, Casteel C (eds.). *The State of Home Safety in America: Facts About Unintentional Injuries in the Home*, 2nd ed. Washington, DC: Home Safety Council. http://www.iccsafe.org/cs/CTC/Documents/guards/resource/guards_Moss_SOHSIA-2004report.pdf. 2004.
12. http://www.nsc.org/learn/safety-knowledge/Pages/safety-at-home.aspx
13. Phelan KJ[1], Khoury J, Kalkwarf H, Lanphear B.Residential injuries in U.S. children and adolescents. Public Health Rep. 2005 Jan-Feb;120(1):63-70.
14. Gielen AC, McDonald EM, Shields WC. Unintentional Home Injuries across the Life Span: Problems and Solutions. The Annual Review of Public Health. 2015; 36:2.1-2.23
15. Alwash R, McCarthy M. Measuring severity of injuries to children from home accidents. *Arch Dis Child.* 1988 Jun;63(6):635–638. [
16. Nfpa.org. An Overview of the U.S. Fire Problem. [online] Available at: https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics/Fact-sheets/FireLossFacts.pdf. 2017.
17. Mack KA, Rudd RA, Mickalide AD, Ballesteros MF. 2013. Fatal unintentional injuries in the home in the U.S., 2000-2008. *Am. J. Prev. Med.* 44:239-246
18. Healthypeople.gov. IVP-28 Data Details | Healthy People 2020. [online] Available at: https://www.healthypeople.gov/node/4763/data_details. (n.d.).
19. Peck M, Brewer AC, Pressman M, Blank E, Mickalide A. Hot tap water legislation in the United States. J Burn Care Res. 2010;31:918–25. [
20. American Burn Association Scalds: a burning issue. A campaign kit for burn awareness week. 2000available from http://www.ameriburn.org/Preven/Scald2000PreventionKit.pdf; Internet.

21. American Burn Association Scald injury prevention educator's guide. A community fire and burn prevention program supported by the United States Fire Administration Federal Emergency Management Agency. available from http://www.ameriburn.org/Preven/ScaldInjuryEducator%27sGuide.pdf; Internet.
22. CDC Wonder DATA
23. McLoughlin E, McGuire A. The causes, cost, and prevention of childhood burn injuries. Amer J Dis Child. 1990;144:677–83. [
24. Alden NE, Bessey PQ, Rabbitts A, Hyden PJ, Yurt RW. Tap water scalds among seniors and the elderly: socioeconomics and implications for prevention. Burns. 2007;33:666–9.
25. Moritz AR, Henriques FC. Studies of thermal injury, II: the relative importance of time and surface temperature in the causation of cutaneous burns. Am J Pathol. 1947;23:695–720.
26. Rohde D, Corcoran J, Sydes M, Higginson A. The association between smoke alarm presence and injury and death rates: A systematic review and meta-analysis. *Fire Saf J*. 2016;81:58-63. doi:10.1016/j.firesaf.2016.01.008.
27. Kendrick D, Young B, Mason-Jones AJ, Ilyas N, Achana FA, et al. 2013. Home safety education and provision of safety equipment for injury prevention. *Cochrane Database Syst. Rev.* 9:CD005014
28. Phelan KJ, Khoury J, Xu Y, Liddy S, Hornung R, Lanphear BP. A randomized controlled trial of home injury hazard reduction: the HOME injury study. Arch Pediatr Adolesc Med. 2011 Apr;165(4):339-45
29. Turner S, Arthur G, Lyons RA, et al. Modification of the home environment for the reduction of injuries. In: Turner S, ed. *Cochrane Database of Systematic Reviews*. Chichester, UK: John Wiley & Sons, Ltd; 2011:CD003600. doi:10.1002/14651858.CD003600.pub3.
30. Spiegel CN, Lindaman FC. Children can't fly: a program to prevent childhood morbidity and mortality from window falls. 1977. *Inj Prev*. 1995;1(3):194-198. http://www.ncbi.nlm.nih.gov/pubmed/9346026. Accessed June 1, 2018.
31. Peek-Asa C, Allareddy V, Yang J, Taylor C, Lundell J, Zwerling C. When one is not enough: prevalence and characteristics of homes not adequately protected by smoke alarms. *Inj Prev,* 2005;11(6):364-8.
32. Ballesteros MF, Jackson ML, Martin MW. Working toward the elimination of residential fire deaths: The Centers for Disease Control and Prevention's Smoke Alarm Installation and Fire Safety Education (SAIFE) program. *J Burn Care Rehabil.* 2005;26(5):434-9.
33. Kendrick D, Smith S, Sutton AJ, et al. The effect of education and home safety equipment on childhood thermal injury prevention: meta-analysis and meta-regression. *Inj Prev.* 2009;15(3):197-204.
34. DiGuiseppi C, Goss CW, Higgins JPT. Interventions for promoting smoke alarm ownership and function (Review). *Cochrane Database of Systematic Reviews*. 2001;(2): CD002246.
35. Mallonnee S, Istre GR, Rosenberg M, Reddish-Douglas M, Jordan F. Surveillance and prevention of residential-fire injuries. *N Engl J Med.* 1996;335(1):27-31.
36. Dudley T, Creppage K, Shanahan M, Proescholdbell S. Using GIS to Evaluate a Fire Safety Program in North Carolina. *J Community Health.* 2013;38(5):951-7.
37. Istre GR, McCoy MA, Moore BJ, et al. Preventing deaths and injuries from house fires: an outcome evaluation of a community-based smoke alarm installation programme. *Inj Prev.* 2014;20(2):97-102.
38. Krieger J, Higgins DL. Housing and health: time again for public health action. Am J Public Health. 2002 May;92(5):758-68. Review.
39. Gielen AC, Wilson ME, Faden RR, Wissow L, Harvilchuck JD. In-home injury prevention practices for infants and toddlers: the role of parental beliefs, barriers, and housing quality. Health Educ Q. 1995 Feb;22(1):85-95.
40. Gielen AC, Shields WC, Ma X, McDonald EM, Frattaroli S, Bishai D Home Safety and Low-Income Urban Housing Quality. Pediatrics 2012 Dec; 130(6): 1053-9

41. Cdc.gov. CDC - Lead - Healthy Homes. [online] Available at: https://www.cdc.gov/nceh/lead/healthyhomes.htm. 2015.
42. Thomson H, Thomas S, Sellstrom E, Petticrew M. The health impacts of housing improvement: a systematic review of intervention studies from 1887 to 2007.Am J Public Health. 2009 Nov;99 Suppl 3:S681-92.
43. Hud.gov. Housing Choice Vouchers Fact Sheet | HUD.gov / U.S. Department of Housing and Urban Development (HUD). [online] Available at: https://www.hud.gov/program_offices/public_indian_housing/programs/hcv/about/fact_sheet. (n.d.).
44. Who.int. WHO | The public health approach. [online] Available at: http://www.who.int/violenceprevention/approach/public_health/en/ Accessed June 1, 2018.
45. Cdc.gov. The Public Health Approach to Violence Prevention Violence Prevention Injury Center CDC. Available at:https://www.cdc.gov/violenceprevention/overview/publichealthapproach.html Accessed June 1, 2018.
46. Better Mental Health for All: A Public Health Approach to Mental Health Improvement. London: Faculty of Public Health and Mental Health Foundation. 2018.
47. https://www.cdc.gov/violenceprevention/overview/publichealthapproach.html. 2015.
48. Sprc.org. Suicide Prevention: The Public Health Approach. [online] Available at: http://www.sprc.org/sites/default/files/migrate/library/phasp.pdf. (n.d.).
49. Cdc.gov. Principles of Epidemiology in Public Health Practice https://www.cdc.gov/ophss/csels/dsepd/ss1978/lesson5/section4.html Accessed June 1, 2018.
50. https://www.cpsc.gov/Safety-Education/Safety-Guides/General-Information/National-Electronic-Injury-Surveillance-System-NEISS
51. Omaki E, Shields WC, McDonald E, Aitken ME, Bishai D, Case J, Gielen A. Evaluating a smartphone application to improve child passenger safety and fire safety knowledge and behavior. Inj Prev. 2017 Feb;23(1):58. doi: 10.1136/injuryprev-2016-042161.
52. *Community Risk Reduction: A Fire Service Context*. Washington, D.C.: Vision 20/20, 2014.

Part 1

Examining the burden of home injuries

Chapter 2

Scald burns in children under 3 years: an analysis of NEISS narratives to inform a scald burn prevention program

Wendy C Shields, Eileen M McDonald, Kaitlin Pfisterer, Andrea C Gielen
Injury Prevention 2015 Oct;21(5):296-300

ABSTRACT

Background objectives:
To determine the incidence of pediatric scald burns for children under 3 years of age treated in US hospital emergency departments. To quantify injury patterns associated with scald burns to inform prevention recommendation messaging.

Methods:
The National Electronic Injury Surveillance System (NEISS) coding manual was reviewed for cause of injury. Its database was queried to identify cases among patients up to age 3 years old with a diagnosis of scald burns between 1 January 2009 and 31 December 2012. The resulting data set was downloaded and case narratives were reviewed to identify injury patterns associated with scald burns.

Results:
The NEISS query identified 2104 scald burn cases between 2009 and 2012, yielding a national estimate of 11,028 scald burns in children younger than 3 years old annually. The analysis of the case narratives resulted in the identification of six precipitating and/or contributing factors including: grabbed/pulled, cooking, bathing, consuming, appliance and other.

Conclusions:
NEISS is a valuable tool to identify scald burn risks. The NEISS data system provided an opportunity to identify and examine scald burns in children under 3 years of age. Interpretation of NEISS results is limited due to the lack of consistency and detail in narratives about the injury event. Nevertheless, the information that was available on precipitating and/ or contributing factors suggests that caretakers should test the temperature of their water heaters, test bath water before bathing children and be made aware of risk of scalds from hot liquids so that they exercise close supervision of children.

INTRODUCTION

Burns are a significant cause of mortality and morbidity for young children in the USA, and globally. Burns are the second leading cause of injury death for children under 5 years and an estimated 83 000 children under the age of 14 years are treated in hospital emergency rooms for burn-related injuries annually. (1) Burns are also a significant contributor to healthcare costs as scald burn deaths and injuries among American children ages 14 years and below total about $44 million each year, with the youngest children (ages 0–4 years) accounting for over 90% of this cost. (2)

Scald burns from hot water or other liquids, such as coffee, are the leading cause of burn-related emergency room visits and hospitalization for young children. (3) Among the sources of scald burns, hot tap water is responsible for about a quarter of all scald burns and is associated with more deaths and hospitalizations in children than any other hot liquid. (4–6) Additional sources of pediatric scald burns include steam vaporizers, soup, grease and noodles. (7–10)

The severity of tap water scald burns depends on the temperature of the liquid and the duration of time the skin is exposed. (11) Previous work from individual burn units has given insight into patterns of scald burns in children including room of occurrence and precipitating activity (12)(13) In the household, tap water scald burns predominately occur in kitchens and bathrooms. (12) Scald burns occurring in the bathroom present a great danger for young children, as more of the body is exposed to hot water during bathing. (13) For young children experiencing scald burns in the bathroom, known patterns include falling into the bathtub, coming into contact with hot running water, and being placed into excessively hot water accidentally or intentionally. (13)

The preponderance of educational interventions seeking to prevent scald burns aim to reduce risk from hot water hazards. Interventions have had mixed results. A pooled analysis of 16 studies showed varying outcomes, but overall, families participating in the intervention arms were found to be more likely to have a discrete study-defined ‘safe hot water temperature’ than families in the control arms (OR=1.41, 95% CI (1.07 to 1.86). (14) Some of the strategies used as part of the educational interventions included conducting home safety visits with a review of identified home hazards; (15–23) providing educational literature, (15)(19)(22–26) providing free thermometers (15)(25)(26) and reduced cost safety equipment; (16)(18)(19)(22) holding educational courses, (17)(23)(24) counselling sessions (16)(24)(27) and first-aid training; (18)(23) and raising awareness of tap water scald burn dangers. (24) Other promising work comes from the UK where Wynn et al (28) recently created a large case-control study to investigate the relationships between modifiable factors and scald burns in children less than 5 years old. In the UK, researchers have also been successful in reducing hot water risk via the installation of antiscald burn devices in social

housing. (27) A similar effort targeting the installation of antiscald burn devices in a focused prevention programme was conducted in California, with 60% of antiscald burn devices still functioning 6–9 months post installation. (29) In Sweden, researchers have focused on delegating the responsibility of child and adolescent burn/scald burn prevention to the national government, by creating a national child home visiting programme for families, which includes scald burn prevention education. (30)

The American Burn Association (ABA) Prevention Committee endorses the following recommendations to prevent scald burns from tap water: setting home water heaters no higher than 49°C/120°F , providing adequate and constant supervision, and avoiding flushing toilets, running water or using dish or clothes washers while others are showering. (11) Recognizing the variety of other scald burn sources, the ABA recommends a number of other precautions, especially with regards to cooking-related scald burns and microwave scald burns. (11) To prevent cooking-related scald burns, the ABA suggests establishing a 'safe area' out of the traffic path between the stove and the sink where children can play safely, while also being supervised, cooking on back burners and placing hot items in the centre of the table during meal time. With regards to the use of microwave ovens, the ABA suggests never heating bottles of baby formula in them, placing the microwave at a safe height, puncturing plastic wrap to allow steam to escape during cooking, and never putting hot coffee or tea in a mug normally used by a child. In an effort to prevent other scald burns, the ABA also recommends locating potpourri pots where they cannot be tipped and replacing hot steam vaporizers with cool mist humidifiers. (11)

Though the epidemiology of scald burns has been documented and scald prevention has been included in home safety interventions, to date, limited data has been available about precipitating and contributing circumstances leading to a burn injury from a large nationally representative sample. We were interested in understanding the circumstances surrounding pediatric scald burns to inform an infant scald burn prevention programme. The details provided by The National Electronic Injury Surveillance System (NEISS) make it an ideal source of data to assess mechanisms of scald burns among infants for a nationally representative sample. (31) To our knowledge, no previous study has examined NEISS narratives to explore precipitating and contributing factors leading to infant scald burn injuries.

METHODS

We queried the NEISS-All Injury Program (NEISS-AIP) using the following parameters: age 1–35 months, with a diagnosis of scald burn between the years 2009 and 2012. NEISS is a publicly available surveillance system overseen by the US Consumer Product Safety Commission to track injuries from consumer products. NEISS is a probability sample of hospital emergency departments in the USA and its territories and produces a national estimate of the number of injuries treated in hospital emergency rooms. The NEISS programme uses a nationally representative sample from 100 US hospitals. NEISS includes patient information from each NEISS hospital for every emergency department visit associated with a consumer product. The information collected in the NEISS-AIP includes age, gender, primary diagnosis, injury disposition, as well as a short narrative, which describes the circumstances of the injury. The text-based information is entered by an onsite NEISS hospital coordinator who reviews all emergency department records for the day, and then transcribes and codes qualifying records. NEISS data can be used to provide estimates tailored by year of injury, product involved in the injury, sex and age of the injured patient, diagnosis, disposition, location and mechanism of injury, and body part injured. From our query, the NEISS system generated a sample data file from the 100 participating NEISS hospitals as well as a national estimate of scald burns among children less than 3 years old between 1 January 2009 and 31 December 2012. The generated data files included details about race, gender, place of injury and hospital disposition and narrative text which described details about the injury. NEISS text narratives are generally two sentences long. The first sentence states age, gender and a brief description of circumstances surrounding the injury. The second sentence describes the diagnosis. The narrative field is limited to a total of 142 characters. To code the case narratives, we conducted a traditional content analysis in its simplest form. We first reviewed 100 randomly selected case narratives and created seven mutually exclusive categories into which we coded text as either a precipitating or contributing factor of the injury event. Any disagreement was discussed among the authors, and the definition of each category was refined. Over time, we collapsed two of the categories into one resulting in six discrete categories. Another one of the authors (KP) reviewed the remaining case narratives and coded them. Exemplar case narratives were identified to illustrate the meaning of each precipitating or contributing factor. This study was approved by the institutional review board of the Johns Hopkins Bloomberg School of Public Health.

RESULTS

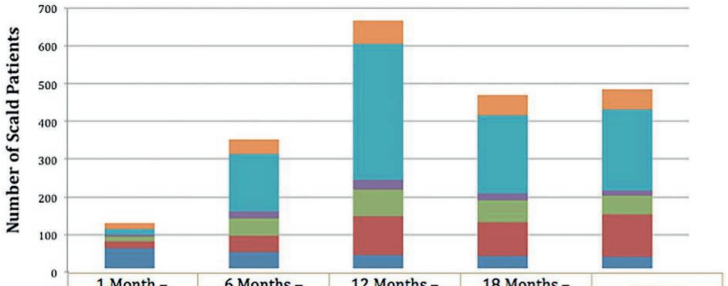
The NEISS query from years 2009 through 2012 resulted in a total sample of 2104 cases, with an average of 526 cases per year. The NEISS generated a national estimate of 44 136 cases for this 4-year period, with an average number of 11,034 cases per year.

A description of the sample is provided in table 1. The majority of patients were male (57.7%) and between 12 months and 23 months of age (54.0%); 49.2% were white. Most injuries occurred in the home (97.6%), and most patients were examined and released (74.3%)

Table 1: Demographics of Children Less than 3 Years Old with Scald Burns

		NEISS Patients N = 2,104 (%)
Race *(n=1,208)	White	594 (49.2)
	African American	459 (38.0)
	Other	155 (12.8)
Gender	Male	1,214 (57.7)
	Female	889 (42.3)
	Not recorded	1 (.05)
Age	1 to 11 months	482 (22.9)
	12 to 23 months	1,136 (54.0)
	24 to 35 months	486 (23.1)
Location of Injury *(n=1,687)	Home	1,646 (97.6)
	Other	41 (2.4)
Disposition	Examined and released	1,563 (74.3)
	Treat and admitted for hospitalization	307 (14.6)
	Treated and transferred	216 (10.3)
	Other	18 (0.8)

The NEISS query provided a total of 2104 cases and all cases had narratives. The review of these narratives resulted in the creation of six injury categories of precipitating or contributing causes including: grabbed/pulled (45.34%); cooking (17.35%); bathing (11.64%); child or parent consuming beverage or food (11.41%); other/not specified (10.41%); appliance (3.85%). The bathing category is inclusive of bathing in a tub or being exposed to hot water in a sink (see figure 1). Different patterns across the categories were seen by age (see figure 1). Compared with older children, patients 1–5 months old were most likely to be scalded by bathing (49.6%). Grabbed/pulled (47.5%) was the leading category of precipitating or contributing cause for scald burn injury for all other ages of young children.



	1 Month – 5 Months	6 Months – 11 Months	12 Months – 17 Months	18 Months – 23 Months	2 Years
Other/ NA	14 (10.9%)	38 (10.8%)	60 (9.0%)	53 (11.3%)	54 (11.1%)
Grabbed/Pulled	17 (13.2%)	154 (43.6%)	361 (54.2%)	208 (44.3%)	214 (44.0%)
Appliance	5 (3.9%)	19 (5.4%)	26 (3.9%)	17 (3.6%)	14 (2.9%)
Consuming	13 (10.1%)	45 (12.7%)	71 (10.7%)	60 (12.8%)	51 (10.5%)
Cooking	16 (12.4%)	45 (12.7%)	102 (15.3%)	90 (19.1%)	112 (23.0%)
Bathing	64 (49.6%)	52 (14.7%)	46 (6.9%)	42 (8.9%)	41 (8.4%)

Figure 1 National Electronic Injury Surveillance System (NEISS) data: precipitating or contributing factors of scald burn by age.

Figure 1: Scald Burns by age and factors

The typical grab/pull injury resulted from a child pulling on something from the floor or when being held by someone. Cooking injuries usually resulted from a child being burned while being held or playing in the kitchen while an adult was cooking. Tap water that was too hot was most commonly the cause of the bathing injuries. Injuries coded as related to consuming something usually occurred when the child was being held by an adult who was eating or drinking something hot. Lastly, the typical appliance injury was a result of children being in contact with or too close to humidifiers and steam from irons (see table 2).

Table 2: Recommendations for Preventing Scald Burns among Children Younger than 3: National Annual Estimates, Narrative Examples and Prevention Recommendations

% (National Annual Estimate)	Precipitating or Contributing Factors	Example of Narrative	Prevention Recommendation
45.5% (5,018.8)	Grabbed/ Pulled	"Crawling on floor under table, pulled tablecloth down and cup of hot water spilled" "Patient reached on table and pulled a cup of hot Ramen Noodles on him" "Pulled cup of scalding drink off counter"	• Place hot items at the center of the table[11] • Avoid use of tablecloths to limit child's ability to pull and drag items onto self or others[11,32]
11.6% (1,280)	Cooking	"Patient pulled a hot boiling pot of pasta off the stove onto self" "Patient's mother was frying hot oil in a pan when some splashed out into face" "Burned when pulling to stand while mom cooking in microwave; mom spilled hot water"	• Keep children away from stove and sink and all hot hazardous surfaces[11] • Keep all pot handles faced away from the front of the stove[11,32] • Never heat baby bottles in microwave[11,32] • Place microwave at a height that is safe for adults but away from child's reach[11] • Create a "child free" zone in and around the kitchen to limit child's access to potentially dangerous situations[11]
17.3% (1,914)	Bathing	"Mom says she left patient w/ 9yo sibling in tub. He turned hot water on." "Mom placed patient into the hot water filled tub, thought water cooled off enough" "Was being bathed by a grandmother in sink and accidently kicked hot water"	• Check water heater setting to ensure that it is no higher than 49°C/120F degrees [10,32] and retest temperature periodically • Face the child away from the faucet when bathing a child in tub or sink[11,32] • Constantly supervise the child during bathing[11,32]

% (National Annual Estimate)	Precipitating or Contributing Factors	Example of Narrative	Prevention Recommendation
11.4% (1,258)	Consuming	"Took a sip of her dad's hot coffee cup burning mouth" "Being fed hot baby food while in mother's lap, child grabbed the bowl and hot food fell onto thigh, scald burn to thigh" "Was on mom's lap, when mom was drinking tea, & mom spilled tea"	• Do not drink hot beverages /eat hot foods when holding a child [11,32] • Make sure all food and beverages are not too hot before giving to a child
3.8% (424.8)	Appliance	"Was on bed with hot steam humidifier next to her. DX: Facial burns" "Burned hands on radiator heater" "Burned lower leg with steam from iron; DX: Burned lower leg"	• Recommend cool mist vaporizers instead of steam humidifiers[11] • Use physical barriers (e.g., radiator covers) to keep child separated from hot items • Make sure to unplug and turn off all appliances when finished[32] • Supervise child to prevent reach and grab appliances.
10.3% (1,132.7	Other	"Picked up hot oil incense burner" "Dropped a lit candle over her head and was burned by hot wax"	• Avoid using products with open flames or open containers with hot liquids • Enhanced supervision and vigilance around flames and other hot liquids
Total: 100% (11,028)			

DISCUSSION

NEISS is a valuable tool to explore the epidemiology of scald injuries in young children. Our study demonstrated that scald burns are a significant problem for children younger than 3 years of age in the USA, with a national estimate of 11 028 emergency department visits. Our findings are similar to previous work, which identified hot water (from bathing) and hot liquids like coffee as significant contributors to scald burns. (2)(3–5) Unlike our study much of this previous work was limited to scalds from one agent, for example, tap water burns or vaporizers. (5–8) These studies examined the scald burns specific to the type of agent rather than as a large group. This manuscript adds detail about the circumstances surrounding the scald injuries from a national sample and categorizes them into precipitating and contributing factors. From our analysis of NEISS case narratives, we determined that patterns of precipitating or contributing causes appear to be related to children's developmental abilities, with older, more mobile children being more likely to be scalded after pulling or grabbing an item, whereas younger children were more likely be burned due to the actions of others. Nearly all injuries occurred in the home (97.6%), with pulling/grabbing being the leading precipitating factor (45.34%) for scald injuries. Details about these injury patterns can aid providers in how to appropriately counsel parents and caretakers about risk factors and how to prevent them. One prevention recommendation is lowering of the water temperature by adjusting the water heater setting. Numerous studies have demonstrated a statistically significant reduction in water temperature via a variety of home interventions. (14) Two previous community intervention trials demonstrated reductions in burn rates in young children. (14) Parents and caretakers also need to be counselled about the dangers of holding children while drinking hot liquids and while cooking. Parents may not be aware of a young baby's ability to grab and pull on things, which often spilled the hot liquid onto the child. Our work helps to identify the ages at which these injuries most often occur and can be used to enhance the prevention messages about supervision. This work was limited by our sole reliance on NEISS as the source of data; our work is only as robust as the NEISS data itself. The quality of the NEISS data relies on documentation from the emergency room clinicians and the details provided in the narrative descriptions. Additionally, it must be noted that the NEISS surveillance system was developed by the Consumer Product Safety Commission to track injuries from consumer products. (31) It is unknown to what extent scald injures not associated with consumer products are missed by this surveillance system. Additionally, we queried only injuries coded as scald burn in the NEISS system; it is possible that some scald burns could have been miscoded as thermal burns and therefore missed in our analysis. This type of surveillance system has the potential to produce certain biases. Despite these limitations, the NEISS scald burn narratives are important as they allowed us to examine a nationally representative sample to determine precipitating and

contributing factors of scald burns. This is the first example we could find of using more than anecdotal reports or data from a single hospital to inform a scald prevention programme. Our analysis of the NEISS narratives has allowed for the development of messages, which can be shared with parents as part of a well child visit or added to home-based safety interventions. Case narratives from NEISS are an important yet underused tool to inform prevention education. Though time-intensive to compile and review, the insight gained from the narratives provides information that can be used to inform prevention programs. NEISS data could be more useful for prevention efforts if NEISS coders (healthcare providers) were instructed to provide more detail about the precipitating and contributing factors that resulted in the injury. For instance, notations about the status of adult supervision whenever a child is injured could be informative to inform prevention messages. More details about precipitating and contributing factors of the injury event could inform if certain products or home environments are more or less risky for injury to occur. Currently, such details are entered at the discretion of the coder (healthcare provider) and frequently result in an incomplete picture of the circumstances leading up to an injury event, thus limiting the use for intervention development. A more standardized approach to collection of the case narratives could better inform prevention efforts. Currently available prevention and parenting guidance regarding scald prevention were developed with a common-sense approach to known risk factors such as water heater temperature. This study adds age-specific knowledge about precipitating and contributing factors, which can be used to better target prevention messages for parents and care givers. For example, the study demonstrated that younger children, patients 1–5 months old were most likely to be scalded by bathing. Grabbed/pulled was the leading category of precipitating or contributing cause for scald burn injury for children older than 5 months. These findings can be used to better tailor prevention messages to parents with an emphasis on bathing safety to the parents of newborns whereas patterns of children older than 5 months should be made aware about dangers from grab and pull scald burn injuries.

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REFERENCES

1. Alisa Ann Ruch Burn Foundation. AARBF Fire and Burn Statistics. http://o1.aolcdn.com/hss/storage/patch/57dbe95f8026990ef0ee009aaf4ed569; Internet (accessed 12 Jun 2014).
2. Safe Kids Lee/Collier Counties. Burn Prevention. http://safekidsleecollier.org/safety/burnprevention/burnprevention.html; Internet (accessed 12 Jun 2014).
3. Baker SP, O'Neill B, Ginsburg MJ, et al. The injury fact book. New York, NY: Oxford University Press, Inc, 1992:169.
4. McLoughlin E, McGuire A. The causes, cost, and prevention of childhood burn injuries. Am J Dis Child 1990;144:677–83.
5. Feldman KW, Schaller RT, Feldman JA, et al. Tap water scald burns in children. Pediatrics 1978;62:1–7.
6. Baptiste MS, Feck G. Preventing tap water burns. Am J Public Health 1980;70:727–9.
7. Aggarwal A, Edlick RF, Himel HN. Steam vaporizer burn injuries. J Emerg Med 1995;13:55–8.
8. Dissanaike S, Boshart K, Coleman A, et al. Cooking-related pediatric burns: risk factors and the role of differential cooling rates among commonly implicated substances. J Burn Care Res 2009;30:593–8. (9) Shalom A, Bryant A, Smith-Meek M, et al. Noodles stay hotter longer. J Burn Care Res 2007;28:474–7.
9. Shalom A, Bryant A, Smith-Meek M, Parsons LR, Munster A. Noodle stay hotter longer. Burn Care Res. 2007 May-Jun;28(3):474-7.
10. Greenhalgh DG, Bridges P, Coombs E, et al. Instant cup of soup: design flaw increase risk of burns. J Burn Care Res 2006;27:476–81.
11. American Burn Association. Scalds: a burning issue. A campaign kit for burn awareness week. 2000. http://www.ameriburn.org/Preven/2000Prevention/ Scald2000PrevetionKit.pdf; Internet (accessed 12 Jun 2014).
12. Gielen AC, McDonald EM, McKenzie LB. Chapter 31: Behavioral approach. Injury research: theories, methods, and approaches. In: Guohua Li, Susan P, eds. Baker. New York: Springer, 2012:274–296.
13. Yeoh C, Nixon JW, Dickson W, et al. Patterns of scald injuries. Arch Dis Child 1994;71:156–8.
14. Kendrick D, Young B, Mason-Jones AJ, et al. Home safety education and provision of safety equipment for injury prevention. Cochrane Database Sys Rev 2012;9: CD005014.
15. Babul S, Olsen L, Janssen P, et al. A randomized trial to assess the effectiveness of an infant home safety programme. Int J Inj Contr Saf Promot 2007;14:109–17.
16. Gielen AC, McDonald EM, Wilson MEH, et al. Effects of improved access to safety counseling products and home visits on parents' safety practices: results of a randomized trial. Arch Pediatr Adolesc Med 2002;156:33–40.
17. Kelly B, Sein C, McCarthy PL. Safety education in a pediatric primary care setting. Pediatrics 1987;79:818–24.
18. Kendrick D, Marsh P, Fielding K, et al. Preventing injuries in children: cluster randomized controlled trial in primary care. BMJ 1999;318:980–3.
19. King WJ, Klassen TP, LeBlanc J, et al. The effectiveness of a home visit to prevent childhood injury. Pediatrics 2001;108:382–8.
20. Nansel TR, Weaver N, Donlin M, et al. Baby Be Safe: the effect of tailored communications for pediatric injury prevention provided in a primary care setting. Patient Educ Couns 2002;46:175–90.
21. Nansel TR, Weaver NL, Jacobsen HA, et al. Preventing unintentional pediatric injuries: a tailored intervention for parents and providers. Health Educ Res 2008;23:656–69.
22. Phelan KJ, Khoury J, Xu Y, et al. A randomized controlled trial of home injury hazard reduction: the HOME injury study. Inj Prev 2010;16(Suppl):A171.
23. Thomas KA, Hassanein RS, Christophersen ER. Evaluation of group well-child care for improving burn prevention practices in the home. Pediatrics 1984;74:879–82.
24. Georgieff K, Maw C. The Wakefield district burns and scalds prevention project: health development unit. Wakefield Metropolitan District Council, 2004.

25. Katcher ML, Landry GL, Shapiro MM. Liquid-crystal thermometer use in pediatric office counseling about tap water burn prevention. Pediatrics 1989;83:766–71.
26. Sangvai S, Cipriani L, Colborn DK, et al. Studying injury prevention: practices, problems and pitfalls in implementation. Clinical Pediatrics 2007;46:228–35.
27. Phillips CJ, Humphreys I, Kendrick D, et al. Preventing bath water scalds: a cost effectiveness analysis of introducing bath thermostatic mixer valves in social housing. Inj Prev 2011;17:238–42.
28. Wynn P, Stewart J, Kumar A, et al. Keeping children safe at home: a protocol for a case-control study of modifiable risk factors for scalds. Inj Prev 2014;20:e11.
29. Cagle KM, Davis JW, Dominic W, et al. Results of a focused scald-prevention program. J Burn Care Res 2006;27:859–63. (30) Child Safety Europe. Child safety report card 2012 Sweden. http://www. childsafetyeurope.org/reportcards/info/sweden-report-card.pdf; Internet (accessed 12 Jun 2014).
30. United States Consumer Product Safety Commission. National Electronic Injury Surveillance System (NEISS). http://www.cpsc.gov/en/Safety-Education/Safety-Guides/ General-Information/National-Electronic-Injury-Surveillance-System-NEISS/; Internet (accessed 12 Jun 2014).
31. Home Safe Home: Fire & Burn Prevention Guide for Families. Home Safe Home Checklist. http://burnprevention.org/wp-content/uploads/2014/07/Home_Safety_ Checklist.pdf; Internet (accessed 29 Sep 2014) .

Chapter 3

Structural Housing Elements associated with Home Injuries in Children

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ABSTRACT

Objective

To quantify unintentional injuries associated with housing elements among children less than 18 years old treated in US hospital emergency departments.

Methods

The National Electronic Injury Surveillance System (NEISS) coding manual was reviewed, and all product codes that identified products permanently affixed to a home (housing elements) were identified. A query of the 2008 NEISS data for children under 18 determined the numbers of cases by severity code for each identified housing element. Housing elements were then tabulated by the number of cases for each severity code. The top 10 cases by severity code, (1) hospitalized or (2) treated in emergency departments, were included in a case review. Ten per cent of all cases or a minimum of 100 cases were randomly selected for review for each of the identified housing elements to assess if the case description could inform prevention efforts.

Results

Twelve housing elements (bathtub, cabinet, carpet, ceiling/wall, counter, door, fence, floor, nail, porch, stairs and window) were identified as the leading causes of injuries resulting in hospitalizations or emergency department visits. A list of potential interventions was generated based on the review of the case histories. Suggested changes for NEISS coding are also offered to enhance future prevention research.

Conclusions

NEISS is a valuable tool to identify home injury risks and inform design decisions for housing elements. Improved understanding of housing elements associated with injuries has the potential to enhance home inspection forms. However, interpretation of NEISS results is limited by lack of clarity about how the housing element was involved in the injury event.

INTRODUCTION

Home injuries are common, accounting for one-third of all unintentional injuries in the USA. In addition, the home is the second most common place for fatal injuries.(1) Children, in particular, experience injuries in their home environments at high rates.(1, 2) According to the report, The State of Home Safety in America, almost 2100 children younger than 15 years of age die every year from injuries in and around the home; for every death, there are almost 1600 non-fatal home injuries.(2) Home injuries to children is a global health issue. In the UK, approximately 40 000 emergency hospital admissions among children under 5 years of age are reported annually.(3) In 2005, WHO and Unicef issued a call for a greater global effort to prevent child injury, culminating in the World report on child injury prevention, which sought to bring awareness about the global problem of child injuries and to provide recommendations that all countries can follow to reduce child injuries effectively.(4) While it is well accepted that how an individual interacts with his environment can be causally related to his injury risk and that safety products such as stair gates can mitigate risk, there is little quantitative evidence as to the specific built environment features of the home itself that can contribute to injuries in children. To date, injury prevention home inspection tools have focused more on the presence of countermeasures such as smoke alarms, stair gates and carbon monoxide alarms rather than on housing elements and their association with injuries.(5) Previous work has evaluated the effectiveness of efforts to reduce home injuries primarily from injury countermeasures such as smoke alarms and antiscald devices. The interventions focused on modifying environmental home hazards, such as fitting locks on cupboards, installing stair gates, improving lighting and removing tripping hazards, have shown insufficient evidence that they significantly reduce home injury.(6) Kendrick et al(7) found successes in home safety interventions focusing on safe hot water temperature, working smoke alarms, fire escape plans, fitted stair gates, socket covers and poison and medicine storage. Sharfstein and colleagues found housing characteristics, including heating adequacy, presence of rodents and holes in walls, to be independent predictors of child health status, but this outcome did not include a measure of injury.(8) A few other studies, including our own earlier work, have demonstrated that living in poor quality housing conditions in poor neighborhoods is associated with increased risk of home injury for children, and can also be significant barriers to using home safety products.(9–12) Modifying the home environment could have a significant impact on home injury outcomes. Researchers in New Zealand found that home injuries were potentially related to a structural aspect of the home environment.(13) To wit, Keall et al(14) successfully targeted fall injuries through a successful home modification programme (e.g., handrails, repairs to steps, non-slip modifications, lighting, etc.), resulting in a significant decrease in falls. The purpose of this paper is to add to this small body of literature data on specific built environment features of

homes that are associated with children's injury using the National Electronic Injury Surveillance System (NEISS). NEISS is a publicly available database overseen by the US Consumer Product Safety Commission (CPSC). NEISS has been used to explore injuries from a wide variety of products, including those from recreational activities including mountain biking,(15) unicycles(16) and water tubing(17); occupational injuries from ladders(18) and nail guns,(19) and home injuries including hot tubs (20) and bunk beds.(21) Although focused on consumer product-related injuries, NEISS also captures information about injuries more broadly, and thus, can help identify hazardous conditions in the home.(22) We first present frequencies of the leading types of structural housing elements associated with child injury, followed by a summary of the narrative description of these injuries. We conclude with recommendations that could be implemented either during home construction or as a part of home inspections to prevent the identified injuries. Finally, we make suggestions about enhancements to NEISS, which would make it more useful for practitioners.

METHODS

The NEISS-All Injury Program (NEISS-AIP) uses data from a nationally representative sample of 62 hospitals in the USA. NEISS consists of a probability sample of hospital emergency departments (EDs) in the USA and its territories that is used to produce national estimates of the number of consumer product-related injuries treated in hospital EDs. (23) (For additional details on the design and implementation of NEISS, see http://www.cpsc.gov/neiss/2001d011–6b6.pdf.) We used NEISS 2008–2012 data for quantitative analysis. To define eligible injuries, we first reviewed the NEISS coding manual (http:// www.cpsc.gov/neiss/ completemanual.pdf) to determine codes that were related to the home environment. Consistent with the purpose of our analysis, we defined eligible injuries as those associated with 'structural housing elements that were attached to the home'. Examples of attached items included floors, windows, cabinets, bathtubs, etc. Examples of excluded unattached items are curtains and televisions. In all, 26 codes reflecting attached structural housing elements were selected for analysis. We queried the NEISS-AIP database for 2008 and identified the top 10 structural housing elements associated with emergency room visits and the top 10 structural housing elements associated with hospitalizations for children aged 1 month to 18 years. We then selected the 12 structural housing elements, which represented the combined top 10 lists for both emergency room visits and hospitalizations. We then queried the 2008 NEISS-AIP for each of the identified structural housing elements for children aged 1 month to 18 years; the query generated a sample for the 62 NEISS hospitals as well as a national estimate. The sample file included race, age, gender, injury disposition and a case narrative for each record. A random sample of narratives (approximately

10% of total number of injuries or at a minimum n=100 if 10% was less than n=100) were selected for review. The study team conducted a review of these narratives to identify potential preventive measures in light of currently available countermeasures and with attention to the time and cost of the proposed modification. We distinguished primary prevention solutions (e.g., anti-slip coating in tubs and floors, locking devices on windows) that need to be incorporated during construction of new homes from secondary solutions (i.e., grab bars, removal of protruding nails) that could be addressed during home inspections. Examination and discussion of the case narratives was used to identify preventive measures. The Institutional Review Board of the Johns Hopkins Bloomberg School of Public Health approved this study.

RESULTS

Housing-Related Injuries Identified

The twelve housing elements associated with the highest number of ED visits or hospitalizations from the NEISS data set are shown in Table 1. The NEISS sample and national estimates of emergency department visits for each of these structural housing elements are also displayed in Table 1. The NEISS estimate of emergency department visits associated with the identified housing elements ranged from a high of 206,668 (67.96 per 100,000 annually) for floors, to a low of 19,282 (6.34 per 100,000 annually) for injuries associated with counters. The analysis identified well-documented injury risks, such as stairs, with an estimated 150,015 (49.33 per 100,000 annually) ED visits and bathtubs with 49,789 (16.37 per 100,000 annually) estimated ED visits. Our analysis also identified less obvious injury risks such as the estimated 77,195 ED (25.39 per 100,000 annually) visits associated with ceilings and 31,243 (10.27 per 100,000 annually) injuries associated with protruding nails.

Table 1. Housing-Related Injuries Identified from NEISS-AIP 2008

Housing Element	ED Visits NEISS Sample	ED Visits National Estimate	ED Visits National Estimate Rate (per 100,000)
Floor	6886	206,668	67.96
Stair	4983	150,015	49.33
Door	3033	92,228	30.33
Ceiling	2424	77,195	25.39
Bathtub	1595	49,789	16.37
Cabinet	1149	36,988	12.16
Window	916	27,670	9.10
Nail	892	31,243	10.27
Carpet	812	19,600	6.45
Porch	746	24,644	8.10
Fence	687	21,715	7.14
Counter	670	19,282	6.34

Demographics

As displayed in Table 2, males account for the majority of injuries for all housing elements; the percentage was highest for fences where males accounted for 67% of injuries compared to only 51% of injuries on stairs. The vast majority of injuries resulted in children being treated and released – more than 90% for every element except injuries associated with windows which was 89%. The lowest mean age for children was 47.1 months for injuries associated with carpets, while the highest mean ages were associated with fences (108.7), windows (105.5), and nails (102.3).

Table 2. Demographics and Disposition of Injuries Caused by the 12 Housing Elements

Housing Element	Mean Age (N= Months)	Sex= Male N(%)	Race= White N(%)	Disposition = Treated and Released N(%)
Bathtub	72.7	858 (53.79)	675 (42.32)	1523 (95.49)
Cabinet	62.2	704 (61.27)	515 (44.82)	1114 (96.95)
Carpet	47.1	452 (55.67)	299 (26.82)	772 (95.07)
Ceiling	93.5	1530 (62.12)	1001 (41.30)	2389 (98.56)
Counter	57.0	393 (58.66)	308 (45.97)	637 (95.07)
Door	74.9	1655 (54.57)	1147 (37.82)	2997 (98.15)
Fence	108.7	460 (67.45)	272 (39.88)	644 (94.43)
Floor	50.2	3682 (53.47)	2551 (37.05)	6480 (96.10)
Nail	102.3	564 (63.23)	373 (41.82)	864 (96.86)
Porch	85.3	429 (57.51)	334 (44.77)	690 (92.49)
Stair	85.2	2535 (50.87)	1992 (39.98)	4793 (96.19)
Window	105.5	582 (63.54)	350 (38.21)	816 (89.08)

Case narratives and Potential Solutions

Case narratives providing more details about injury events were reviewed and organized by each of the 12 housing elements. Examples of narratives that were typical and provided the range of experiences were selected for display in Table 3.(please see table 3 at the end of the chapter) Many injuries resulted from slips, trips and falls particularly those associated with stairs, carpets and bathtubs. Nail injuries generally resulted in lacerations and puncture wounds. Door injuries resulted from doors being closed on fingers to doors falling on children. The scenarios include varying amounts of information and there is no consistent structure to the level of detail provided. In some cases, there is an interaction of the child with the housing element after some risky behavior (e.g., child running or jumping); in other cases, the housing element seemed to mal-function in the absence of any specific risky behavior by the child (e.g., shower door fell); and, finally, in other cases the housing element seemed to have been used appropriately and the child was injured in the absence of any specific risky behavior (e.g., slipped in tub).

After reviewing each narrative, the authors identified a number of potential countermeasures to prevent injuries associated with each housing element. For example, bathtub narratives describe many examples of slips and falls generating a countermeasure recommendation of installing tubs with slip resistant surfaces. The door case narratives revealed serious injuries to fingers including amputation, which could be minimized by installing doorstops as a countermeasure.

DISCUSSION

The NEISS database is a tremendous national resource which has demonstrated real-world utility since its inception. The examination and presentation of NEISS data have led to product recalls (e.g., lawn darts, high-powered magnet sets), (24, 25) creation of voluntary standards (e.g., window blind cords), (26) and even awareness of injury sources, leading to the development of new, safer equipment (e.g., tractor rollover protective structures).(27) It has had a significant impact in recreational, household, and occupational products, which affect people daily. Injury surveillance systems are employed in other countries, though none have been as extensively utilized for reporting in the peer-reviewed literature as the NEISS system. A review of The Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP) data has shown great variance of sensitivity, and systematic errors in data capture.(28) The National Injury Surveillance Unit of Australia has an acknowledged shortcoming in that it lacks a source of national quantitative data suitable for monitoring consumer product safety.(29) The Home and Leisure Accident Surveillance System (HASS/LASS) of the UK was

discontinued in 2003.(30) This manuscript reports on our utilization of the NEISS database to explore the burden of unintentional injuries associated with housing elements among children less than 18 years old treated in U.S. hospital emergency departments.

Demographically our results are in line with other national samples with males experiencing more injuries than females.(31)The great majority of injured patients for each of the housing elements explored were treated and released from the emergency department; which is also consistent with reporting on injuries broadly.(31) The NEISS data system provided an opportunity to identify housing elements associated with home injuries and to suggest countermeasures that could be used to prevent them either at the time of home construction or during home inspections (e.g., for resale, mortgages, or as part of home visiting programs). Previous research using the NEISS data system has reported products with substantially lower yearly estimates than structural housing elements. For example, Thompson et al reported on an estimated 64,657 (3,232 per yr.) inflatable bounce house injuries over a 20-year period ending in 2010.(32)D'Souza reported on an estimated 572,580 (35,786 injuries annually) bunk bed injuries over a 16-year period ending in 2005.(21) Injuries associated with ladders were also reported by D'Souzawith an estimated 2,177,888 injuries in the United States over a 16-year period ending in 2005.(33) D'Souza's ladder work reported on an average yearly estimate of 136,118, ranking it below the highest two housing elements we identified in our analysis: floors at 206,668 and stairs at 150,015.

When case narratives provided sufficient detail about the circumstances surrounding the injury, we could offer recommendations for prevention in other cases, sufficient detail was not offered in the narrative to truly understand housing element's contribution to the injury, our original intent was to code each injury as being associated with the condition or the housing element. For example, if an injury associated with a door was due to a defect in the door as opposed to a child running into the door but this was not possible because of the lack of necessary detail in the case narratives. It would be extremely helpful if all individuals from hospital administrators, to intake clerks, to clinical staff an well as NEISS coders were trained to note as specifically as possible the circumstances surrounding an injury event and to extract as much detail as possible so that that precipitating events and causation could be better elucidated and understood from the NEISS narratives.(34) It would also be helpful if the NEISS narrative field allowed for more text to the entered; currently only 141 characters are permitted for the narrative details, which is supposed to include a description of what the victim was doing when the injury occurred, the product involved, location and verbatim quotes. The character limit may not allow space for to detail the condition of the products. We observed several instances of the narrative text being truncated mid-description and think that, at least in some

cases, time allows for coders to record a description longer than 141 characters. It may be prudent to pilot these suggestions with a small sample to estimate the time and cost burden as well as to gage the benefit of the added information. It may also be possible to consider these changes to the data system when the system is next upgraded. Additionally, it would also be useful to validate the conclusions we draw about the role of the housing element itself by follow-back interviews with parents or the child when old enough. Our suggested enhancements to the NEISS system are not novel. As early as 1997 the Government Accountability Office produced a report entitled "Consumer Product Safety Commission: Better data needed to help identify and analyze potential hazards" which called attention to the NEISS system's inability to generate estimates for anything smaller than a national sample limiting it utility for state and regional estimates and making interstate comparisons impossible. The same report noted that the NEISS system lacked the detail necessary to assess causality that is whether the product in question caused the injury or merely was involved with the injury. It additionally noted that NEISS did not contain E codes which briefly describe the circumstances of the injury and suggested that such detail would be help in understanding the injuries reported by the NEISS system.(35) More recent work has explored the utility of using NEISS narratives text to identify exposure information in case-control studies.(36) Graves et all found the narrative useful but noted that the utility was limited to the information which was asked and recorded throughout the clinical encounter.(36)

Utilizing NEISS data to inform the relationship between housing elements and injury risks presents several limitations. The NEISS database does not capture visits of patients who seek treatment at non-ED locations such as their primary care provider or an urgent care center, therefore treatment at urgent and primary care centers are excluded from the national estimates. Information regarding follow-up care is not available in the NEISS system preventing analysis beyond the initial ED visit. Details offered in the case narratives were frequently insufficient in understanding the relationship between the injury event and the precipitating events and housing element condition. Additionally, case narratives of child injuries do not routinely include information about whether the injury event was witnessed by an adult or if the child was being supervised by an adult at the time of the event. This lack of detail prevents a full understanding of the cause of injury and therefore limits our ability to fully understand which preventive measures could reduce injuries. The addition of standardized fields to collect detail about condition of product, precipitating events, and adult supervision could greatly enhance the utility of the NEISS data set. Again, a pilot trial of a system of standardized fields would be necessary to estimate the time and cost burden. Many of the narrative fields we examined included some elements of the standardized fields we are suggesting indicating that in some cases the detail is available. However, the information was not recorded systematically or routinely making the analysis and synthesis less feasible.

Our recommendations are complimentary to those put forward in the 2008 World report on child injury prevention which calls specifically for enhanced quality and quantity of data for child injury prevention. While the NEISS system is already responsive to several recommendations made by the World report on child injury prevention, further enhancements to the system will improve on these activities. With more details on causes of injury, NEISS could be used to help implement specific actions to prevent and control child injuries. Further, the greater detail on cause of injury and causation through the narratives will enhance the quality and quantity of data for child injury prevention.(4)

Studying NEISS revealed that structural housing elements vary in their propensity to injure.

Structural housing elements are very common source of injury. NEISS narratives are a valuable tool to identify potential countermeasures both primary and secondary for injury prevention.

This analysis can be used as a foundation for evidence-based programs to inspect housing structures to make them safer. Individuals conducting homes inspections or building new housing could benefit from prevention measures which were identified from this analysis. Additionally, we hope that the injury community broadly, and the CPSC specifically, consider modifications to the NEISS system, particularly the narratives to allow for the capture of greater details which could be used to establish a more comprehensive understanding of the involvement of a product in causing or contributing to an injury as well as the precipitating and contributing factors surrounding injury events. Such detail would allow for the development of more robust injury prevention initiatives.

REFERENCES

1. Runyan CW, Casteel C, Perkis D, *et al.* Unintentional injuries in the home in the United States Part I: mortality. *Am J Prev Med*. 2005;28:73-9.
2. Finkelstein EA, Corso PS, Miller TR. *The Incidence and Economic Burden of Injuries in the United States*. New York: Oxford University Press; 2006:161.
3. Public Health England (2014). Reducing unintentional injuries in and around the home among children under five years. London, Public Health England.
4. Peden M, Oyebite K, *et al*. World Report on Child Injury Prevention. Geneva, Switzerland. World Health Organization. 2008
5. Phelan KJ, Koury J, Xu Y, *et al*. Validation of a Home Injury Survey. *Inj Prev.* 2009;15:300-6. doi:10.1136/ip.2008.020958.
6. Turner S, Arthur G, Lyons RA, *et al*. Modification of the home environment for the reduction of injuries. *Cochrane Database Syst Rev*. 2011:2. doi: 10.1002/14651858.CD003600.pub3.
7. Kendrick D, Young B, Mason-Jones AJ, *et al*. Home safety education and provision of safety equipment for injury prevention. *Cochrane Database Syst Rev*. 2012;9. doi: 10.1002/14651858.CD005014.pub3.
8. Sharfstein J, Sandel M, Kahn R, *et al*. Is child health at risk while families wait for housing vouchers? *Am J Public Health*. 2001;91:1191-92.
9. Gielen AC, Wilson MEH, Faden R, *et al*. In-home injury prevention practices for infants and toddlers: the role of parental beliefs, barriers, and housing quality. *Heal Educ Quart*. 1995;22:85-95.
10. Cubbin C, Smith GS. Socioeconomic inequalities in injury: critical issues in design and analysis. *Annual Rev Publ Health.* 2002;23:349-375.
11. LeBlanc JC, Pless B, King JW *et al*. Home safety measures and the risk of unintentional injury among young children: a multicentre case-control study. *Canadian Med Assoc J*. 2006;175:883-887.
12. Kendrick D, Mulvaney C, Burton P, *et al*. Relationship between child, family, and neighborhood characteristics and childhood injury: a cohort study. *Soc Science Med*. 2005;61:1905-15.
13. Keall MD; Howden-Chapman P; Baker MG, *et al*. Formulating a programme of repairs to structural home injury hazards in New Zealand. *Accid Anal Prev.* 2013;57:124-30.
14. Keall MD, Pierse N, Howden-Chapman P, *et al*. *Lancet* 2014;385:231–238
15. Nelson NG, McKenzie LB. Mountain biking-related injuries treated in emergency departments in the United States, 1994-2007. *Am J Sports Med*. 2011;39:404-9. doi: 10.1177/ 0363546510383478
16. Wang ML. Unicycle injuries in the United States. *J Emerg Med.*2013;44:502-7. 2013. doi: 10.1016/j.jemermed.2013.05.024.
17. Heinsimer KR, Nelson NG, Roberts KJ, *et al*. Water tubing-related injuries treated in US emergency departments, 1991-2009. *J Phys Act Health*. 2013;10:151-9.
18. Socias CM, Chaumont Menéndez CK, Collins JW, *et al*; Centers for Disease Control and Prevention (CDC). MMWR Morb Mortal Wkly Rep. 2014;63:341-6. *Erratum in: MMWR Morb Mortal Wkly Rep*. 2014;9;63:416.
19. Lipscomb HJ, Schoenfisch AL. Nail gun injuries treated in U.S emergency departments, 2006-2011: Not just a worker safety issue. *Am J Ind Med*. doi:10.1002/ajim.22457
20. Alhajj M, Nelson NG, McKenzie LB. Hot tub, whirlpool, and spa-related injuries in the U.S., 1990-2007. *Am J Prev Med*. 2009;37:531-6. doi: 10.1016/j.amepre.2009.08.024.
21. D'Souza AL, Smith GA, McKenzie LB. Bunk bed-related injuries among children and adolescents treated in emergency departments in the United States, 1990-2005. *Pediatrics.* 2008;121:e1696-702. doi: 10.1542/peds.2007-2555.
22. Mao SJ, McKenzie LB, Xiang H, *et al*. Injuries associated with bathtubs and showers among children in the United States. *Pediatrics.* 2009;124: 541-547.
23. Schroeder T, Ault K. The NEISS Sample (Design and Implementation) 1997 to Present. U.S. Consumer Product Safety Commission, 2001.http://www.cpsc.gov/neiss/2001d011-6b6.pdf (accessed August 1, 2010)

24. U.S. Consumer Product Safety Commission. Following Recent Injury CPSC Reissues Warning: Lawn Darts Are Banned and Should Be Destroyed. 1997.http://www.cpsc.gov/en/Newsroom/News-Releases/1997/Following-Recent-Injury-CPSC-Reissues-Warning-Lawn-Darts-Are-Banned-and-Should-Be-Destroyed/ Date Accessed: 7/7/2015.
25. U.S. Consumer Product Safety Commission. Buckyballs and Buckycubes High-Powered Magnet Sets Recalled Due to Ingestion Hazard; Craig Zucker To Fund A Recall Trust, Settles With CPSC. 2014. http://www.cpsc.gov/en/Newsroom/News-Releases/2014/Buckyballs-and-Buckycubes-High-Powered-Magnet-Sets-Recalled/ Date Accessed: 7/7/2015
26. U.S. Consumer Product Safety Commission. Window Bling Cords Voluntary Standards Activities. 2013. http://www.cpsc.gov/en/Regulations-Laws--Standards/Voluntary-Standards/Window-Blind-Cords/ Date Accessed: 7/7/2015
27. Reynolds S, Groves W. Effectiveness of roll-over protective structures in reducing farm tractor fatalities. *Am J Prev Med. 2010*. doi:10.1016/S0749-3797(00)00142-2
28. Hopkins R. Farm equipment injuries in a rural county, 1980 through 1985: the emergency department as a source of data for prevention. *Annals of Emergency Medicine*.1989:18:758-762.
29. Harrison J. Australian Injury Surveillance Data Standards. *Annals of Emergency Medicine.* 2010 http://www.cdc.gov/nchs/data/ice/ice95v2/c04.pdf
30. The Royal Society for the Prevention of Accidents. HASS and LASS Home & Leisure Accident Surveillance System. http://www.hassandlass.org.uk/ Date Accessed: 7/7/2015
31. CDC. Nonfatal Injury Data. *Centers for Disease Control and Prevention*. http://www.cdc.gov/injury/wisqars/nonfatal.html. Date Accessed: 7/7/2015
32. Thompson MC, Chounthirath T, Xiang H, *et al*. Pediatric inflatable bouncer-related injuries in the United States, 1990-2010. *Pediatrics.* 2012;130:1076-83. doi:10.1542/peds.2012-0473.
33. D'Souza AL, Smith GA, Trifiletti LB. Ladder-related injuries treated in emergency departments in the United States, 1990-2005. *Am J Prev Med*. 2007;32:413-8.
34. U.S. Consumer Product Safety Commission. NEISS Coding Manual.1982. https://www.cpsc.gov//Global/Neiss_prod/completemanual.pdf
35. U.S. General Accounting Office. Consumer Product Safety Commission: Better data needed to help identify and analyze potential hazards (HEHS-97-147). Washington, DC: General Accounting Office; 1997 [7 July 2015]; http://www.gao.gov/products/HEHS-97-147
36. Graves JM, Whitehill JM, Hagel BE, Rivara FP. Making the most of injury surveillance data: using narrative text to identify exposure information in case-control studies. *Injury*. 2015;46:891-7. doi: 10.1016/j.injury.2014.11.012.

Table 3. Potential Counter measures as indicated by case reviews

Housing Element	NEISS Case Narratives	Prevention measures
Bathtub	"Fell in tub hitting head DX: closed head injury" (age 7 yr.)	Install a slip-resistant mat into bathtub or shower floor
	"Patient was pregnant and slipped while getting out of the shower onto wet floor strained lower back" (age 17 yr.)	Install slip-resistant flooring in bathrooms, especially around baths/showers
	"Patient getting out of the bath tub and slipped and fell striking chin laceration face" (age 3 yr.)	Install a slip-resistant mat just outside bathtub or shower; install grab bars to improve stability; install water-resistant padding on top areas of bathtubs to create a "forgiving" surfacing
	"Burned by water in tub, bath water too hot." (age 8 yr.)	Install anti-scald devices such as Thermostatic Mixing Valves (TMV)to limit water temperature
	"Patient was in the tub with brother, shower door fell on both boys, had numerous cuts, has RT lower leg wound. DX-RT lower leg laceration" (age 3 yr.)	Check for shower doors that may be loose and repair
	"Patient was trying to sit down in the shower, the soap dish broke and cut her." (age 7 yr.)	Install shower systems with integrated and inverted soap dishes such that nothing protrudes into the shower space
Cabinet	"Laceration to elbow fell onto corner of bookshelf at home" (age 2 yr.)	Install corner guards and cushions on all hard surfaces in the home. Place corner guards on cabinet corners
	"Patient ran into china cabinet glass broke and cut leg" (age 11 yr.)	Install stickers on glass doors to make them more visible to residents
	"Slammed hand in cupboard door. DX. Finger skin avulsion, hand contusion" (age 15 months)	Install door stops that prevent hands/feet from getting pinched, crushed or lacerated
	"Patient sustained an injury to her face when a kitchen cabinet came loose and fell on patients Left side of body." (age 7 yr.)	Inspect installed cabinets to ensure stability
Carpet	"Fell half flight of stairs, carpeted stairs with plastic on it, cried immediately, DX closed head injury" (age 21 months)	Inspect all carpets and rugs for tripping hazards
	Patient sustained fracture to lower leg after tripping over a carpet" (age 15 months)	Inspect all carpets and rugs for tripping hazards (eliminate throw rugs or install non-skid tape underneath to maintain stability)
Ceiling/Wall	"Lacerated eye, sconce fell from wall" (age 5 yr.)	Inspect all lighting and other fixtures and stable and secure (properly installed) Ensure that all ceiling pieces fixtures are stable
	"Fell on corner of wall when running; DX lacerated scalp" (age 3 yr.)	Install corner cushions on walls

Housing Element	NEISS Case Narratives	Prevention measures
Counter	"A countertop fell on finger hematoma subdual left third finger" (age 9 months)	Inspect for loose countertops
	"Hit forehead on corner of counter, laceration" (age 2 yr.)	Inspect that all counter tops are properly installed and secure, require edges or corners that are rounded (bullnose)
Door	"Patient's mother was closing a door when patients finger got caught in door resulting in an open distal phalangeal fracture" (age 4 yr.)	Install door stops to prevent hands/feet from getting pinched, crushed or lacerated
	"Heavy bi-fold closet door fell on patient who was on floor at home, mom heard noise and found patient under fallen door, loc; subdural hematoma" (age 3 yr.)	Inspect all doors to ensure proper installation and structural integrity; replace old/broken doors to prevent from falling
	"Patient at grandmother's house and cut head on screen door." (age 7 months)	Inspect all doors to ensure proper installation and structural integrity; install door stops to prevent hands/feet from getting pinched, crushed or lacerated
Fence	"Gate fell on him, DX fractured upper leg" (age 3 yr.)	Inspect gates and fencing for structural integrity
Floor	"DX FB R FT: Splinter in L FT, states she got it sliding in her sock feet in foyer" (age 7 yr.)	Inspect condition of wood floors to holes, loose or missing boards, and overall condition
	"Laceration: child running at aunt's house, fell onto cousin, then onto the hardwood floor" (age 3 yr.)	Apply non-slip surface to floors to reduce slips and falls
	"Patient sustained a laceration to RT lower leg on a piece of broken floor tiling laceration leg" (age 11 yr.)	Inspect condition of wood floors to holes, loose or missing boards, and overall condition
Nail	"Laceration to hand and tooth injury when this teen tripped over a nail – admitted for repairs" (age 16 yr.)	Inspect for any protruding nails/screws, particularly on floors, walls and cabinets and replace or address any that are protruding
	"Patients mom states child was jumping on bed and hit foot on a nail in the wall DX: puncture wound left foot" (age 3 yr.)	
	"Patient cut hand on a nail sticking out of a cabinet at home" (age 16 months)	
	"Stepped on a board with nails sticking out of it thru shoe into foot" (age 5 yr.)	Inspect home for unsafe items/conditions Remove any loose boards/pieces of wood/building supplies

Housing Element	NEISS Case Narratives	Prevention measures
Porch	"Patient got splinter in his RT foot yesterday walking on deck. Removed. Today wound painful, red, draining pus, IV abx needed." (age 7 yr.)	Inspect outside decking for proper installation, structural integrity and overall condition
	"Fell through railing on porch. DX supracondylar fracture humerus" (age 6 yr.)	Inspect all railings to ensure proper installation, structural integrity and overall condition Ensure that all components of the porch are in good condition
	"Fell porch – Fracture elbow" (age 5 yr.)	Install banisters/fences around porch, particularly if it's high
	"Patient with fracture to left ankle after missing step off porch" (age 18 yr.)	Install railing for porch steps
	"Running, slipped on wet porch and fell, L elbow pain DX: elbow contusion" (age 10 yr.)	Add coating to reduce slips and falls
Stairs	"Being carried by mom who was walking upstairs & tripped over a toy & fell hitting patient's head against wooden step, no loc (age 1 month)	Clear the stairs to prevent slipping on objects such as books, toys, clothes
	"Patient slipped and fell on ice covered sidewalk, pt. hit head on a concrete step." (age 13 yr.)	Educate residents about need to clear sidewalks and stairs of ice and snow to prevent falls
	"Patient fell down 10 stairs. DX: R frontotemporal SDH" (age 2 yr.)	Install baby-gates at top and bottom of stairs Educate residents about how to use and when to stop using
	"Patient fell 10 ft off side of stairs onto ground." (age 2 yr.)	Inspect all external stairs to ensure proper railings and banisters are in place and in good condition
	"NS: Fell down 4 carpeted steps, impacted carpeted floor, c/o occipital head injury, denies l.o.c." (age 5 yr.)	Check for any loose boards

Housing Element	NEISS Case Narratives	Prevention measures
Window	"Cut to arm on broken window glass DX: Arm laceration" (age 16 yr.)	Inspect all windows to ensure proper installation and in good condition
	"Pushing on window which broke/lacerations to both forearms" (age 7 yr.)	
	"Contusion to hand window fell on hand at home" (age 2 yr.)	Inspect all windows to ensure proper installation and in good condition; Install window stops to limit abrupt window closures Place window guards or stoppers to prevent window from falling on hand or head
	"Patient fell 5 stories from window." (age 2 yr.)	Install window guards on all windows above ground to prevent falls
	"Patient pushed out window screen and fell from 2nd floor window onto concrete. DX: R sdh x2, R occ skull FX, closed head injury" (age 1 yr.)	
	"Patient pushed a TV stand up to a window and fell 4 stories out to the ground. In care of babysitter at time. In & out conscious." (age 2 yr.)	
	"Left wrist laceration from putting arm through glass window." (age 16 yr.)	Use shatter-proof glass in windows

Part 2

Risk and protective factors regarding safety in the home

Chapter 4

Improving Smoke Alarm self-report via a prompted questionnaire

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ABSTRACT

Previous work has demonstrated discrepancies between self-reported and observed smoke alarm functionality. This study aimed to improve self-report of smoke alarm status. Parents of children were asked if they had: 1) any working smoke alarm; and 2) a working smoke alarm on every level of their home (Brief Form). Subsequently, parents answered an Extended Form prompting them to consider each level and how they knew the smoke alarms were functioning. In total, 554 participants completed both forms. On the Brief Form, 96% of participants reported having any smoke alarm and 92% reported having a working alarm on every level. On the Extended Form, 85% of parents reported having any smoke alarm and 73% reported having a working alarm on every level. Prompting residents to consider the presence and functionality of smoke alarms on each level of their home increased the opportunity to provided tailored communication to improve smoke alarm coverage.

INTRODUCTION

In 2016, there were approximately 352,000 residential fires resulting in 2,950 civilian deaths and 12,775 civilian injuries.[1] A working smoke alarm is known to reduce the risk of dying in a fire by 50%,[2] however, many homes lack the recommended number of smoke alarms (i.e., one on every level of the home).[3] Sixty percent of home fire deaths occur in homes with no smoke alarms or smoke alarms that do not work. [1]

Previous work also demonstrated discrepancies between self-reported and observed smoke alarm functionality with positive predictive values ranging from 26% to 90%.[4-6] When answering commonly used questions to assess smoke alarm status, the general public over-reports because they may not consider all levels of the home and because they may be unaware of indicators of alarm functionality.[5]

While observed data may be the recognized gold standard, direct observations may not be feasible from a resource or time perspective. Self-reported smoke alarm information is still useful [6] and it may be possible to enhance data quality by improving how and what questions are asked. The goal of the research presented here is to compare two self-reported measurement options to determine how to enhance the accurate reporting of the presence and functionality of smoke alarms. As part of a larger study on child home safety, we compared a Brief Form and an Extended Form of questions about smoke alarm status.

Self-report of health indictors is the primary mechanism by which providers and community health practitioners elicit information for the populations they serve. Overreporting of health behaviors has been associated with social desirability bias and also the lack of understanding of survey questions. [7] It is recommended that pediatricians counsel parents about a range of injury prevention behaviors. [8]However, no standardized set of self-reported questions have been validated to ensure the accurate reporting of injury risk factors. Our previous work around safe sleep has demonstrated that parents report more risk factors when asked a more detailed set of questions as compared to that which they reported to their providers. [9]Similarly fire fighters promoting smoke alarms often rely on residents' self-report when conducting community canvassing programs. [6] Inaccurate report of smoke alarm functionality limits the ability of providers and fire fighters to provide potentially lifesaving educational information and smoke alarms.

METHODS

The methods for this study have been previously described.[10] Briefly, parents of children 4-7 years old were recruited during a visit to the Pediatric Emergency Department (PED) at the Johns Hopkins Hospital or the Arkansas Children's Hospital. Parents were randomized to receive a tailored educational intervention to improve either fire safety or child passenger safety behaviors. Tailored education was delivered via a smartphone app that was downloaded for free by study participants. Upon downloading the app, respondents completed a baseline assessment of their study group's behavior and related beliefs. Based on their responses, a personalized feedback report with tailored education was immediately delivered in the app. The Johns Hopkins Bloomberg School of Public Health institutional review board approved the study. Participants provided written consent prior to the start of the study

Data for this analysis come from the baseline assessment of the fire safety arm of the study. As part of the assessment, respondents were first asked if they had: 1) any working smoke alarms; and 2) a working smoke alarm on every level of their home. These two questions constitute the Brief Form. Later in the assessment, they answered an Extended Form, which asked them to identify the number of levels in their home (including the basement and attic), and then were prompted for each of those level to report whether a smoke alarm was present, if it was working, and how they knew it was working. (Figure 1) Answers were summarized to create two variables comparable to the items assessed on the Brief Form: any working smoke alarm and a working smoke alarm on every level. Responses from the Brief and Extended Forms were compared using a Kuder-Richardson test, a measure of internal consistency for binomial data.

RESULTS

A total of 554 respondents completed both the Brief and Extended Forms. The mean age was 31 years old, 92% of respondents were female, 60% were African American, and 94% had completed high school or received a GED. Approximately one third (33%) were unemployed and 59% were receiving income assistance. (Table 1)

Comparing responses to the two forms, more respondents reported any smoke alarms on the Brief Form (n=531, 96%) compared to the Extended Form (n=478, 85%). Table 2 compares the reports of working smoke alarms between the two forms. Again, more respondents reported more working smoke alarms on all levels on the Brief Form (n=508, 92%) compared to the Extended Form (n=411, 73%).

A total of 111 participants reported a working smoke alarm on every level on the Brief Form, but not on the Extended Form. When asked about the reason they did not have a working smoke alarm on every level, respondents most often cited that they thought they did have a working smoke alarm on every level (n=37), nuisance alarms (i.e., the alarm went off when cooking or showering) (n=23), or they didn't think they needed one on every level (n=19). (Table 3) The Kuder-Richardson coefficient was 0.51.

DISCUSSION

Our results show that question phrasing and quantity changed respondents' report of smoke alarm functionality, presumably for more accurate reporting of smoke alarm presence and functionality. Because there are times when self-reported information is the most feasible way to obtain information, researchers need to carefully consider question phrasing, question order, and other prompts to enhance respondents' answers. By first assessing the number of levels in one's home, we were able to alter respondents' answers. And, by asking respondents to provide a basis for their report of a "working smoke alarm" we may have encouraged more accurate reporting.

Prompting residents with more detailed questions increased the opportunity for tailored feedback. For research purposes, devoting more items to measuring a self-reported behavior of interest may increase validity. For educational purposes, tailored messages have been demonstrated to be more effective than generic messages.[12] However, messages that are tailored to a person's reported behaviors are likely to have limited impact when over-reporting occurs. This study provides valuable insight into the effect of more directed survey items to increase reporting accuracy and thereby providing more opportunities for the provision of tailored safety messages.

The potential limitations of our study include the fact that all participants were parents of young children. It is unknown to what extent their responses would be similar to participants without children. Parents of young children may be exposed to injury prevention messages at greater rates than the general population. An additional potential limitation is that majority of our participants were renters (65%) and low income (73%). It is possible that owner occupants or those with higher income may have better awareness of their homes smoke alarm functionality.

Accurate reporting of presence and functionality of smoke alarms is essential for several reasons. First, in the context of research on smoke alarms which often relies on self-report, valid and reliable measures are needed for rigorous and reproducible studies. Second, interventions such as smoke alarm installation programs often rely on residents' reports of not having working alarms as the

indication that they need to enter the home. Third, educational programs need correct information on whether alarms are present and working to provide the correct educational messages.

Implications for Policy and Practice

Though this study focused in the ability of an enhanced questionnaire to enhance reporting of smoke alarm functionality if has applicability for other behaviors where self-report is the primary mechanism by which parents and residents can avail themselves of life saving educational information and live saving products. Other examples from the literature in which parents or residents have been found to over report safety behaviors includes stair gates, seat belt use, and bicycle helmet use. [3,13,14] There may be benefits to examining the questions asked in these and future studies for consideration about how an enhanced questionnaire may improve the opportunity for the delivery of education.

Extended Form Smoke Alarm Questions

1. Let's think about the alarms in your home closely. Does your home have a basement?
2. Does your home have an attic that someone spends time in?
3. Other than the basement and the attic, how many other levels are in your home?

Repeated for each level of the home:

4a. Thinking about the [basement/attic/Nth level], do you have a working smoke alarm on that floor?

4b. How do you know the smoke alarm on the [basement/attic/Nth level] is working?

- The batteries were changed in the last 6 months.
- The alarm was tested in the last 6 months.
- The alarm is hardwired
- The light is on.
- The alarm beeps regularly.*
- Actually, I'm not sure my smoke alarm is working.

Figure 1. Extended Form Smoke Alarm Questions

Table 1. Respondent Demographics

		N	%
Participant Age	Mean (SD)	31.46	(7.08)
Participant Gender	Male	43	8%
	Female	5014	92%
Race	Black/African American	330	60%
	White/Caucasian	182	33%
	Other	34	6%
Hispanic or Latino	Yes	19	3%
	No	529	97%
Education	Less than high school (HS)	32	6%
	High school or GED	166	30%
	Greater than HS	196	36%
	Completed college or above	152	28%
Per Capita Income	$5,000 or less	199	41%
	$5,001-$10,000	157	32%
	More than 10,000	130	27%
Parent Receives Aid	Yes	318	59%
	No	224	41%
Employment	Yes, full time	289	53%
	Yes, part time	75	14%
	No	178	33%
Homeowner Status	Own	180	33%
	Rent	353	65%
	I don't know	9	2%
Child's Age	Mean (SD)	5.30	(1.16)
Child's Gender	Male	304	55%
	Female	250	45%

Table 2. Self-report of having a working smoke alarm on every level.

		Extended Form		
		Yes	No	Total
Brief Form	Yes	397	111	508 (92%)
	No/Don't know	8	38	46 (8%)
	Total	405 (73%)	149 (27%)	554

Table 3. Reported Reasons for not having a working smoke alarm on every level among

Reason	N (%)
Thought they had a working SA on every level	37 (33%)
Smoke alarms go off while cooking or showering	23 (21%)
Didn't think they needed a working SA on every level	21 (19%)
Never thought or decided about having a SA on every level	16 (14%)
Barriers to obtaining/installing smoke alarm (i.e. not enough time/money, don't know how to install, landlord won't allow)	14 (13%)
Total	111

***** results from n=111 participants responding having a working smoke alarm on every level on the brief form, but not on the extended form

REFERENCES

1. Haynes H. Fire loss in the United States During 2016, National Fire Protection Agency. Sept 2017
2. Douglas MR, Mallonee S, Istre GR. Estimating the proportion of homes with functioning smoke alarms: a comparison of telephone survey and household survey results. Am J Public Health 1999;89:1112e14.
3. Chen LH, Gielen AC, McDonald EM. Validity of self-reported home safety practices. Inj Prev 2003;9:73e5.
4. Robertson AS, Rivara FP, Ebel BE, et al. Validation of parent self-reported home safety practices. Inj Prev 2005;11:209e12.
5. Hatfield PM, Staresinic AG, Sorkness CA, et al. Validating self-reported home safety practices in a culturally diverse non-inner-city population. Inj Prev 2006;12:52e7.
6. Stepnitz R, Shields W, McDonald E, *et al.* Validity of smoke alarm self-report measures and reasons for over-reporting. *Inj Prev* 2012;18:298–302.
7. Ahrens, M. Smoke alarms in U S. Home Fires. Quincy, MASS: National Fire Protection agency. September 2011 Available at https://www.dli.mn.gov/CCLD/rm/PDF/1309_9.pdf
8. Hatfield PM, Staresinic AG, Sorkness CA, Peterson NM, Schirmer J, Katcher ML. Validating self reported home safety practices in a culturally diverse non-inner city population. Inj Prev. 2006 Feb;12(1):52-7
9. American Academy of Pediatrics. TIPP: The Injury Prevention Program patient education handouts. http://patiented.solutions. aap.org/handout-collection.aspx?categoryid=32033. Accessed April 1 2019
10. Mahoney P, Solomon B, McDonald EM, Shields WC, Gielen AC. Improving maternal disclosure of unsafe infant sleep practices in primary care. In Press JAMA Peds
11. Omaki E, Shields WC, McDonald E, Aitken ME, Bishai D, Case J, Gielen A. Evaluating a smartphone application to improve child passenger safety and fire safety knowledge and behavior. Inj Prev. 2017 Feb;23(1):58. doi: 10.1136/injuryprev-2016-042161.
12. Dijkstra A, DeVries H. The development of computer-generated tailored interventions. Patient Edu Couns. 1999;36:193–203.
13. Nelson D E. Validity of self-reported data on injury prevention behavior: lessons from observational and self-reported surveys of safety belt use in the US. Inj Prev 1996267–69.
14. Schieber RA, Sacks JJ. Measuring community bicycle helmet use among children. Public Health Rep 2001;116:113–21.

Chapter 5

Home Safety and Low-Income Urban Housing Quality

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ABSTRACT

Objectives
Living in substandard housing may be one factor that increases the risk of fire and burn injuries in low-income urban environments. The purposes of this study are to: 1) describe the frequency and characteristics of substandard housing in urban homes with young children and 2) explore the hypothesis that better housing quality is associated with a greater likelihood of having working smoke alarms and safe hot water temperatures.

Patients & Methods
A total 246 caregivers of children ages 0-7 years were recruited from a pediatric emergency department and a well child-clinic. In-home observations were completed using 46 items from the Housing and Urban Development's Housing Quality Standards.

Results
Virtually all homes (99%) failed the housing quality measure. Items with the highest failure rates were those related to heating and cooling; walls, ceilings, and floors; and sanitation and safety domains. One working smoke alarm was observed in 82% of the homes, 42% had one on every level, and 62% had safe hot water temperatures. For every increase of 1 item in the number of housing quality items passed, the odds of having any working smoke alarm increased by 10%, the odds of having one on every level by 18%, and the odds of having safe hot water temperatures by 8%.

Conclusions
Many children may be at heightened risk for fire and scald burns by virtue of their home environment. Stronger collaboration between housing, health care, and injury prevention professionals is urgently needed to maximize opportunities to improve home safety.

INTRODUCTION

Children living in low income, urban environments are at increased risk for fire and scald burns in their homes. (1,2) Programs, including those conducted in pediatric health care, that encourage parents to reduce home injury hazards have been evaluated with mixed results. (3,4)Thus, there remains a gap in understanding how to best enhance home safety to reduce child injuries, including fires and burns.

For low income, urban communities, addressing substandard housing may hold promise. (5)According to the Centers for Disease Control and Prevention, "Childhood lead poisoning, injuries, respiratory diseases such as asthma, and quality of life issues have been linked to the more than 6 million sub- standard housing units nationwide." (6)The evidence on home injury risk and housing quality is limited. Studies have used different outcomes (e.g., fatalities or hazards such as no working smoke alarm), as well as different indicators of housing quality such as an inter- viewer assessment of a home needing repair, (7)a home that lacks indoor plumbing,(8) or census tract variables such as housing code violations, (9)vacancy rates, (10) or age of housing stock. (11) Only 1 study, conducted.15 years ago, used a standard government assessment; the authors found that substandard housing was associated with more injury hazards, including no working smoke alarms and unsafe hot water temperatures. (12)

With this suggestive evidence that housing quality is associated with child home injury risk and the avail- ability of a newer standardized tool to measure housing quality, it is timely to further explore these relationships. The aims of this article are to (1) describe the frequency and characteristics of substandard housing in homes with young children and (2) explore the hypothesis that better housing quality is associated with a greater likelihood of having working smoke alarms and safe hot water temperatures.

PATIENTS & METHODS

Sample

The data for this analysis come from 246 parents with children 0 to 7 years old who participated in 1 of 2 studies con- ducted in East Baltimore, Safety in Seconds (SIS) (13) and the CARES Parent Study (CPS). (14)

The authors of the SIS study evaluated the effects of a computer-tailored re- port on safety behaviors of parents. From September 2004 to December 2005, 901 parents from the Johns Hopkins Pediatric Emergency Department participated in a randomized controlled trial. Intervention parents received a 4-page tailored report on smoke alarms, poison storage, and car seats. Control parents received

a 4-page generic report on health issues. Parents completed follow-up telephone surveys at 2 weeks (n = 759) and 4 months (n = 719). Home observations of smoke alarms and hot water temperatures were conducted on a random sample of 100 families (50 intervention and 50 control), who form the sample for the present analysis. The parents were 98% African American; 11% had more than a high school education; 68% earned ≤$5000 per capita per year; 23% were ≥30 years old; and 24% were married or in a couple relationship.

The CPS evaluated the impact of a mobile safety center (MSC), a 40-foot vehicle outfitted like a home environment that contains interactive educational exhibits and provides education and low-cost safety products. From July 2005 to May 2006, 296 parents were enrolled at a community health center. The interventions included either a prescribed or optional MSC visit as part of a well-child care visit; the control group was given a schedule of MSC community locations. Follow-up interviews and home observations of smoke alarms and hot water temperatures were completed between 2 weeks and 4 months after enrollment with 146 families, who form the second sample used in the present analysis. The parents in this sample were 97% African American; 18% had more than a high school education; 71% earned ≤$5000 per capita per year; 22% were ≥30 years of age; and 25% were married or in a couple relationship.

Measures

Housing Quality

The national Housing Choice Voucher Program is the primary form of federal housing assistance in the United States (“Section 8” housing). Vouchers are used to pay for homes deemed to be “decent, safe, and sanitary” according to the US Department of Housing and Urban Development’s (HUD) Housing Quality Standards (HQS). (15) Housing Choice Voucher Program homes are required to pass HQS inspections annually. The 120 HQS items focus mostly on structural elements of housing and some neighborhood features. Trained housing inspectors complete the assessment.

In the 1990s, HUD conducted pilot tests to explore whether a subset of 64 items would be a valid assessment and whether the resident could reliably complete the assessment. More than 4000 residents in 3 states completed surveys by using this subset of items. High rates of agreement were found between inspector and resident completed assessments (.80%) and in test-retest reliability (.80%).(16,17)

Because the shorter survey performed well, it was used in both the SIS and CPS studies. For the present analysis, we retained 46 items that focused specifically on structural elements of the home environment. Items were dropped because

they focused on neighborhood features (n = 8) or had missing data (n = 4)*; 6 items were combined with another item as required by the scoring instructions.

These 46 items cover 6 housing domains: kitchens and bathrooms (11 items); electrical wiring (5 items); heating and cooling (4 items); walls, ceilings, and floors (7 items); sanitation and safety (11 items); and outside the home (8 items). Consistent with the HUD requirements, each item is scored as "pass" or "fail," and the entire unit fails to meet the minimum housing quality standards if a single item fails.

Safety Behaviors

During the home observations in both the SIS and CPS studies, data collectors located and tested smoke alarms and tested the temperature of the hot water at the kitchen sink. Three dichotomous variables were created: any working smoke alarm (yes/no), working smoke alarms on all levels of the home (yes/ no), and safe hot water temperature (≤48.9°C) (yes/no). Having 1 working smoke alarm is also a measure in the sanitation and safety domain of the HQS; therefore, this item was dropped when we analyzed smoke alarm outcomes.

Sociodemographic Factors

Data were collected on child's age and gender. Data on the respondent characteristics included the following: ethnicity, relationship to child, age, education, marital status, employment status, per capita annual income, and whether the home was rented or owned.

Data Analysis

For the first study aim, we present simple descriptive statistics on the housing quality results. For the second aim, we compare the number of housing quality items passed to the presence of working smoke alarms and safe hot water temperatures by using logistic regression, adjusting for the study sample and significant sociodemographic covariates.

* Does the refrigerator keep food cold enough that it does not spoil? How many times did the heating break down for 6 hours or more? Was your home ever so cold for 24 hours or more that someone in your home was uncomfortable? Do you see any problems with the roof such as sagging, holes or missing roofing?

RESULTS

Sample

The children were 2.5 years old on average; they were roughly equally di- vided between boys and girls (Table 1). Respondents were mostly African American (98%), child's mother (93%), 20 to 29 years old (61%), and unmarried (76%). One-half (50%) were employed, 15% had more than high school education, and 69% earned ≤$5000 per capita per year. Data on whether the home was rented or owned were missing for 57 participants (23%); for the remainder of the sample (n = 173), 92% were living in rental property.

Table 1. Sociodemographic Characteristics of the Sample (N=246)
East Baltimore, MD

Variable	Mean	SD
Child Age (months)	31	24
	Frequency	%
Child Gender		
Boy	133	54
Girl	113	46
Respondent Relationship to Child		
Mother	229	93
Father	6	2
Other	11	4
Respondent Age		
14-19 years	40	16
20-29 years	148	61
>30 years	55	23
Respondent Education		
Less than high school	71	29
High school graduate	138	56
More than high school	37	15
Respondent Marital Status		
Married	60	24
Single, divorced, widowed	186	76
Respondent Employment		
None	121	50
Yes, full time	83	34
Yes, part time	39	16
Annual per capita Income		
≤ $5000	161	69
> $ 5000	73	31

Rates and Characteristics of Substandard Housing

Table 2 presents housing quality domain data, including the mean number of items failed, mean item failure rate, and frequency distribution of items failed. Any failed item results in failing the entire assessment. For the total sample, the mean number of items failed was 8.2 out of the total 46 items, an 18% mean item failure rate. However, only 2 homes failed no items, meaning that 99% of the homes in this sample failed the housing quality assessment.

The data in Table 2 also demonstrate that the domain with the highest item failure rate was domain 4 (walls, ceilings, and floors) with the mean number of items failed 2.2 out of 7 (31%). Domain 3 (heating and cooling) and domain 5 (sanitation and safety) had average item failure rates of 22% and 20%, respectively. The domain with the lowest mean item failure rate was do- main 6 (outside), for which 0.8 out of 8 items failed on average (10%). Domain 2 (electrical) and domain 6 (outside) had the highest proportion of homes with no failed items (53% and 50%, respectively), and domain 5 (sanitation and safety) had the lowest (11%).

The detailed listing of the housing quality items is presented in Table 3, along with the proportion of homes that passed each item. For ease of presentation, the 32 items with ≥80% passing are listed in the Appendix. The 14 items with passing rates below 80% (Table 3) came from all 6 domains. The 4 items with the lowest proportion of homes passing included having a heating system that provides enough heat in every room (44%); no paint that is easy to chip or peel off 44%); no mold, mildew, or water dam- age on walls, floors, or ceilings (44%); and having a working smoke alarm on every level (42%). Fifty percent (50%) of respondents reported having seen a rat within the past week; 59% reported that all their windows had working locks.

Table 2. Housing Quality Measures of 246 Homes in East Baltimore, MD

Domain	Total Number of Items	Average Number of Items Failed by Domain		Frequency and Percent of Homes That Failed by Number of Items Failed and by Domain		
		Mean Number of Items Failed	Mean Item Failure Rate, %	Number of Items Failed	Number of Homes That Failed	Cumulative Percent
Domain 1, kitchens bathrooms	11	1.4	13	0	71	29
				1	77	60
				2	53	82
				3+	45	100
Domain 2, electrical	5	0.7	14	0	130	53
				1	70	81
				2+	46	100
Domain 3, heating and cooling	4	0.9	22	0	91	37
				1	105	80
				2+	50	100
Domain 4, walls, ceilings, floors	7	2.2	31	0	56	23
				1	58	46
				2	40	63
				3	27	74
				4	27	85
				5+	38	100
Domain 5, sanitation safety	11	2.2	20	0	28	11
				1	50	32
				2	70	60
				3	59	84
				4+	39	100
Domain 6, Outside the home	8	0.8	10	0	122	50
				1	75	80
				2+	49	100
Total	46	8.2	18	0	2	1
				1-4	62	26
				5-9	98	66
				10-12	39	82
				≥13	45	100

Association Between Substandard Housing and Safety Behaviors

Table 4 shows that 82% of the sample had at least 1 working smoke alarm; 42% had 1 on every level; and 62% had safe hot water temperatures. Respondent age was associated with having working smoke alarms on every level, and respondent education was associated with having safe hot water temperatures in bivariate analyses (data not shown); these variables were included in the logistic regressions. The adjusted logistic regression analyses revealed that for every increase of 1 in the number of housing quality items passed, the odds of having

any working smoke alarm increased by 10%, the odds of having 1 on every level by 18%, and the odds of having safe hot water temperatures by 8%.

Table 4 Relationship Between Housing Quality and Safety Behaviors Among 246 Residents in East Baltimore, Maryland, Distribution of Outcome Variables and Logistic Regression Analyses

Outcome Variable	Frequency (%)	Adjusted Odds Ratio [a] (95% Confidence Interval) for Number of HQ Items Passed	*P*
Working smoke alarm	202 (82)	1.10 (1.03–1.17)	.01
Working smoke alarm on every level	104 (42)	1.18 (1.1–1.27)	.00
Safe hot water temperature	152 (62)	1.08 (1.02–1.14)	.01

[a]All models adjusted for the data set from which the sample was drawn; working smoke alarm on every level adjusted for respondent's age; safe hot water temperature adjusted for respondent education level.

DISCUSSION

In this low income, urban sample of homes with young children, we found that 99% would be considered sub- standard. The most common problems were inadequate heating systems; peeling paint; walls, floors, or ceilings that have mold, mildew, or water damage; evidence of rats; and windows without locks. The odds ratios were significant and substantial for the association be- tween the number of housing quality items failed and not having safe hot water temperatures or working smoke alarms. These results, while intuitive, are important because they add to the literature demonstrating an association between substandard housing and pediatric health problems previously demonstrated for lead poisoning and asthma. (5,6)Pediatricians caring for low income families can use these results to inform their injury prevention anticipatory guidance and consider having referral re- sources for housing needs available.

The authors of a recent systematic review of interventions to address injury-related structural deficiencies in housing noted the absence of research on improving the implementation of safety-related building and housing codes. (18) To the extent that HUD standards reflect commonly accepted building codes, our data provide some of the first empirical evidence linking structural deficiencies to home injury prevention behaviors. We were limited to data on only 2 safety behaviors, but results suggest other injury hazards and safety behaviors should be investigated.

The study does not elucidate why families in poor quality housing would be less likely to have working smoke alarms and safe hot water temperatures, nor did we have specific hypotheses in this exploratory study. Poverty is a common risk factor for both substandard housing and lower rates of smoke alarms and safe hot water temperatures. Because our sample was predominantly low in- come,

the independent effect of housing quality cannot be isolated. It is likely that a constellation of factors is associated with being able to implement safety behaviors and home modifications and that poor housing quality is a marker for some of these.

Table 3. Housing Quality Measures of 246 Homes in East Baltimore, MD
Percent of Homes Passing by Item and Domain for Items with <80% Passing

Domain	Housing Quality Item (Passing Response)	% Passing
Domain 1		
Kitchens and bathrooms	Do all stove burners work? (Yes)	78
Domain 2		
Electrical	Do all ceiling and wall mounted light fixtures work? (Yes)	78
	Ask parent: How many times have fuses blown or circuit breakers tripped in last 3 months? (None)	73
Domain 3		
Heating and cooling	Does the heating system provide enough heat in every room? Yes)	44
Domain 4		
Walls, ceilings and floors	Is there any paint that can be chipped or peeled by finger scraping? (No)	44
	Is there any area of peeling paint or broken plaster bigger than the size of this page? (No)	79
	Are there any floor problems such as boards, tiles, carpeting or linoleum that are missing, curled, or loose? (No)	75
	Is there mildew, mold, or water damage on any wall, floor or ceiling? (No)	44
	Is there any place where floor problems can cause you to trip?	71
Domain 5		
Sanitation and safety	Ask Parent: did you see a rat anywhere in your building or outside around the grounds this week? (No)	50
	Ask Parent: have you seen any cockroaches in your home this week (No)	77
	Do all windows have locks that work? (Yes)	59
	Is there a working smoke detector on each floor in your home? (Yes)	42
Domain 6		
Outside the home	Ask parent: Is there enough light for safety? (Yes)	79

Many of the homes in this study were rental properties. For smoke alarms, landlords are responsible for putting smoke alarms in the home, but residents are responsible for maintaining them, and our data could not distinguish be- tween absent alarms, disabled alarms, or alarms with nonworking batteries. Landlords are also responsible for con- trolling the water temperature in rental properties, and we do not know whether the homes in our study had central or individual water heaters, which would determine whether the resident had access. We also do not know if the water heaters were of the newer type with preset safe

temperatures. However, although hot water temperature is generally correlated with the water heater setting, we have evidence that this is not always the case, (19) and the 2009 International Residential Code for 1- and 2-family dwellings recommends thermostatic mixing valves that regulate the water temperature at the faucet. (20,21)

The sample consists of parents enrolled in child safety intervention trials, and thus, is not representative of homes in any defined geographic area. We do not have further detail on the structural characteristics of the homes or actual home injuries, which would be useful to collect in future studies. Nevertheless, the sample does reflect a large number of homes within low income, urban neighborhoods in East Baltimore.

An important strength of the study is the use of home observations. These data are the first to our knowledge to use a standardized housing quality assessment tool to describe housing characteristics in this level of detail. The results are important because they demonstrate that a large number of low-income, urban children may be at heightened risk for not only the well-documented lead poisoning and asthma that can be traced to the home environment but also for fire and scald burns. Moreover, the inadequate smoke alarm coverage and unsafe hot water temperatures have implications for entire families.

Our findings suggest that there are other safety modifications to include in the HUD's standard housing quality assessments, especially for homes that are being inspected for occupancy by families with young children. High rates of homes with evidence of rats and cock roaches raises concern that there are also toxic chemicals in the home being used to kill them. The availability of lockable cabinets or other safe places to store such hazardous products should be included in housing quality assessments. Given the high failure rate for the heating and cooling domain, the presence of a working carbon monoxide alarm should be included for the protection of entire families.

CONCLUSIONS

Based on our findings and the availability of evidence-based solutions to many home injury risks, stronger collaboration between housing, health care, and injury prevention professionals is urgently needed to maximize the policy opportunities available to improve home safety.

REFERENCES

1. Istre GR, McCoy MA, Osborn L, Barnard JJ, Bolton A. Deaths and injuries from house fires. N Engl J Med. 2001;344(25):1911–1916
2. McDonald EM, Girasek D, Gielen AC. Home injuries. In: Liller K, ed. Injury Prevention for Children and Adolescents, 2nd ed, Chapter 5. Washington, DC: American Public Health Association; 2012
3. Kendrick D, Coupland C, Mulvaney C, et al. Home safety education and provision of safety equipment for injury prevention. Cochrane Database Syst Rev. 2007;2(1): CD005014
4. Turner S, cation of reduction Syst Rev. Arthur G, Lyons RA, et al. Modifications of the home environment for the of injuries. Cochrane Database 2011;2(2):CD003600 doi:10.1002/ 14651858.CD003600.pub3
5. Morley RL, Mickalide AD, Mack KA. Healthy and Safe Homes Research, Practice, and Policy. Washington, DC: American Public Health Association; 2011
6. Centers for Disease Control and Prevention. CDC's health homes initiative: lead. Available at: www.cdc.gov/nceh/lead/healthyhomes. htm. Accessed July 7, 2012
7. Greaves P, Glick DC, Kronenfield JJ, Jackson K. Determinants of controllable in-home child safety hazards. Health Educ Res. 1994;9(3):307–315
8. Edelman LS. Social and economic factors associated with the risk of burn injury. Burns. 2007;33(8):958–965
9. O'Campo P, Rao RP, Gielen AC, Royalty W, Wilson M. Injury-producing events among children in low-income communities: the role of community characteristics. J Urban Health. 2000;77(1):34–49
10. Shai D. Income, housing, and fire injuries: a census tract analysis. Public Health Rep. 2006;121(2):149–154
11. Shenassa ED, Stubbendick A, Brown MJ. Social disparities in housing and related pediatric injury: a multilevel study. Am J Public Health. 2004;94(4):633–639
12. Gielen AC, Wilson MEH, Faden RR, Wissow L, Harvilchuck JD. In-home injury prevention practices for infants and toddlers: the role of parental beliefs, barriers, and housing quality. Health Educ Q. 1995;22(1):85–95
13. Gielen AC, McKenzie LB, McDonald EM, et al. Using a computer kiosk to promote child safety: results of a randomized, controlled trial in an urban pediatric emergency department. Pediatrics. 2007; 120(2):330–339
14. Gielen AC, McDonald EM, Frattaroli S, et al; CARES (Children ARE Safe) Mobile Safety Center Partnership. If you build it, will they come? Using a mobile safety center to disseminate safety information and products to low-income urban families. Inj Prev. 2009;15(2):95–99
15. Housing Choice Voucher Program Guide- book. Chapter 10: housing quality standards. US Department of Housing and Urban Development Web Site. Available at: www. hud.gov/offices/pih/programs/hcv/forms/ guidebook.cfm. Updated January 10, 2008. Accessed July 6, 2012
16. Report and Test Results Examine Effective- ness of Mail Surveys. HUD user policy development and research information service. Available at: www.huduser.org/ periodicals/rrr/rrr_11_2000/1100_5.html. Accessed July 6, 2012
17. US Department of Housing and Urban Development, Office of Policy Development and Research. Resident assessment of housing quality: lessons from pilot surveys. Prepared by: Building Research Council, School of Architecture, University of Illinois at Urbana-Champaign, Champaign, IL, December 1998. HUD Web site. Available at: www.huduser.org/Publications/pdf/quality. pdf. Accessed July 6, 2012
18. DiGuiseppi C, Jacobs DE, Phelan KJ, et al. Housing interventions and control of injury- related structural deficiencies: a review of the evidence. J Pub Health Mngmnt Prac. 2010;16(5):S34–S43

19. Shields W, Perry E, McDonald E, et al. Too hot to handle: an examination of hot water temperature and water heaters in a sample of urban homes. Poster presentation at the American Burn Association Annual Meeting, April 2012; Seattle, WA
20. International Code Council, Inc. International Residential Code for One- and Two-family Dwellings. Washington, DC: International Code Council, Inc; 2012
21. Kendrick D, Smith S, Sutton AJ, et al. The effect of education and home safety equipment on childhood thermal injury prevention: meta-analysis and meta-regression. Inj Prev. 2009;15(3):197–204

Appendix.

Housing Quality Measures of 246 Homes in East Baltimore,Maryland: Percent of Homes Passing by Item and Domain for Items with ≥80% Passing

Domain	Housing Quality Item (Passing Response)	% Passing
Domain 1		
Bathrooms	Does your kitchen have a working oven? (Yes)	96
	Does the tap water have a problem with color or bad odor? (No)	98
	Is there a working light fixture in the kitchen ceiling or wall? (Yes)	94
	How many working outlets are in the kitchen? (2 or more)	91
	Is their hot and cold running water at each kitchen/bath sink/tub?(Yes)	88
	Is there water leaking from any kitchen/bath sink, drain, or pipe? (No)	87
	Is any kitchen or bath sink, tub or shower clogged? (No)	87
	Does the bathroom have a window that opens or a ventilation system that works? (Yes)	82
	Ask parent: How many times did the toilets not work for 6 hours or more? (None)	80
	Ask parent: Has any bathroom floor been covered by water because of plumbing problems? (No)	80
Domain2		
Electrical	Is all the building's wiring in your home enclosed in walls or metal coverings? (Yes)	88
	Do all electrical outlets and switches have cover plates? (Yes)	92
	Not counting the bathroom, does each room have at least one working outlet? (Yes)	98
Domain 3		
	In cold weather do you ever need to use your oven to heat your home? (No)	86
	If your home comes with air conditioning, does it work correctly? (Yes)	96
	Can you adjust the heat when it is too hot or too cold? (Yes)	86
Domain 4		
Walls, ceilings and floors	Are there any holes or large cracks where outdoor air or rain can come in? (No)	87
	Do you see any walls, ceilings, or floors with serious problems like sagging, leaning, buckling or large holes? (No)	82
Domain 5		
	Ask parent: In your home, do you smell bad odors such as sewer, natural gas, etc. (No)	92
	Do all outside doors have locks that work? (Yes)	97
	Do all bedrooms have a window you can open? (Yes)	88
	Does any window have broken glass that can cut someone? (No)	95

	Ask parent: In the last 3 months has your mail been stolen or tampered with? (No)	97
	In case of fire, do you have a least 2 ways out of the home? (Yes)	93
	Are secure handrails on all stairs and landings? (Yes)	89
Domain 6		
Outside of home	Is the condition of any porch or balcony dangerous? (No)	96
	Are any outside handrails, steps or stairs unsafe? (No)	89
	Is any sidewalk, driveway, or parking lot damaged in a way that could cause you to trip? (No)	91
	Are fences or gates in bad condition? (Yes)	90
	Do you see any walls with serious leaning, buckling or large holes? (No)	94
	Does the garbage service pick up each week? (Yes)	98
	Ask parent: Do you have either covered dumpsters or covered cans for your garbage and trash? (Yes)	80

Chapter 6

Still Too Hot: Examination of Water Temperature and Water Heater Characteristics 24 Years After Manufacturers Adopt Voluntary Temperature Setting

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ABSTRACT

Objective:
Although water heater manufacturers adopted a voluntary standard in the 1980's to pre-set thermostats on new water heaters to 49°C/120°F, tap water scald burns cause an estimated 1,500 hospital admissions and 100 deaths per year in the United States. This study reports on water temperatures in 976 urban homes and identifies water heater and household characteristics associated with having safe temperatures.

Methods:
The temperature of the hot water, type and size of water heater, date of manufacture and the setting of the temperature gauge were recorded. Demographic data including number of people living in the home and home ownership were also recorded.

Results:
Hot water temperature was unsafe in 41% of homes. Homeowners were more likely to have safer hot water temperature ($\leq$ 49°C/120°F) than renters (63% vs. 54%; $p<0.01$). For 11% of gas water heaters, the water temperature was $\geq$ 54°C/130°F, although the gauge was set at less than 75% of its maximum setting. In a multivariate logistic regression, electric water heaters were more likely to have safe hot water temperatures than gas water heaters (OR=4.99; $p<0.01$). Water heaters with more gallons per person in the household were more likely to be at or below the recommended 49°C/120°F.

Conclusions:
Our results suggest that hot water temperatures remain dangerously high for a substantial proportion of urban homes despite the adoption of voluntary standards to preset temperature settings by manufacturers. This research highlights the need for improved prevention strategies such as installing thermostatic mixing valves to ensure a safer temperature.

INTRODUCTION

Burns from tap water result in an estimated 1500 hospital admissions and approximately 100 deaths per year. (1,2) The severity of tap water scalds depends on the temperature of the water and the length of time the skin is exposed. (2) Human exposure to hot water at 140°F can lead to a serious burn within 3 seconds, whereas at 49°C/120°F a serious burn takes about 10 minutes.(3) Because thinner skin burns more quickly, children and older adults are at increased risk. Young children are disproportionately affected by scald burns, as approximately 21,000 children are treated for scald burns from all causes each year, and scald burns represent an estimated 65% of burn hospitalizations for children ages 4 and under.(4) Hot tap water causes nearly 25% of all scald burns and is associated with more scald burn deaths and hospitalizations in children than any other hot liquid.(5,6,7,8) Data from the National Electronic Injury Surveillance System reveal that during 2001 to 2006 among adults over 65 years there were an estimated 51,700 emergency department visits for scald burns from all causes.(9) Compared to younger adults, the elderly who suffer scald burns from tap water have higher death rates, longer hospitalizations, and more severe health outcomes.(10,11) In addition to age, lower socioeconomic status has also been associated with increased risk for scald burns from all causes.(10,12,13,14)

The economic burden stemming from scald burns is enormous. In the United States, the annual cost for scald burn deaths and injuries from all causes among children 14 years and younger is about $44 million and children younger than 5 years contribute over 90% of this cost. (4) For New York City alone, societal cost estimates for tap water scald injuries to people of all ages from 1996 to 2003 were between $102 and $149 million. (12)

Tap water scalds primarily occur in residential kitchens and bathrooms. (15) Scalds in the bath are especially hazardous for young children because of the large surface area of the body exposed during bathing. (16) Some common mechanisms of scald injury in the bathroom include falling into the bathtub, coming into contact with hot running water, and being placed into excessively hot water accidentally or intentionally. (16)

Intervening to Reduce Tap Water Scalds

The Consumer Product Safety Commission (CPSC) recommends that water heater manufacturers preset the temperature of water heaters to 49°C/120°F. Efforts to regulate tap water temperature at the state level began in Florida in 1980 when the state legislature called for water heater temperatures to be pre-set at 125°F.(17) In response to the Florida effort and similar laws in other states, manufacturers voluntarily adopted the 49°C/120°F standard recommended by CPSC in 1988.(7,15,17,18) Few studies on the prevalence of hot water

temperatures at or below this recommended level have been conducted since this standard was adopted. Gielen et al. observed 63% of families with safe hot water temperature (19) while Shields et al. reported 64% of homes with older adults having safe hot water temperature. (20) While these data demonstrate that many homes have unsafe water temperatures, the impact of mandating the 49°C/120°F setting on new water heaters as a passive injury prevention strategy has been specifically evaluated twice, with mixed results. In 1983 Washington state enacted legislation which required manufacturers to preset the temperature of new water heaters and landlords to set the temperature of water heaters used in rental properties at 49°C/120°F.(15,17) This intervention resulted in significantly reduced household hot water temperatures and injuries resulting from scalds in King County, Washington.(17) In 1996, the New York City Administrative Code was amended to require that all multi-unit dwellings constructed or renovated after 1997 have water heaters set at 49°C/120°F.(12) Unlike in Washington, the evaluation did not find an effect of this law on the incidence of tap water scald burns.(12)

Considering the demands on and the design of water heaters, delivering hot water at a consistent temperature is difficult. As a hot water tank is depleted, replenished and reheated, water temperature will not be constant throughout the tank. Water heater thermostats are not designed to provide precise estimates of water temperatures but instead to activate heating elements when water temperature falls below the set temperature. The American National Standards Institute codes allow for water temperatures to vary 10 degrees above and below the thermostat setting.(21) In addition, the gauge controlling the thermostat often follows arbitrary units such as a 1-10 scale as opposed to a temperature scale (like found on an oven). Furthermore, the temperature at the tap may be affected by the length, material and insulation of the pipes carrying the water. For these reasons, the gauge on a water heater may be unreliable as an indicator of the hot water temperature at the tap. However, we could find no studies reporting on the relationship between gauge setting and actual temperature.

The research reviewed above describes the risk of injury associated with tap water scald burns and the efforts of advocates and water heater manufacturers to reduce these risks. Despite these efforts, the fact that thousands continue to suffer tap water scalds suggests that many homes still have unsafe hot water temperatures. To our knowledge, there have been no investigations of how the various types of water heaters and gauge settings may contribute to the problem. As part of a larger study of fire and burn risks in an urban area, we had an opportunity to shed some light on this issue. The aims of this paper are to describe the observed temperature of hot water in a large sample of urban homes; and to identify water heater and household characteristics associated with temperatures at unsafe levels.

METHODS

Water temperatures were tested as part of a home observation in follow-up to a randomized community trial which aimed to improve home safety.(22) The trial included a visit from the Baltimore City Fire Department (BCFD) during which firefighters installed smoke alarms and accompanying safety educators provided information about injury risks and the benefits of working smoke alarms, carbon monoxide alarms, and safe hot water temperatures.

A sample of 708 homes participating in the intervention visit ("participants") were visited between 6-9 months later for a follow up survey and observations of the home safety behaviors addressed during the BCFD visit. A sample of 278 neighboring households that were not available to participate in the intervention visit was also recruited and completed the survey and observations. These "non-participant" households were recruited from the same blocks as the participants. All households voluntarily participated in the study and all came from one of 12 census tracts in Baltimore City that had been selected to participate in the community trial. Data were collected between January 2011 and December 2011.

The study was approved by the Johns Hopkins Institutional Review Board. Data were collected through an interviewer-administered, computer-assisted survey conducted in the home. Following the survey, data collectors used a standard protocol to record the hot water temperature and to observe selected water heater characteristics, as described below. Of the 986 households surveyed, hot water temperature measurements were available for 975 (99%). Of these, we observed the water heater characteristics in 883 households (91%); the remainder were not accessible to the data collectors, or the resident did not grant permission.

Measures

Household Characteristics

Respondents reported household size, income, owner status and composition. Using self-reported household income and the number of people supported on that income, the household was classified as living in poverty if the income was below the 2010 Federal Poverty Guidelines.(23)

Observed Hot Water Temperature

A standard kitchen candy thermometer was used to test the temperature of the hot tap water. Candy thermometers provide a measure of temperatures between 75^{o}F and 400^{o}F. Water temperature was tested in the kitchen. Data collectors were instructed to completely open the hot water faucet for one minute, fill a cup with that water, and then measure the temperature with the candy thermometer. Hot water was considered "safe" if the temperature was 49°C/120°F or less.

Water Heater Characteristics
Data collectors observed and recorded characteristics of the water heater including type (gas or electric), date of manufacture, capacity, and the descriptors used on the temperature gauge (i.e., 1, 2, 3… or vacation setting, warm, hot, hottest). Gallons of water per person living in the home was obtained by dividing the water heater capacity by the reported number of people living in the home. Data collectors made a sketch of the gauge indicating the temperature setting.

Gauge
To standardize the setting of the gauge, the total area of the gauge was translated into a 0-100% scale based on the available area for the setting. For example, if the gauge was set at 3 and the highest possible setting was 6, the setting was calculated as 3/6 or 50%. The 0-100% scale for gauges was then divided into quarters and analyzed as a categorical variable. Virtually all of the electric water heaters (96%) did not have a visible gauge and therefore only gas water heaters were included in our analysis of gauge.

Data Analysis

Chi-squared testing was used to compare household characteristics and water heater features between homes with safe versus unsafe hot water temperatures. We also examined whether proportions of safe hot water temperatures differed between the two samples (participants and non-participants in the intervention) and between measures taken in the winter (November-February) versus summer (March-October) months.

A multivariate logistic regression analysis was performed on the presence of safe hot water temperature, including homeowner status, type of water heater, and gallons per person. Poverty status and age of the water heater were not associated with the presence of safe hot water temperatures in bivariate analyses and therefore were not included in the model. Number of people in the home and water heater volume were excluded from the model because these variables were combined to create a gallon per person variable. Households with missing data were excluded from the model. All analyses were performed using Stata software (Stata version 11, StataCorp, College Station, TX).

RESULTS

Hot water was observed to be above the recommended 49°C/120°F in 401 homes (41%), including 260 homes (27%) with temperatures at or above 54°C/130°F. Homeowners were more likely to have safe hot water temperature than renters (63% vs. 54%; $p<0.01$) (Table 1). Homes with safe hot water temperature on average have fewer people than homes with unsafe hot water.

No differences in hot water safety were detected between participants and non-participants or between winter and summer seasons.

A majority (74%) of water heaters observed were gas water heaters of 40 gallons or less. Electric water heaters were more likely than gas water heaters to have safe hot water temperatures (85% vs. 55%; p<0.01) (Table 2). Large water heaters with over 40 gallons were more likely than smaller ones to have safe hot water temperatures (67% vs. 57%; p=0.02). Increasing hot water capacity per person in the home was found to be protective; households with over thirty gallons of hot water per person were less likely to have unsafe hot water temperatures (73% vs. 27%; p<0.01). No difference in water temperatures was observed across water heaters of different ages; only 159 (29%) water heaters were more than 10 years old and 7 of these were manufactured before the voluntary standard was adopted 24 years ago.

Table 1. Household characteristics

	Hot Water 120 or Less N=574	Hot Water Over 120 N=401	Total N=975	Test Statistic
	N (%)	N (%)	N (%)	
Household Income[1]				
At or below the 2010 Federal Poverty Level	123 (57)	94 (43)	217 (100)	$\chi 2=1.7$ (p=0.19)
Above the 2010 Federal Poverty Level	363 (62)	225 (38)	588 (100)	
Homeowner Status[1]				
Rent	238 (54)	202 (46)	440 (100)	$\chi 2=7.6$ (p<0.01)
Own or pay mortgage	330 (63)	195 (37)	525 (100)	
Number of People Who Live in the Home	2.99 (0.07)	3.39 (0.09)	3.16 (0.06)	t=3.4 (p<0.01)

Although the hot water temperature was generally correlated with the gauge setting on the gas water heaters, there were instances of concerning inconsistencies. Among gas water heaters, three of the ten gauges that were set at less than 25% of their maximum setting had unsafe hot water temperatures (Figure 1). Furthermore, for 76 (11%), the water temperature was dangerously hot (at or above 130°F) although the gauge was set at less than 75% of its maximum setting.

In the multivariate logistic regression including the homeowner status, type of water heater, and number of gallons per person, all three variables retained their significance (Table 3). Homeowners were more likely to have safe hot water temperatures than rental properties (OR=1.47; p=0.02). The odds of having a safe hot water temperature were 4.99 times higher for homes with an electric

water heater compared to homes with a gas water heater (p<0.01) and 2.12 times higher for homes with over 30 gallons per person in the home compared to 10 or less gallons per person (p=0.01).

Table 2. Water heater safety

Hot Water Characteristics	Hot Water 120 or less N=524	Hot Water over 120 N=359	Total N=883	Test Statistic
	N (%)	N (%)	N (%)	
Type of Water Heater[2]				
Gas	402 (55)	333 (45)	735 (100)	χ^2=40.7 (p<0.01)
Electric	107 (85)	19 (15)	126 (100)	
Volume of Water Heater[2]				
Small (40 gallons or less)	361 (57)	277 (43)	638 (100)	χ^2=5.4 (p=0.02)
Large (More than 40 gallons)	108 (67)	54 (33)	162 (100)	
Age of Water Heater[2]				
0-2 years	53 (53)	47 (47)	100 (100)	X^2=2.5 (p=0.47)
3-5 years	56 (60)	37 (40)	93 (100)	
5-10 years	106 (55)	88 (45)	194 (100)	
More than 10 years	97 (61)	62 (39)	159 (100)	
Gallons per Person[2]				
10 gallons	144 (51)	139 (49)	283 (100)	χ^2=20.5 (p<0.01)
11 to 20 gallons	191 (58)	138 (42)	329 (100)	
21 to 30 gallons	69 (71)	28 (29)	97 (100)	
Over 30 gallons	64 (73)	24 (27)	88 (100)	
Gauge Setting[3] (Gas Heaters Only)				
0-25%	7 (70)	3 (30)	10 (100)	χ^2=63.9 (p<0.01)
26-50%	50 (71)	20 (29)	70 (100)	
51-75%	224 (66)	118 (34)	342 (100)	
76-100%	97 (36)	174 (64)	271 (100)	

(1) Of the 976 households with hot water temperature measurements, 170 did not provide information on the household poverty status, and 10 did not provide information on the homeowner status.
(2) Of the 884 households with hot water temperature measurements, N=22 the type of water heater could not be determined, N=337 the age of the water heater could not be determined, and N=83 the volume could not be determined, and N=86 gallons per person could not be determined.
(3) Of the 736 gas water heaters included in the gauge analysis, N=42 the gauge setting could not be determined.

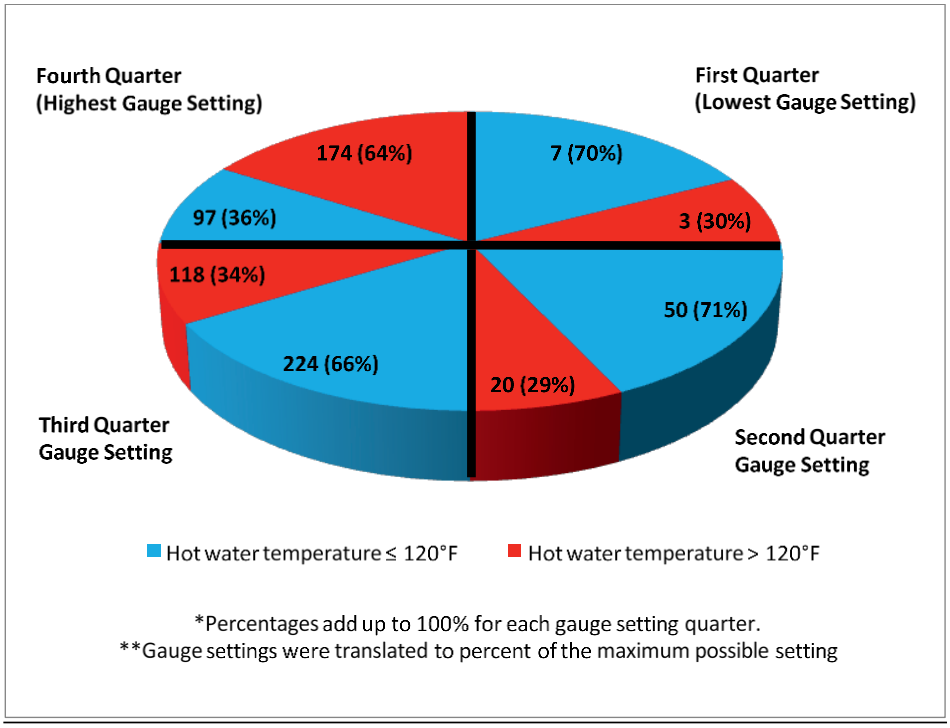

Figure 1. Water Heater Gauge Setting and Hot Water Temperature among gas water heaters, N=693

DISCUSSION

Our results demonstrate that hot water is at dangerously high temperatures in 4 out of 10 homes in a large urban sample, despite the fact that voluntary standards by water heater manufacturers to preset temperatures at the factory were adopted over twenty years ago. Almost all (99%) of the water heaters in our sample were purchased since the voluntary standard was implemented.

Table 3. Multiple logistic regression analysis of safe hot water temperature (N=787)

	Odds Ratio	Standard Error	P-value
Homeowner Status			
Rent	1		
Own	1.47	0.23	.02
Type			
Gas	1		
Electric	4.99	1.40	<0.01
Gallons per person			
10 gallons	1		
11 to 20 gallons	1.22	0.21	0.25
21 to 30 gallons	1.69	0.46	0.05
Over 30 gallons	2.12	0.60	0.01

Two protective factors emerged which warrant mention. The first is that electric water heaters were significantly more likely to be at a safe temperature compared to gas water heaters, even after adjusting for homeowner's status and gallons per person. Unlike gas water heaters, adjusting the temperature on an electric water heater requires a licensed professional. Though electric water heaters appear to be protective, recommendations of electric versus gas will need to include cost considerations, as electric heaters cost three times as much to operate as gas.(24) A further consideration is that gas is not available in all places. Moreover, families, especially those living in rental properties may not have a choice between a gas or an electric water heater.

The second protective factor that emerged was that larger water heaters were more likely to have safe temperatures. The amount of water per person was a significant factor associated with the water temperature, even after adjusting for whether the water heater was gas or electric. We hypothesize that residents may increase the temperature to provide sufficient hot water for household needs such as showers. Therefore, it may be prudent to advise consumers (including landlords) to consider manufacturer recommendation matching the number of people in the home to the volume of the water heater. Information is currently available on water heaters advising consumers of the product's energy efficiency rating; safety information could be added to those materials to help families understand the importance of choosing a water heater with the appropriate capacity to meet the needs to the family.

As water heater temperature continues to pose scald burn risks despite the voluntary standard, it is important to consider additional technological control measures. We were surprised by the variation in water heater thermostat dials, and that none were observed to have an indicator of a safe temperature or a safe temperature range. Furthermore, our data support the previously recognized discrepancies between water heater gauges and the temperature of the water produced. Although gauge setting in our sample is generally correlated with

temperature, it is not always the case. In 11% of gas water heaters we found that the water temperature was dangerously hot (at or above 130°F), although the gauge was set at less than 75% of its maximum setting. Although it may not be technologically feasible to have a gauge that represents the exact temperature at the tap, efforts to better design the water heater thermostat are needed to enable professionals and residents to easily set it to 49°C/120°F and help them understand the potential variation between the set temperature and the maximum temperature.

Given the limitations of reducing tap water temperature through current thermostat technology alone, other existing strategies should be prioritized. One potential solution is to equip faucets with anti- scald devices, such as a thermostatic mixer valve as recommended by the 2009 International Residential Code for One- and Two-family Dwellings.(25) Thermostatic mixer equipped valves limit water temperature to a maximum of 120°F.(25) Thermostatic mixer valves allow hot tap water to be set at a fixed temperature outside of the water heater and without affecting the temperature of stored hot water in the tank.(26) Other anti-scald devices such as anti-scald aerators and scald guards interrupt the flow of water at a set temperature, usually before the temperature reaches 49°C/120°F, allowing the water to reach a safe level before the faucet reactivates.(4) Edwards et al. quantified the effects of a thermostatic control system on the prevalence of dangerous water temperatures in a cluster randomized controlled trial in London.(27) Results showed that the prevalence of dangerous hot water temperatures was significantly reduced and gas consumption was not significantly affected.(27) The cost of installing thermostatic mixing valves has been estimated at $250 per room ($100 for the valve and $150 for installation).(28) A cost analysis of mass installation in government managed housing in England estimated installation costs at £13.68 (~$22), which included parts, maintenance, and educational material but not labor. (29) Kendrick et al. believe that mass installation could result in significant savings to the British national health care system. (26) Financial incentives to include such technology in renovation and remodeling plans should be assessed.

Whether and how the voluntary standard is being implemented is another consideration that may explain the high settings recorded on some of the water heaters in our sample. We are unaware of any effort to observe manufacturer participation in the voluntary agreement. Nor do we know who installed the water heaters in the homes we observed, and if the installer or the resident had adjusted the temperature above the manufacturers' preset level.

Until engineering solutions can be implemented on a large scale, attention must be paid to educational messages. Educational messages aimed at informing families of the dangers of high water temperatures are needed. In addition, routinely encouraging heads of household to set their water heaters to 49°C/120°F can provide a no cost strategy to address this risk. (30, 31)

Importantly, our study demonstrates the challenges of implementing such recommendations. A majority of water heaters we examined did not have easy-to-understand gauge settings to allow consumers to set their hot water heater to 49°C/120°F. It is vitally important that educational messages be revised to include instructions to test hot water temperatures after adjusting gauges to ensure that a safe temperature is achieved through the gauge adjustment. This message is consistent with current American Burn Association recommendations. (4) In addition to providing a gauge as to the temperature, the water heater could indicate that the recommended temperature is 49°C/120°F and provide educational information about how fast a scald burn can occur at higher temperatures.

A complementary approach to the above engineering and educational strategies is to consider policy options for improving the safety of water heaters, a consumer product. Past efforts to intervene at the state level prompted voluntary action by water heater manufacturers. Factory presets of safe hot water temperatures offered a first step toward increasing the safety of hot water heaters. We now know that additional efforts are needed. In our opinion, designing water heaters with gauges that are easy to read and labeling that explains the risk and how to test and adjust the temperature is a needed next step and represents a basic component of safety for this consumer product. As such, this is an area the U.S. Consumer Product Safety Commission is well-positioned to assess and determine whether their experience and authority could be useful in improving the current situation.

There are limitations to our study. Our findings are based on a single water temperature reading, and do not take into consideration possible fluctuations in the hot water temperature that may occur, for example, throughout the course of the day. Furthermore, water heater gauges in our sample varied considerably; we standardized the dial to a more intuitive percentage, but this does not reflect the true complexity of the gauge setting. Finally, our sample, although large and diverse, was self- selected and generalizations to other urban areas should take this into consideration. Despite these limitations, our results provide the first systematic assessment of water heater temperatures in a large sample of urban homes, and clearly demonstrate the need for more comprehensive scald prevention interventions and engineering solutions.

REFERENCES

1. Peck M, Brewer AC, Pressman M, Blank E, Mickalide A. Hot tap water legislation in the United States. J Burn Care Res 2010;31:918-25.
2. American Burn Association. Scalds: a burning issue. A campaign kit for burn awareness week 2000; available from http://www.ameriburn.org/Preven/Scald2000PreventionKit.pdf; Internet.
3. Moritz AR, Henriques FC. Studies of thermal injury, II: the relative importance of time and surface temperature in the causation of cutaneous burns. Am J Pathol 1947;23:695-720.
4. American Burn Association. Scald injury prevention educator's guide. A community fire and burn prevention program supported by the United States Fire Administration Federal Emergency Management Agency; available from http://www.ameriburn.org/Preven/ScaldInjury Educator%27sGuide.pdf; Internet.
5. Safe Kids USA. Burn and scald prevention fact sheet; available from http://www.safekids. org/our-work/research/fact-sheets/burn-and-scald-prevention-fact-sheet.html; Internet.
6. McLoughlin E, McGuire A. The causes, cost, and prevention of childhood burn injuries. Amer J Dis Child. 1990; 144: 677-83.
7. Feldman KW, Schaller RT, Feldman JA, McMillon M. Tap water scald burns in children. Pediatrics. 1978; 62(1): 1- 7.
8. Baptiste MS, Feck G. Preventing tap water burns. Am J Public Health. 1980; 70(7): 727-729.
9. Centers for Disease Control and Prevention. Nonfatal scald-related burns among adults aged ≥65 years --- United States, 2001—2006. MMWR 2009;58/36:993-6.
10. Rimmer RB, Wiegand S, Foster KN, Wadsworth MM, Jacober K, Matthews MR, Drachman D, Caruso DM. Scald burns in young children—a review of Arizona burn center pediatric patients and a proposal for prevention in the Hispanic community. J Burn Care Res 2008;595-605.
11. Alden NE, Bessey PQ, Rabbitts A, Hyden PJ, Yurt RW. Tap water scalds among seniors and the elderly: socio-economics and implications for prevention. Burns 2007;33:666-9.
12. Leahy NE, Hyden PJ, Bessey PQ, Rabbitts A, Freudenberg N, Yurt RW. The impact of a legislative intervention to reduce tap water scald burns in an urban community. J Burn Care Res 2007;28:805-10.
13. Harvey LA, Poulos RG, Finch CF, Olivier J, Harvey JG. Hospitalized hot tap water scald patients following the introduction of regulations in NSW, Australia: Who have we missed? Burns 2010;36:912-9.
14. Lyons RA, Jones SJ, Deacon T, Heaven M. Socioeconomic variation in injury in children and older people: a population-based study. Inj Prev 2003;9:33-7.
15. Gielen AC, McDonald EM, McKenzie LB. Chapter 31: Behavioral Approach. Injury Research: Theories, Methods, and Approaches. Ed. Guohua Li, Susan P. Baker. New York: Springer, 2012.
16. Yeoh CH, Nixon JW, Dickson W, Kemp A, Sibert JR. Patters of injuries. Arch Dis Child 1994;71:156-8.
17. Erdmann TC, Feldman KW, Rivara FP, Heimbach DM, Wall HA. Tap water burn prevention: the effect of legislation. Pediatrics 1991;88:572-7.
18. Katcher M. Efforts to Prevent Burns from Hot Tap Water. Political Approaches to Injury Control at the State Level. Ed. Abraham B. Bergman. Seattle: University of Washington Press, 1992.
19. Gielen AC, McDonald EM, Wilson ME, Hwang WT, Serwint JR, Andrews JS, Wang MC. Effects of improved access to safety counseling, products, and home visits on parents' safety practices: Results of a randomized trial. Arch Pediatr Adolesc Med 2002;156(1):33-40.
20. Shields WC, Perry EC, Szanton SL, McDonald EM, Andrews MR, Stepnitz RL, Gielen AC. Knowledge and injury prevention practices in homes of older adults. Geriatric Nursing 2012;Jul23
21. Ron George Design & Consulting Services. Plumbing to prevent domestic hot water scalds. HGExperts Legal Experts Directory, 2012; available from http://www.hgexperts.com/ article.asp?id=5135; Internet.

22. Gielen AC, Shields W, Frattaroli S, McDonald E, Jones V, Bishai D, O'Brocki R, Perry E, Bates-Hopkins B, Tracey P, Parsons, S. "Enhancing Fire Department Home Visiting Programs: Results of a Community Intervention Trial. "In Press, Journal of Burn Care and Research.
23. U.S. Department of Health & Human Services, the Assistant Secretary of Planning and Evaluation. The HHS poverty guidelines for the remainder of 2010 (August 2010); available from http://aspe.hhs.gov/poverty/10poverty.shtml; Internet.
24. California Energy Commission, Consumer Energy Center. Water Heaters, 2012; available from http://www.consumerenergycenter.org/home/appliances/waterheaters.html; Internet.
25. International Code Council, Inc. 2009 International Residential Code for One- and Two-family Dwellings. Country Club Hills, IL: Publications 2009.
26. Kendrick D, Smith S, Sutton AJ, Mulvaney C, Watson M, Coupland C, Mason-Jones A. The effect of education and home safety equipment on childhood thermal injury prevention: meta-analysis and meta-regression. Inj Prev 2009;15:197-204.
27. Edwards P, Durand MA, Hollister M, Green J, Lutchmun S, Kessel A, Roberts I. Scald risk in social housing can be reduced through thermostatic control system without increasing legionella risk: a cluster randomized trial. Arc Dis Child 2011;96:1097-1102.
28. Paul CL, Redman S, Evans D. The cost and availability of devices for preventing childhood injuries. J Paediatr Child Health 2008;28.1:22-6.
29. Phillips CJ, Humphreys I, Kendrick D, Stewart J, Hayes M, Nish L, Stone D, Coupland C, Towner E. Preventing bath water scalds: a cost-effectiveness analysis of introducing bath thermostatic mixer valves in social housing. Inj Prev 2011;17:238-243.
30. Safe Kids USA. Burn and scald prevention tips fact sheet ; available from http://www.safekids.org/safety-basics/safety-resources-by-risk-area/fire-burn-and-scalds/burn-and-scald-prevention-1.html; Internet
31. CDC USA. Protect the Ones You love: Child injuries are preventable. Burn Safety the Reality: available from http://www.cdc.gov/Safechild/Burns/; Internet

Chapter 7

Association Between Unintentional Child Injury in the Home and Parental Implementation of Modifications for Safety

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BACKGROUND

Medical attention for an injury can increase parents' perception of their child's susceptibility to injury.(1) Understanding subsequent parental actions to avert future injuries can inform prevention efforts. In this study, we describe the injured body part and parents' reports of: 1) the cause of the injury; 2) what could have prevented it; and 3) changes made afterwards.

METHODS

We reviewed charts of Pediatric Emergency Department (PED) patients who sought care for an unintentional home injury between January to December 2012, and contacted the parent for a home interview. The chart review provided details about the injury and the child's age and sex. The parental interview, which was audio-recorded and transcribed, provided parent responses to:

1. Please describe how your child got injured;
2. Do you think there is anything that could have prevented the injury (if so, what); and
3. Have you done anything to change the area of the home where the child was injured (if so, what)?

Home interviews were conducted on average 27 days (ranging from 5-57 days) following PED visit. A codebook of parental responses was generated and analyzed to yield the following groups of codes:

1. Body part injured: head/neck/face; leg; arm/hand; or other
2. Injury mechanism: fall; cut/pierce; burn; struck by/against; Carbon Monoxide (CO) poisoning
3. Item(s) involved: toys; furnishings; house features; food/beverage; other
4. Parent Perception of Preventability: child behavior; adult supervision; safer environment
5. Changes made: Increased supervision; Got rid of/replaced item; safer environment (restricted access to dangerous Item)

We tallied the code groups and arranged cross tabulations of injury mechanisms and body parts. At recruitment, we obtained written parental informed consent, per our Institutional Review Board approval.

RESULTS

One hundred four children (42 females and 61 males), ages 6 months – 7 years (mean 2.85; SD 1.8), who were predominately Black (82%) experienced 123 injuries. One injury mechanism was associated with 86% of the injuries; 13% included two mechanisms (Table 1). The most common mechanism was a fall (46%), and the most common body part injured was the head/neck/face area (62%); most children (95%) had one injured body part, whereas five children (5%) had two.

Table 1. Body Part and Mechanism of Injury for 123 Injuries in 104 Children Injured in their Homes

Mechanism	Body Part					
	Head/Neck/Face (n=76)	Leg (n=17)	Arm/Hand (n=23)	Other (n=7)	Total (n=123)	
Fall	44	3	8	2	57	(46%)
Cut/Pierce	13	6	7	0	26	(21%)
Burn	6	5	6	3	20	(16%)
Struck by/Against	13	3	2	0	18	(15%)
CO Poisoning	0	0	0	2	2	(2%)

*Missing 3 participants; these 3 participants contributed 5 injuries (3 falls plus 2 cut/pierce).

In all but two cases an item was identified as contributing to the injury: 35% involved a house feature; 33% house furnishings, 11% food/beverage, and 8% toys (Table 2). Parent, who were mostly female (92%) high school graduates (78%), identified at least one prevention strategy (82%). Of the 110 suggestions were, 40% for a safer environment (e.g., store hazardous product), 31% modified child's behavior (e.g., new rules), and 29% for increased supervision. Fifty-nine (57%) parents reported making changes, 51% modified the environment; 27% got rid of/replaced item; and 10% increased supervision.

Table 2. Items and Prevention Suggestions for 120 Injuries for 104 Children Injured in their Homes

Item and Injuries (n=120)	Items Identified[+] (n= 122)	Prevention Suggestions[+a] (n=110)	Changes Made[+b] (n=83)
TOYS			
Total Injuries: (10) 8%	Wheeled toys (4) Baseball bat (1) Toy gun (1) Unspecified toy (4) Total Items: 10	Adult Supervision (3) Modify Child Behavior (4) Safer Environment (3) Total Suggestions: 10	Increased supervision (0) Got rid of/replaced (3) Modified Environment (6) Total Changes: 9
FURNISHINGS			
Total Injuries: (40) 33%	Tables (8) Chairs/couch (14) Bed (12) Other (8) Total Items: 42	Adult Supervision (10) Modify Child Behavior (17) Safer Environment (11) Total Suggestions: 38	Increased supervision (4) Got rid of/replaced (9) Modified Environment (14) Total Changes: 27
HOUSE FEATURE			
Total Injuries: (42) 35%	Floor (16) Stairs (8) Door (4) Wall/Ceiling (4) Other (10) Total Items: 42	Adult Supervision (8) Modify Child Behavior (10) Safer Environment (14) Total Suggestions: 32	Increased supervision (2) Got rid of/replaced (7) Modified Environment (19) Total Changes: 28
FOOD/BEVERAGE			
Total Injuries: (13) 11%	Hot water/coffee (5) Hot soup (6) Can (2) Total Items: 13	Adult Supervision (7) Modify Child Behavior (2) Safer Environment (5) Total Suggestions: 14	Increased supervision (1) Got rid of/replaced (1) Modified Environment (7) Total Changes: 9
OTHER ITEMS			
Total Injuries: (15) 12%	Beauty Supply (3) Iron (2) Child Item (2) Other (8) Total Items: 15	Adult Supervision (4) Modify Child Behavior (1) Safer Environment (11) Total Suggestions: 16	Increased supervision (1) Got rid of/replaced (2) Modified Environment (7) Total Changes 10

+These are not mutually exclusive; the same individual could have mentioned more than one item or suggestion for prevention of a given injury; [a] 85 parents provided 110 suggestions for prevention; [b] 59 parents made 83 changes

DISCUSSION

This study explores how parents changed their homes after a medically attended injury to prevent reoccurrence. Most parents identified a prevention strategy, commonly an environmental modification (e.g., storing hazard), however only 57% made modifications. Parents' endorsement of environmental modification (e.g., passive strategies) is encouraging because this approach is a preferred injury prevention strategy.(2) Increasing supervision (e.g., active strategies), represented a smaller proportion (29%) of parents' suggestions. Evidence suggests that supervision can reduce injuries to young children; however, research is required to address the many challenges parents face in these efforts.(3,4)

Limitations of these findings include parental self-report about the injury could be impacted by time that elapsed from injury event to interview and social desirability bias. Safety changes reported by parents to prevent reoccurrence of medically attended home injuries can inform future prevention efforts that are more likely to be adopted in the future by other parents.

REFERENCES

1. Morrongiello BA, Howard AW, Rothman L, Sandomierski M, Once bitten, twice shy? Medically-attended injuries can sensitize parents to children's risk of injuries on playgrounds. Injury Prevention 2009;15:50–54.
2. Gielen AG, McDonald E, Shields W. Unintentional home injuries across the lifespan: Problems and Solutions. Annual Review of Public Health. 2015:36, 231-256.
3. Schnitzer P. G., Dowd M. D., Kruse R. L., Morrongiello B. A. (2015). Supervision and risk of unintentional injury in young children. Injury Prevention , 21, e63–e70. DOI:10.1136/injuryprev-2013-041128.
4. Morrongiello BA, Ondejko L, Littlejohn A. Understanding toddlers' in-home injuries: II. Examining parental strategies, and their efficacy, for managing child injury risk. J Pediatr Psychol 2004;29:433–46

Part 3

Evaluation of a community Intervention to reduce safety risks in the home

Chapter 8

Enhancing Fire Department Home Visiting Programs: Results of a Community Intervention Trial

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ABSTRACT

Background
This study evaluates the impact of an enhanced fire department home visiting program on community participation and installation of smoke alarms and describes the rate of fire and burn hazards observed in homes.

Methods
Communities were randomly assigned to receive either a standard or enhanced home visiting program. Prior to implementing the program, 603 household surveys were completed to determine comparability between the communities. During a one-year intervention period, 171 home visit events took place with 8,080 homes.

Results
At baseline, 60% of homes did not have working smoke alarms on every level; 44% had unsafe water temperatures; and 72% did not have CO alarms. Residents in the enhanced community relative to those in the standard community were significantly more likely to let the fire fighters into their homes (75% vs 62%). Among entered homes, those in the enhanced community were significantly more likely to agree to have smoke alarms installed (95% vs 92%), to be left with a working smoke alarm on every level of the home (84% vs 78%) and to have more smoke alarms installed per home visited (1.89 vs 1.74).

Conclusions
The high baseline rates of home hazards suggest that fire department home visiting programs should take an “all hazards” approach. CHWs and other community partnerships can be effective in promoting fire departments’ fire and life safety goals. Public health academic centers should partner with the fire service to help generate evidence on program effectiveness that can inform decision making about resource allocation for prevention.

INTRODUCTION

Fire departments in the United States respond to approximately 374,000 residential fires each year (1). There are more than 2,000 deaths due to residential fires every year, and in 2009, fire and other burns led to 381,012 medical visits. (2,3) The lifetime costs generated in a single year by hospitalizations due to fires and burns is an estimated $1.2 billion (4). Injuries due to fire disproportionately affect those with lower incomes and living in poor urban environment.(5,6)

Smoke alarms substantially reduce the risk of death in the event of a fire, and increasing their use is a national health objective in the United States (7). Almost two-thirds (63%) of all residential fire deaths occur in homes without working smoke alarms (8). Rates of working smoke alarms on every level of a home, the recommended standard, range between 22%-40% in high risk urban communities. (8,9,10)

The CDC-sponsored Smoke Alarm Installation and Fire Safety Education (SAIFE) program has been found to increase smoke alarm coverage in high-risk communities (11). The program recommends installing 10-year lithium battery smoke alarms on each level of a home, educating the resident about smoke alarm maintenance and fire safety, and community promotion. How to implement such a program to maximize community participation remains uncertain.

Community health workers (CHWs) are often turned to for community promotion. However, a recent systematic review found mixed evidence of their effectiveness, (12) and only two studies involving home injury prevention (13,14). Almost two decades ago, Schwartz et al (13) found that a CHW intervention addressing multiple home safety behaviors increased smoke alarm coverage by 14%. Gielen et al (14) found that a single CHW home visit after a pediatric health care visit had no effect on smoke alarm use. Thus, the contribution of CHWs to promoting smoke alarm canvassing programs is unclear.

To date, there have been no studies comparing different methods of accessing homes to provide smoke alarms at the community level. With strong evidence supporting their effectiveness and community wide installation programs, and the availability of 10-year lithium battery alarms, it is timely to explore how to maximize participation in these programs.

The Johns Hopkins Center for Injury Research and Policy (JHCIRP) addressed this question in partnership with the Baltimore City Fire Department (BCFD), the Maryland Department of Health and Mental Hygiene's (DHMH) SAIFE program, the Environmental Justice Partnership's (EJP) community outreach program, and the Urban Health Institute's (UHI) community health worker program. Together, we conducted the Johns Hopkins Home Safety Study to evaluate strategies to maximize participation in the BCFD's smoke alarm home visiting program.

The primary aim of this paper is to evaluate the impact of an enhanced BCFD home visiting program on community participation and installation of smoke alarms when compared to their standard program. We hypothesized that enhancing the BCFD's standard home visiting program with a community promotion component would increase the number of residents who participated in the program and thus an increase in the number of homes properly protected.

To determine comparability of the communities that were to receive the home visiting programs, we conducted baseline household surveys. Thus, a secondary aim of this paper is to describe the rates of fire and burn hazards in a large urban area. The study was approved by the Johns Hopkins Institutional Review Board.

METHODS

Standard Study Condition. The BCFD home visiting program has provided home safety education and installed smoke alarms free of charge to any Baltimore City resident for three decades. At the outset of our study and partly in response to focus groups conducted as part of our formative research (15), the Office of the Fire Marshal developed a new department-wide Manual of Procedures (MOP) for the program and conducted trainings with personnel responsible for making home visits. It required that all existing alarms be tested, and firefighters were to install a new 10-year lithium battery alarm on every level unless it was already protected with a working lithium battery or hard-wired alarm. One firefighter was designated to provide fire safety education in the home, but there was no community promotion.

Enhanced Study Condition. The enhanced intervention included the same services as the standard condition, with several additional components. The enhancements were developed in response to focus groups (15) and with input from the previously listed partners (JHCIRP, BCFD, EJP, UHI) and new partners we engaged during the planning process (community agencies, organizations, and residents). The enhancements were designed to address three issues: 1) residents did not know when the fire department was going to be in their neighborhood so they were often not home or not prepared to let them in; 2) some firefighters were uncomfortable with providing resident education; and 3) there were missed opportunities to address other important fire and life safety education issues once inside the home.

The enhancements included: 1) community promotion of the home visiting event in advance by EJP, project staff and CHWs; 2) tailored home safety education provided by a health educator who accompanied the firefighter into the home; and 3) when available, the CARES (Children ARE Safe) Mobile Safety Center, a 40-foot "house on wheels" with interactive educational exhibits parked in the neighborhood; families were encouraged by the CHWs to visit for additional

safety education and low cost safety products (16). The community promotion component included having neighborhood associations “spread the word” (e.g., through listservs or newsletters), posting lawn signs and posters, and having a team of two CHWs go door-to-door encouraging residents to be home for the event and delivering a scripted educational message or leaving a door hang tag if no one was home. On the day of the event, the CHWs again went door-to-door in advance of the firefighters letting residents know they were coming. During the home visit, a study health educator delivered tailored safety messages reinforcing the firefighter’s fire safety messages and addressing CO poisoning and scald burns.

Neighborhood Selection and Random Assignment. To create two comparable study communities, we used census tracts because of the size of the population and the availability of data on relevant indicators: 1) housing vacancy rate; 2) number of previously attempted BCFD home visits; 3) percent of successful BCFD home visits (defined as BCFD gained entry into the home); 4) residential fire rate; 5) percent of dwellings built after 1984; and 6) percent of dwellings that were owner-occupied properties.

Six census tracts were needed in each study community for an adequate number of households to test our hypotheses. To select the tracts, we first formed 10,000 random pairs of census tract sets (six in each set) out of all 49 census tracts in East Baltimore. Using data from the BCFD and the 2000 U.S. Census Bureau, (17) we computed a summary statistic for each set based on its un-weighted average of the 6 indicators listed above. The quality of matching in each pair of sets was assessed as the difference between the two sets of the raw sum of the indicators.

The 10,000 matched sets were sorted by the quality of the matching, and the top one percentile of matched scores was selected for further consideration. The study team physically drove through the top candidate locations to ensure that the areas had residential properties as expected and would be suitable for the intervention. Two appropriate sets of census tracts were identified, and at a partnership meeting a coin toss was used to assign one as the standard and one as the enhanced community.

The final selection of 12 census tracks included a total of 10,879 residences (5,467 in the standard and 5,412 in the enhanced). Public housing and city managed properties were excluded because the BCFD home visiting program does not serve these residences (n = 1,148). Of the 9731 addresses that were potentially eligible for a home visit in the two study areas, 1657 were eliminated because they were vacant or commercial properties or nonexistent addresses or were missed. During the intervention period, an additional 119 addresses were discovered and added; 113 addresses were eliminated because they were

missed. Thus, a total of 8,080 homes were eligible for the program and form the sample.

Census Data. We used census data (17) to assess the extent to which the study areas were comparable on: proportion with income below poverty line; proportion Black or African American; proportion >16 years in the labor force; proportion >25 years with a high school diploma; proportion receiving public assistance; proportion owner-occupied dwellings; proportion vacant housing; proportion built after 1980. We calculated the proportion for each individual census tract and then calculated the average for the six census tracts in each community.

Baseline Household Surveys. We conducted household surveys with random samples of residences in each study community to further assess comparability. Between July and December 2009, we completed interviews and home observations with 603 households (311 in the enhanced and 292 in the standard communities). In three waves, a random selection of approximately 1,200 addresses were contacted via mail and then visited by interviewers. A new random selection was done when all previously selected addresses had been resolved (i.e., enrolled, refused, deemed ineligible, or did not respond after 5 attempts). Interviews were conducted with an English-speaking adult. Participants were asked if they had been previously visited by the BCFD; smoke alarms, CO alarms, and hot water temperature were tested.

Intervention Trial Outcome Data. Home visits were conducted between April 2010 and April 2011. The BCFD attempted to reach every address in the study communities once. A data collector accompanied the firefighters on all home visits and recorded the outcome data: was the resident was home (yes/no); did the resident allow the fire department to enter the home (yes/no); and did the resident allow the firefighters to install smoke alarms (yes/no). Based on the number and location of all smoke alarms, we created a variable indicating whether the home had a working smoke alarm on every level at the conclusion of the home visit (9-volt or 10 year lithium battery or hard-wired working alarm), and we calculated an average number of alarms installed per home entered.

Data Analysis. Chi-square and t-tests were used.

RESULTS

Comparability of Standard and Enhanced Communities. As seen in Table 1, there were no differences between the study communities on any of the census variables. The study communities relative to the whole of Baltimore City, had a higher percentage of residents living below the poverty line, fewer adults with a high school diploma, fewer owner-occupied housing, and more vacant properties.

Table 1. Neighborhood Characteristics of Selected Census Tracts in East Baltimore and in Baltimore City, MD

	Standard Study Area	Enhanced Study Area	T-statistic (P-value)	Baltimore City
Income below poverty line	28.2%	27.8%	0.042 (0.97)	20.0%
Receiving public assistance	5.2%	6.2%	0.375 (0.72)	5.1%
Black or African American	57.0%	54.0%	0.137 (0.89)	63.3%
16 years and over in labor force	65.3%	60.6%	0.481 (0.64)	62.1%
≥25 years with high school diploma	61.3%	68.6%	0.836 (0.42)	76.9%
Owner-occupied dwellings	46.5%	44.4%	0.162 (0.87)	51.1%
Vacant housing	25.0%	23.4%	0.305 (0.77)	19.3%
Dwellings built after 1980	6.5%	17.8%	1.27 (0.23)	10.7%

Baseline Rates of Prior Program Exposure and Fire and Burn Hazards. As seen in Table 2, there were no differences between study areas in prior exposure to the BCFD home visiting program or in the presence of smoke alarms, CO alarms, and safe hot water temperatures. Although most homes had at least one working smoke alarm, only 38%-42% had one on every level of their home. Roughly one quarter of residents had safe hot water temperatures (<49°C/120°F). Slightly more than one-half of the homes had CO alarms.

Table 2. Baseline Household Survey of a Sample of 603 Homes in Study Areas East Baltimore, MD

	Standard Study Area (N=292) N (%)	Enhanced Study Area (N=311) N (%)	Chi-square (P-value)
Heard of the BCFD home visiting program	226 (77.4)	229 (73.6)	1.18 (0.6)
BCFD home visiting program ever came before	170 (74.9)	159 (67.8)	2.85 (0.2)
At least one working smoke alarm	252 (86.3)	267 (85.9)	0.02 (0.9)
One working smoke alarm on every level	110 (37.8)	131 (42.1)	1.16 (0.3)
Any alarms use 9-volt batteries	202 (89.0)	220 (91.3)	0.70 (0.4)
Any alarms use lithium batteries	10 (6.0)	10 (5.2)	0.12 (0.7)
Hot water temperature ≤ 49°C/120^0 F	169 (58.1)	170 (55.4)	0.44 (0.5)
Working CO alarm	88 (30.1)	78 (25.1)	1.93 (0.2)

Impact of the Enhanced Home Visiting Program. A total of 171 home visit events took place, the results of which are displayed in Table 3. No difference was found between the enhanced and standard communities in the proportion of residents who were home on the day of the event (40%). Residents in the enhanced community relative to those in the standard community were significantly more likely to let the fire fighters come into their homes (75% vs 62%) and agree to having smoke alarms installed (95% vs 92%). At entry, very few homes did not need smoke alarms (16.0% had working hardwired alarms or 10-year lithium battery alarms on every level), and there was no difference between the enhanced and standard communities (14.7% vs 17.6%, X2= 3.19, p=0.07). In the enhanced area, entered homes were significantly more likely than homes in the standard area to be left with a working smoke alarm on every level (84% vs 78%) and to have more smoke alarms installed per home (1.89 vs 1.74).

Table 3. Number of Homes Reached and Smoke Alarms Installed in Study Areas East Baltimore, MD

	Standard Study Area (82 Home Visit Events) N (%)	Enhanced Study Area (89 Home Visit Events) N (%)	Test Statistic (p-value)
Resident Home			
Yes	1588 (39.2)	1628 (40.4)	X^2 =1.11 (0.3)
No	2460 (60.8)	2404 (59.6)	
Total	4048 (100%)	4032 (100%)	
Resident Agreed to Entry			
Yes	983 (61.9)	1214 (74.6)	X^2 =59.60 (<0.0001)
No	605 (38.1)	414 (25.4)	
Total	1588 (100%)	1628 (100%)	
Resident Agreed to Have Alarms Installed			
Yes	883 (92.1)	1077 (94.6)	X^2 =5.22 (0.02)
No/Unknown	76 (7.9)	62 (5.4)	
Total	959 (100%)	1139 (100%)	
Working Alarms on All Levels at End of Visit			
Yes	767 (78.0)	960 (84.3)	X^2 =6.63 (0.01)
No/ Unknown	192 (20.0)	179 (15.7)	
Total	959 (100%)	1139 (100%)	
Total # Alarms Installed (Mean per home)	1663 (1.73)	2153 (1.89)	t=2.79 (0.005)

DISCUSSION

The overall aim of this community based intervention trial was to evaluate the impact of an enhanced fire department home visiting program on community participation and installation of smoke alarms. Our baseline survey demonstrated a high need for the program in that the majority of the residents surveyed had been visited previously by the fire department, and yet, 60% of homes did not have working smoke alarms on every level, 72% had unsafe water temperatures, and 44% did not have CO alarms.

The enhanced home visiting program increased access to homes by 21%, from 62% of residents in the standard to 75% in the enhanced area who let the fire department into their homes. Once inside the home, the majority of home visits were successfully completed, and those in the enhanced community relative to those in the standard were significantly more likely to result in having smoke alarms on all levels (84% vs 78%). All of the installed alarms were the 10-year lithium battery alarms with a hush feature. These new alarms offer longer term protection because the batteries do not have to be changed every six months, and the hush feature allows residents to turn off nuisance alarms without removing the batteries or otherwise disabling the smoke alarm (18).

A recent review of fire and life safety activities in US fire departments revealed that although the vast majority (86%) report conducting prevention education, fewer than 20% report conducting community canvassing programs such as the one evaluated here (19). Our work shows that such programs are feasible and result in increased protection. Prior smoke alarm distribution programs that have evaluated their impact on fire deaths have had mixed results, (20,21) but programs with 10-year batteries are only just now being evaluated, and we fully expect that increased coverage with these longer lasting batteries will result in fewer fire deaths.

To our knowledge, this is the first time CHWs have joined with a fire department to provide community education and promotion in advance of a canvassing program. Previously reported smoke alarm distribution programs have used various combinations of community volunteers, paid staff, and fire personnel with mixed results (13,14,21,22). Our study is most similar to the earlier work by Schwarz et al,(13) who hired community liaisons to engage community members at the block level in advance of having safety inspectors go door-to-door. Like Schwarz's work, we too found that advance notice provided by a recognized community representative resulted in increased access to homes. We were surprised, however, that the advance notice did not result in more residents being home on the day of the event; how to address the 60% of residents who were not home remains a challenge.

We were also surprised that more smoke alarms were installed per home in the enhanced community relative to the standard because the fire department protocol was the same in both. It is possible that residents were more receptive in the enhanced community, which encouraged the fire personnel in their efforts to install alarms on all levels. Perhaps the fire personnel were influenced by knowing they were in the enhanced community and by having a health educator with them. It was not possible to "blind" the fire personnel to study condition given the added intervention components in the enhanced area. Because canvassing was assigned based on the firehouse's designated inspection area that did not align with our study areas, some firefighters provided home visits in both areas in which case they may have been more diligent in the standard community, suggesting our results may underestimate the benefit of the enhanced program.

There are limitations to this study. Our findings, while significant, were likely muted by our decision to define the geographic areas using census tracts rather than natural borders that define neighborhoods. Using census tracts allowed us to access existing data to select a comparable set of households. However, we were limited in our ability to create a robust community level campaign because our enhanced community was made up of pieces of several neighborhoods. It was difficult for community partners to fully engage in promoting the program when their organizations encompassed areas that were part of the intervention and other areas that were not. Researchers designing community interventions will need to consider how best to define community in light of the implications for fully engaging community partners. Finally, something other than our intervention may have produced the observed effect. However, we know of no competing ongoing fire safety events in our study areas, and because both study areas were in Baltimore City, any major fire event or fire safety campaign would probably have affected both study areas equally.

Despite these limitations, our large sample size and demonstrated success in gaining access to homes and installing smoke alarms warrants consideration of the implications for fire department canvassing programs more broadly. First, fire departments serving communities such as ours need to take an "all hazards" approach to public education, given the high prevalence of unsafe water temperatures and lack of CO alarms we observed. Second, fire departments should consider ways to better utilize CHWs and other community partners to promote their fire and life safety goals. Although fire department budgets may preclude hiring CHWs, there are likely a number of opportunities for fire departments to partner with other local agencies and organizations that could provide the same function as the CHWs did in this study. Finally, the partnership between the fire service and a public health academic center was important for being able to systematically collect evidence on program effectiveness that can be used to inform decision making about resource allocation for fire and life safety education.

REFERENCES

1. Ahrens M. Home Structure Fires. National Fire Protection Association. 2011.
2. WISQARS Non-Fatal Injury Report, http://www.cdc.gov/ncipc/wisqars/default.htm, last accessed11/22/2011.
3. WISQARS Fatal Injury Report, http://www.cdc.gov/ncipc/wisqars/default.htm, last accessed 01/27/2012.
4. WISQARS Cost of Injury Report, http://wisqars.cdc.gov:8080/costT/cost_Part1_Finished.jsp, last accessed 2/3/2012.
5. Shai D. Income, housing, and fire injuries: a census tract analysis. Public Health Reports. 2006;121(2):149-154.
6. Schachterle SE, Bishai D, Shields W, et al. Proximity to vacant buildings is associated with increased fire risk in Baltimore, Maryland, homes. Injury Prevention 2011; doi:10.1136/injuryprev-2011-040022: 1-5.
7. Healthy People 2020 Summary of Objectives. Last accessed 08/04/2011 at http://www.healthypeople.gov/2020/topicsobjectives2020/pdfs/Injury.pdf.
8. Stepnitz R, Shields W, Gielen AC. Validity of smoke alarm self-report measures and reasons for over-reporting, Injury Prevention, in press.
9. Warda LJ, Ballesteros, MF. Interventions to prevent residential fire injury. In L. S. Doll, S. E. Bonzo, J. A. Mercy, & D. A. Sleet (Eds.), Handbook of injury and violence prevention (pp. 97–115). New York, NY: Springer. Health, 29, 171–181, 2007.
10. Chen LH, Gielen AC, McDonald EM. Validity of self-reported home safety practices. Injury Prevention. 2003;9:73-75.
11. Ballesteros M, Jackson M, Martin MW. Working towards the elimination of residential fire deaths: CDC's Smoke Alarm Installation and Fire Safety Education. Journal of Burn Care and Rehabilitation 2005;26(5):434-9.
12. Viswanathan M, Kraschnewski JL, Nishikawa B, et al. Outcomes and Costs of Community Health Worker Interventions A Systematic Review Med Care 2010;48: 792–808
13. Schwarz D, Grisso J, Miles C, et al. An injury prevention program in an urban African-American community. AJ PH 1993; 83: 675-680.
14. Gielen AC, McDonald EM, Wilson ME, et al. Effects of improved access to safety counseling, products, and home visits on parents' safety practices: results of a randomized trial. Arch Pediatr Adolesc Med. 2002;156:33– 40.
15. Frattaroli S, McDonald EM, Tran NT, et al. Igniting interest in prevention: Using focus groups with firefighters to inform implementation and enhancement of an urban canvassing project. In press at the Journal of Public Health Practice and Management.
16. Gielen AC, McDonald E, Frattaroli S, et al. CARES (Children ARE Safe) Mobile Safety Center Partnership. If you build it, will they come? Using a mobile safety center to disseminate safety information and products to low-income urban families. Injury Prevention 2009 Apr; 15(2): 95-99.
17. Census Bureau Home Page Available at: http://www.census.gov/. Accessed 11/21/2011, 2011.
18. Peek-Asa C, Yang J, Hamann C, et al. Smoke alarm and battery function 42 months after installation: A randomized trial, Am J Prev Med 2010;39(4):368-371.
19. Gielen AC, McDonald EM, Piver J. Fire and Life Safety Education in U.S. Fire Departments: Results of a National Survey, Final Report to the Home Safety Council. Baltimore (MD): Johns Hopkins Center for Injury Research and Policy, 2007. Available at: http://www.jhsph.edu/bin/o/c/hsc_firesurvey_p001.pdf. Accessed 2/4/12.
20. DiGuiseppi C, Roberts I, Wade A, et al. Incidence of fires and related injuries after giving out free smoke alarms: cluster randomized controlled trial, BMJ, 2002;325(2): 1-4.
21. Mallonee S, Istre GR, Rosenberg M, et al. Surveillance and prevention of residential fire injuries, N Engl J Med 335:27-31, 1996.
22. DiGuiseppi C, Slater S, Roberts I, et al. The Let's Get Alarmed! Initiative: A smoke alarm giveaway programme, Injury Prevention, 1999;5:177-182.

Chapter 9

Some Like it Hot: Results of a Community Intervention Trial Aimed at Improving Safety Behaviors to Prevent Hot Water Scald Burns

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ABSTRACT

Objective

Hot water scalds continue to pose a serious threat in the home, causing over 1500 hospital admissions and 100 deaths each year in the United States. We aimed to determine whether households who participated in an enhanced home safety visit demonstrated improved safety behaviors about hot water compared to homes receiving a standard home visit. This community intervention trial took place between April 2010 and April 2011.

Methods

Hot water temperature and self-reported prevention behaviors were recorded at a baseline visit and retested 6-9 months later in a follow-up visit. Residents whose hot water temperatures remained at an unsafe temperature were asked why they did not adjust the temperatures. Demographic data were also recorded.

Results

A total of 708 households participated. No significant difference emerged between the two study groups in the proportion of households observed to have adjusted their hot water temperature to safe levels between the baseline and follow-up visits ($t = 1.24$; $P = 0.22$). Residents who received the enhanced education were more likely to report testing their water temperature (27% vs 11%; $P < .01$) and turning their hot water temperature below 49°C/120°F (43% vs 32%; $P = .08$). Among those who had unsafe temperature levels and did not reduce the water temperature, the most common reason (26%) offered was that they "liked it hot."

Conclusions

These results demonstrate that water temperatures are unsafe in many urban homes. The effect of educational interventions may be mitigated by personal preferences of hot water temperature.

BACKGROUND

The Consumer Product Safety Commission (CPSC) recommends that water heater manufacturers preset the temperature of hot water heaters to 49°C/120°F. Though this manufacturing recommendation has been in place for decades, hot water scalds are responsible for about 1500 hospital admissions and approximately 100 deaths in the US per year (1,2). Older adults and children are at increased risk for hot water scalds because they have thinner skin that burns more quickly than thicker skin of young and middle-aged adults. Each year approximately 21,000 children are treated for scald burns of all causes, Scald burn injuries comprise about 65% of all burn hospitalizations for children aged 4 and below (3). Hot tap water is responsible for about a quarter of all scald burns in the United States and is associated with more deaths and hospitalizations in children than any other hot liquid (4-7). Older adults who suffer scalds from hot tap water face higher death rates, longer hospitalizations, and more severe health complications than younger adults who sustain similar injuries (8,9).

Costs for scald burn deaths and injuries among American children ages 14 and below total about $44 million each year, with the children aged 0-4 years accounting for over 90% of this cost (3). In New York City, societal costs attributed to tap water scald injuries for people of all ages from 1996 to 2003 were estimated to range from between $102 million and $149 million (10).

The severity of hot tap water scalds depends on the temperature of the water and the duration of time to which the skin is exposed (2). Exposure to water at 49°C/120°F can result in a serious burn in 10 minutes, whereas exposure to water at 140°F can result in a serious burn in as little as 3 seconds (11). In the home, tap water scalds predominately occur in kitchens and bathrooms (12). Scalds occurring in the bathroom present a great danger for young children, as more of the body is exposed to hot water during bathing (13). Young children experiencing scalds in the bathroom, in predictable ways including falling into the bathtub, coming into contact with hot running water, and being placed into excessively hot water accidentally or intentionally (13).

Previous work has demonstrated an association between water temperature and the number of individuals in the home, size of water heater, homeowner status, and type of water heater (14). Interventions to reduce hot water temperatures, mostly educational in nature, have been the focus of much previous research. A pooled analysis of 16 studies showed varying outcomes, but overall, families participating in the intervention arms were found to be more likely to have a discrete study-defined “safe hot water temperature”, than families in the control arms (OR = 1.41, 95% CI [1.07, 1.86]) (15). While existing studies have measured the effect of home safety interventions on a household’s hot water temperature, there are no reports in the literature about reasons why participants in these

educational interventions, who had excessive hot water temperatures, did not turn down their hot water temperature.

This study primarily aimed to determine whether households who participated in an enhanced home safety visit demonstrated improved safety behaviors about hot water compared to homes receiving a standard home visit. We hypothesized that participants in the enhanced area would be more likely to have safe water temperature, and higher self-reported testing behaviors. We also sought to examine household characteristics that predict safe hot water temperature, and based on the literature and our previous work, we hypothesized that rental properties, and homes with fewer residents would be more likely to have safe water temperatures. Finally, we additionally explore participants' self-report of testing behavior and reasons for not adjusting water temperature when they had been counseled to do so, which has not been previously reported in the literature.

METHODS

As part of a community trial evaluating a fire department home visiting program previously described (12), hot water temperatures were tested during a home visit intervention. This community intervention trial took place between April 2010 and April 2011. Two study areas received one of two home visiting interventions. Homes in the standard area received an unannounced home visit from the fire department and for any resident that agreed, the installation of a lithium battery smoke alarm on each level of their home. At this baseline intervention visit, study staff recorded the temperature of the hot water and provided feedback on the safety of the temperature. Homes in the enhanced area received the same services as homes in the standard area, but the visits were enhanced with advance notice of the home visit and opportunities for the resident to receive educational messages from a safety educator who accompanied the firefighter. Education was about current temperature and need for change was provided to all families. Intervention families also received tailored information based on their answers to knowledge questions and a thermometer to assist with water testing. The educational materials were developed with attention to the needs of a low literacy population. Safety educators and data collectors followed standard protocol collection and for delivery of information. A follow-up visit to assess outcomes was made 6-9 months later for families who gave permission for the data collectors to return. All survey items were cognitively interviewed to ensure understanding prior to being used in the field.

Data Collection

Data collection took place inside residents' homes at the time of the fire department home visit (baseline) and six months later (follow-up). After permission to enter the home was granted for the baseline home visit, the firefighters installed the smoke alarms while trained data collectors recorded their activities. When the firefighters finished installing the alarms, the data collectors asked the resident to complete a brief survey about their home visit experience and their home safety knowledge (the baseline survey). This community intervention trial took place between April 2010 and April 2011.

During the fire department home visit, study staff tested the resident's hot water temperature. Hot water was considered unsafe if the temperature was above 49°C/120°F. Study staff informed the resident the temperature of their hot water and advised them to lower the temperature if the hot water was above the recommended 49°C/120°F. Participants in the enhanced area received further education about the dangers of water that is too hot and the risks of scald burns. Participants in the enhanced area whose hot water was above 49°C/120°F were provided specific instructions on how to reduce the temperature setting on their water heater (turn down the gauge on a gas water heater or call an electrician for an electric water heater) and a thermometer to retest the water temperature after adjusting it.

Residents who completed the baseline survey were informed about the six-month follow-up and asked if they would be willing to participate. Six months after the home visit, each participating household was visited to complete the follow-up survey and to have all the installed alarms checked. Residents completed an interviewer-administered, computer-assisted survey. Following the survey, data collectors recorded the temperature of the hot water as described below. Respondents were ineligible if the home had become vacant, if the original respondent had moved, or if the respondent was impaired and unable to complete the follow-up visit. The remainder was lost to follow-up (ten unsuccessful attempts by data collectors to reach the participant and complete the survey).

The Johns Hopkins School of Public Health Institutional Review Board approved this study.

Measures

Demographics

Respondents self-reported household size, education level, income, owner status and household composition at follow-up. Using self-reported household income and the number of people supported on that income, the household was classified as living in poverty if the income was below the 2010 Federal Poverty Guidelines. (16)

Water Heater Characteristics
Water heater type (gas or electric), and size in gallons were observed during follow-up by data collectors while in the home. Using the self-reported household size and observed size of the water heater, we calculated gallons per person.

Observed Hot Water Temperature

Data collectors used a candy thermometer to test the temperature of the hot tap water during the fire department baseline intervention and follow-up visits. Candy thermometers provide a measure of temperatures between 75^{o}F and 400^{o}F. Water temperature was tested in the kitchen. Data collectors were instructed to completely open the hot water faucet for one minute, to fill a cup with that water, and then to measure the temperature with the candy thermometer. Hot water was considered “safe” if the temperature was 49°C/120°F or less.

Self-Reported Prevention Behaviors
Three questions were asked to all respondents during follow-up to determine protective behaviors taken to reduce the chance of scald burns from tap water including testing behavior, and if an adjustment was made by the respondent or landlord.

Reason for Not Adjusting Water Temperature
Participants who reported they had been advised to turn down the hot water temperature at the baseline intervention visit but had not were asked a select-all-that-apply multiple choice question at follow-up about their reason for not adjusting the water temperature.

Statistical Analysis

Descriptive statistics on demographics and household characteristics were generated for the standard and enhanced study areas and compared with a chi-square test. Hot water temperatures as measured during the baseline intervention and follow-up visits were cross-tabulated for the standard and enhanced areas. Differences between standard and enhanced areas in change in safe water temperatures were compared using a paired t-test.

A sub-analysis of participants whose water was too hot at the baseline intervention visit was conducted to examine hot water safety behaviors, including adjusting water heater temperature and retesting water temperature with a thermometer. This subsample was selected because it represents the group of participants that need to change their hot water temperature and are able to do so. Behaviors for the standard and enhanced areas were compared using a chi-square test.

Among those with a gas water heater who were told that their hot water temperature was too high, but did not adjust the water heater temperature,

reasons for not turning down the hot water temperature were tabulated. Only those with a gas water heater were included in this analysis because these residents were instructed how to turn down the temperature of their water heater.

A logistic regression was run to identify the correlates of having safe hot water at follow-up among those whose water was too hot at the baseline intervention visit, adjusted for study group, the gallons per person, reported adjusting the water heater temperature, type of water heater, and home ownership status. Type of water heater, gallons per person and homeownership have been associated with safe hot water temperature in the literature (14). Observations that were missing one or more variables were excluded from the regression.

All analyses were performed in SAS 9.3 (SAS Institute Inc., Cary, NC) P-values less than 0.05 were considered statistically significant.

RESULTS

A total of 2197 residents, 983 in the standard program and 1214 in the enhanced program areas, participated in the baseline fire department home visit. Of these, 680 (69.18%) in the standard program and 709 (58.40%) in the enhanced program completed the baseline survey ($p<0.01$), making them eligible for the six-month follow-up. Of those completing the baseline, 633 (93.08%) in the standard program and 629 (88.72%) in the enhanced group were interested in participating in the follow-up ($p<0.01$).

Between January 2011 and December 2011, 754 follow-up interviews were completed. There was no difference in the completion rates across groups for the follow-up survey: 373 (58.92%) in the standard area and 381 (60.57%) in the enhanced ($p=0.55$) completed the follow-up. Those who did not complete the follow-up either refused, were ineligible, or were lost to follow-up.

Respondents were typically female (72%), with at least a high school diploma or GED (80.85%) and were homeowners (58%). Participants in the standard area were more likely to have children in the home (53% vs. 37%, $p<0.01$) (Table 1).

Table 1. Demographics

		Standard N = 341 (%)	Enhanced N = 367 (%)	Total N = 708* (%)	χ^2
Gender	Male	82 (24.05)	110 (29.97)	192 (27.12)	3.14 (p=0.08)
	Female	259 (75.95)	257 (70.03)	516 (72.88)	
Age	18 to 24	13 (3.82)	14 (3.84)	27 (3.83)	12.89 (p=0.01)
	25 to 34	85 (25.00)	60 (16.44)	145 (20.57)	
	35 to 44	58 (17.06)	74 (20.27)	132 (18.72)	
	45 to 55	80 (23.53)	72 (19.73)	152 (21.56)	
	55 and above	104 (30.59)	145 (39.73)	249 (35.32)	
Household Role	Head of Household	289 (84.75)	302 (82.74)	591 (83.71)	0.52 (p=0.50)
	Other	52 (15.25)	63 (17.26)	115 (16.29)	
Education	< high school diploma	59 (17.35)	76 (20.82)	135 (19.15)	3.80 (p=0.28)
	HS diploma/GED	128 (37.65)	145 (39.73)	273 (38.72)	
	Some college	67 (19.71)	54 (14.79)	121 (17.16)	
	Completed college	86 (25.29)	90 (24.66)	176 (24.96)	
Household income below the poverty line?	Yes	75 (26.69)	83 (27.21)	158 (26.96)	0.02 (p=0.89)
	No	206 (73.31)	222 (72.79)	428 (73.04)	
Homeowner Status	Rent	144 (42.73)	148 (40.66)	292 (41.65)	0.31 (p=0.58)
	Own or pay mortgage	193 (57.27)	216 (59.34)	409 (58.35)	
Children in home (<18 y)	Yes	180 (52.79)	137 (37.33)	317 (44.77)	17.07 (p<0.01)
	No	161 (47.21)	230 (62.67)	391 (55.23)	
Number of people in the home	1 person	34 (10.00)	77 (21.10)	111 (15.74)	18.01 (p<0.01)
	2-3 people	169 (49.71)	174 (47.67)	343 (48.65)	
	4-6 people	119 (35.00)	98 (26.85)	217 (30.78)	
	7 or more people	18 (5.29)	16 (4.38)	34 (4.82)	
Type of Heater	Gas	269 (87.91)	281 (86.46)	550 (87.16)	0.29 (p=0.59)
	Electric	37 (12.09)	44 (13.54)	81 (12.84)	

*Some variables do not add up to 708 due to missing item responses.

Measurements for the hot water temperature for both the baseline intervention visit and the follow-up visit were available for 679 households. Table 2 shows the change between baseline and follow-up of participants who went from safe to unsafe, vice versa, or remained unchanged. The temperature of the water was hotter than recommended (greater than 49°C/120°F degrees) at baseline in 39% of homes (264/679) and in 41% of homes at the follow-up (277/679). At baseline, the 264 homes with unsafe water temperature had a mean temperature of 130.9°. Of these homes, 91 had safe hot water temperature at follow-up with a mean temperature of 113.9°. There was no difference between the standard and

enhanced groups in the percentage of homes changing from unsafe and safe hot water temperatures (t=1.25; p=0.22). In all, roughly two-thirds (65.53%) of those with unsafe hot water temperatures at baseline remained unsafe at follow up.

Table 2. Hot Water Temperature at Baseline and Follow-up (N=679)

Hot water safe*?		Standard Follow-up (n=332)			Enhanced Follow-up (n=347)			Total Follow-up (n=679)		
		Safe	Unsafe	Total	Safe	Unsafe	Total	Safe	Unsafe	Total
BASELINE	Safe	145 (71.43)	58 (28.57)	203 (100)	166 (78.30)	46 (21.70)	212 (100)	311 (74.94)	104 (25.06)	415 (100)
	Unsafe	43 (33.33)	86 (66.67)	129 (100)	48 (35.56)	87 (64.44)	135 (100)	91 (34.47)	173 (65.53)	264 (100)
TOTAL		188 (100)	144 (100)	332 (100)	214 (100)	133 (100)	347 (100)	402 (100)	277 (100)	679 (100)

*Paired t-test between Standard vs. Enhanced for changes from baseline to follow-up: t=1.24 (p=0.22)
*Safe Hot Water Temperature Defined as ≤ 49°C/120°F

Table 3 displays the frequency of self-reported hot water safety behaviors among N=224 participants with a gas water heater who had water that was too hot at the baseline intervention visit. Few participants reported turning down the temperature of the hot water (n=83; 31%) or testing the hot water temperature with a thermometer (n=42; 16%) at follow-up. However, participants in the enhanced group were significantly more likely to report testing the hot water temperature with a thermometer (27 % vs 11 %; p<0.01) and they were somewhat more likely to report turning the temperature down (43% vs 32%; p=.08) although the difference was not statistically significant.

Table 3. Self-reported hot water safety behaviors among residents with a gas water heater whose water was too hot at baseline (N=224)

		Standard N = 129 (%)	Enhanced N = 135 (%)	Total N = 264 (%)	Chi-Square
Have you taken any of the following actions to prevent hot tap water burns in your home in the last 6-9 months?*	Test the hot water with a thermometer	12 (10.53)	30 (27.27)	42 (15.91)	10.31 (p<0.01)
	Turn the hot water heater down below 120°	36 (31.58)	47 (42.73)	83 (31.44)	2.98 (p=0.08)
	Install an anti-scald device	0 (0.00)	1 (0.91)	1 (0.38)	1.04 (p=0.31)
Have you or anyone else (like a landlord) adjusted the temperature setting of your water heater in the last 6-9 months? #	Yes, made it hotter	9 (8.41)	6 (5.61)	15 (5.68)	4.11 (p=0.13)
	Yes, made it cooler	32 (29.91)	46 (42.99)	78 (29.54)	
	No / Don't Know	66 (61.68)	55 (51.40)	121(45.83)	

*Items are not mutually exclusive.

Does not add up to 224 due to missing item responses.

Table 4 describes the reasons why people did not lower their water temperature even after being told at baseline that it was too high. The most frequently cited reason was that they liked it hot (n=28; 26%). Others reported that they did not know how to lower it (n=18; 17%), that they needed help to adjust it (n=7; 7%), that they needed it hot to clean their dishes or laundry (n=6; 6%), and that other people in their home would complain if they turned it down (n=5; 5%).

Table 4. Reported reasons for not turning down water temperature (N=95)*

Reason	Count	Percentage
We like it hot	28	26%
I don't know how	18	17%
We actually did turn it down	13	12%
Not needed	10	9%
Don't know/no reason	9	8%
I need help (from family or landlord) to lower it	7	7%
It will be too cold to get the dishes or laundry clean	6	6%
My family will complain if it is too cold	5	5%
I have not made the time	5	5%
Turned it down did not like it and then turned it back up	4	4%
Bath would be too cold if it was lower	2	2%
No access to change it	0	0%

*Items are not mutually exclusive; respondents were able to select multiple answers.

In the multiple logistic regression model predicting safe hot water temperature at follow-up among those whose water was too hot at the baseline intervention visit (Table 5), study group assignment and self-report of adjusting the water temperature were not significant. Homeowners were had odds 2.41 times higher than renters to have a safe hot water temperature (p=0.02).

Table 5. Logistic Regression of Safe Hot Water Temperature at Follow-up among those with Unsafe Temperatures at Baseline (N=203*)

Odds Ratio of Safe Hot Water Temperature at Follow-up			p-value
Study Group	Standard	Reference	
	Enhanced	1.10	0.77
Gallons Per Person in the home	Per 1 gallon increase	1.01	0.49
Reported adjusting hot water temperature	No / Don't know	Reference	
	Yes, made it hotter	2.41	0.34
	Yes, made it cooler	1.98	0.53
Type of water heater	Gas	Reference	
	Electric	0.66	0.64
Homeowner Status	Rent	Reference	
	Own or pay mortgage	2.41	0.01

*n=61 participants (n=20/91 with safe hot water at follow up; n=41/173 with unsafe hot water at follow up) were missing data on one or more variables in the regression and were excluded

DISCUSSION

This manuscript reports on the results of a community intervention trial aimed at improving observed hot water temperature, and testing behaviors. Based on our results, the hot water intervention was not effective in our sample. Observed hot water temperature remained higher than recommended in 41% of homes at follow-up, with no differences found between groups. Our ability to measure differences between groups may have been muted by the fact that the data collectors informed residents in the standard group when their water temperature was higher than the recommended temperature. In addition, our measurement of observed water temperature may be too crude, as it does not take into account recent water usage from the water heater, which could affect the observed water temperature. This is supported by the fact that we saw shifts from safe hot water temperatures to unsafe temperatures from baseline to follow-up in both samples as well as shifts in the desired direction. Our one-time educational intervention which counseled at-risk individuals to lower their water heater temperature setting may not have been robust enough to affect change. Temperature gauges on water heaters are complicated; the settings on the gauge do not equate to actual temperature readings and require an iterative process of turning the dial back, waiting, and testing the water temperature to reach a desired temperature (14). Residents may be more likely to set their water heater temperature at a safe

setting if the actual water temperature at the tap was more easily determined by a clearly marked safe setting on the gauge.

The effect of the home safety intervention on whether at-risk families lowered their water heater temperature settings is also not ideal, as only 31% of respondents who were counseled to lower their water temperatures reported doing so across the two interventions, and the enhanced intervention that provided more detailed information about testing and turning down the temperature did only slightly better. Participants in the enhanced group were significantly more likely to report testing the water temperature with a thermometer although only 27% of them reported actually doing so. It possible that our one-time intervention was not enough to effect the change we recommended.

Our results are similar to those found by others who have tested educational interventions to promote safe residential hot water temperatures. Work by Babul et al demonstrated that families receiving a home safety intervention were two times more likely to adjust their hot water temperature to safe levels, than families who did not receive a home safety intervention (17). Engineering interventions that install anti-scald devices at the tap have shown more promise in protection from scalding water. Kendrick et al has demonstrated a decrease in scald burns after utilizing this passive intervention (18). While potentially more promising, the installation of anti-scald devices cost about $250 per room ($100 for the valve and $150 for installation) (19). Such an intervention was beyond the budget of our community intervention trial but should be considered, as anti-scald devices may be a cost-effective way to reduce burns from tap water. An educational intervention targeting landlords should also be considered. Rental properties in our sample were more likely to have unsafe water temperatures. An intervention targeting landlords with an injury prevention and liability minimization message may be effective.

An additional finding of note from our work comes from the reasoning of respondents who reported that they did not lower their hot water temperature. Participants whose water was too hot at baseline and did not adjust the temperature before follow-up were asked reasons for not having lowered their water heater setting. The most common reasons for not having lowered the temperature where that they liked it hot (26%) or that they did not know how to adjust their heater setting (17%). It may be necessary to improve risk awareness to affect change in this group. It may also be helpful to recommend that families purchase larger water heaters to accommodate household hot water demand. Our previous work demonstrated that the availability of more hot water for each person (gallons per person) was associated with lower hot water temperatures (14).

Our study results are limited by it having been conducted as part of a community intervention trial, as opposed to a randomized controlled trial. Our hot water

outcomes may be muted by our protocol to inform participants in both the standard and enhanced group when their water was too hot. Though the enhanced group intervention was more robust educationally, it may not have been different enough to effect change between groups.

The research reviewed above describes the risk of injury associated with tap water scald burns and the previous prevention efforts to educate residents/families about the need to test their water temperature and adjust their water heater setting. The aims of this paper are to report on the effect of reported and observed behaviors of an intervention aimed at encouraging residents to test and when need to lower their water temperature in a large sample of urban homes; and to report residents' reasons for not lowering their water temperature.

The human and financial costs of residential scald burns are significant and noteworthy. Most of these burns can be prevented. Our educational intervention experienced some success, but additional attention is needed to determine the best combination of interventions to reduce unintentional scald burns in the US.

REFERENCES

Peck M, Brewer AC, Pressman M, et al. Hot tap water legislation in the United States. J Burn Care Res. 2010; 31: 918- 25. PMid:20864897 http://dx.doi.org/10.1097/BCR.0b013 e3181f93723

American Burn Association. Scalds: a burning issue. A campaign kit for burn awareness week. 2000. Available from: http://www.amer iburn.org/Preven/Scald2000PreventionKit.pdf

American Burn Association. Scald injury prevention educator's guide. A community fire and burn prevention program supported by the United States Fire Administration Federal Emergency Management Agency. Available from: http://www.ameriburn.org/Preven/ScaldInjuryEducator%27sGuide.pdf

Safe Kids USA. Burn and scald prevention fact sheet. Available from: http://www.safekids.org/our-work/research/fac t- sheets/burn- and- scald- prevention- fact- sheet.html

McLoughlin E, McGuire A. The causes, cost, and prevention of childhood burn injuries. *Amer J Dis Child*. 1990; 144: 677-83. http: //dx.doi.org/10.1001/archpedi.1990.02150300075020

Feldman KW, Schaller RT, Feldman JA, et al. Tap water scald burns in children. Pediatrics. 1978; 62(1): 1-7. PMid:683765

Baptiste MS, Feck G. Preventing tap water burns. *Am J Public Health.* 1980; 70(7): 727-729. http://dx.doi.org/10.2105/AJPH.70 .7.727

Rimmer RB, Weigand S, Foster KN, et al. Scald burns in young children-a review of Arizona burn center pediatric patients and a proposal for prevention in the Hispanic community. *J Burn Care Res*. 2008; 595-605. PMid:18535476 http://dx.doi.org/10.1097/BCR.0b013e31817db8a4

Alden NE, Bessey PQ, Rabbitts A, et al. Tap water scalds among seniors and the elderly: socio-economics and implications for prevention. Burns. 2007; 33: 666-9. PMid:17478044 http://dx.doi .org/10.1016/j.burns.2006.10.003

Leahy NE, Hyden PJ, Bessey PQ, et al. The impact of a legislative intervention to reduce tap water scald burns in an urban community. *J Burn Care Res.* 2007; 28: 805-10. PMid:17925648

Moritz AR, Henriques FC. Studies of thermal injury, II: the relative importance of time and surface temperature in the causation of cutaneous burns. *Am J Pathol*. 1947; 23: 695-720. PMid:19970955

Gielen AC, Shields W, Frattaroli S, et al. Enhancing fire department home visiting programs: results of a community intervention trial. *J Burn Care Res.* 2013; 34(4): e250-6. PMid:23237821 http://dx.doi.org/10.1097/BCR.0b013e3182685b3a

Yeoh CH, Nixon JW, Dickson W, et al. Patterns of injuries. *Arch Dis Child*. 1994; 71: 156-8. PMid:7944540 http://dx.doi.org/10. 1136/adc.71.2.156

Shields WC, McDonald E, Frattaroli S, *et al*. Still too hot: examination of water temperature and water heater characteristics 24 years after manufacturers adopt voluntary temperature setting. *J Burn Care Res*. 2013; 34: 281-7. PMid:23514986 http://dx.doi.org/10. 1097/BCR.0b013e31827e645f

Kendrick D, Young B, Mason-Jones AJ, et al. Home safety education and provision of safety equipment for injury prevention. *Cochrane Database of Systematic Reviews*. 2012; 9. http://dx.doi.org/1 0.1002/14651858.CD005014.pub3

Health and Human Services Department. Delayed update of the HHS poverty guidelines for the remainder of 2010. Available from: https://federalregister.gov/a/2010- 19129

Babul S, Olsen L, Janssen P, *et al*. A randomized trial to assess the effectiveness of an infant home safety programme. *Int J Contr Saf Promot.* 2007; 14(2): 109-17. PMid:17510847 http://dx.doi.org/10.1080/17457300701272474

Kendrick D, Stewart J, Coupland C, *et al*. Randomized controlled trial of thermostatic mixer valves in reducing bath hot tap water temperature in families with young children in social housing: A protocol. Trials. 2008; 9: 14. PMid:18348736 http://dx.doi.o rg/10.1186/1745- 6215- 9- 14

Paul CL, Redman S, Evans D. The cost and availability of devices for preventing childhood injuries. *J Paediatr Child Health*. 2008; 28(1): 22-6. http://dx.doi.org/10.1111/j.1440- 1754.1992.tb02612.x

Part 4

Strategies to improve the implementation of home safety measures

Chapter 10

Unintentional Home Injuries Across the Life Span: Problems and Solutions

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ABSTRACT

Home injuries cause more than 30,000 deaths and 12 million nonfatal injuries annually in the United States. They generate an estimated $222 billion in lifetime costs annually. Despite some data limitations in documenting home as the location of an injury, much progress has been made in identifying effective prevention strategies that reduce injury or mitigate risk behaviors.

The current interest in public health in the role of housing in health offers unparalleled opportunities for injury prevention professionals concerned with home injuries. Sharing the science of injury prevention with the wide array of professionals—such as architects, home builders, home visitors, and fire and emergency medical services providers—who create home environments and interact with residents could be a useful approach. A collaborative national effort to reduce the burden of home injuries is needed.

INTRODUCTION

Two separate but related strands of research have led to a new appreciation of the importance of the magnitude of home injuries in the U.S., and the need to prevent them. First is the emphasis in public health on social determinants of health, which has been incorporated in the national Department of Health and Human Services (DHHS) 2020 health objectives for the nation, and specifically includes safe and healthy housing as an indicator (108). According to the World Health Organization, social determinants of health are "the circumstances in which people are born, grow up, live, work and age…… These circumstances are in turn shaped by a wider set of forces: economics, social policies, and politics (130)." Related to housing and health, social determinants can include characteristics of the physical environment where there are clear injury risks, such as lack of working smoke alarms, tap water that is too hot, deteriorating stairs, and poor-quality electrical wiring.

Contemporary public health's second related area of research important to home injury prevention is the environmental health field's inclusion of injury in the conceptualization of healthy housing (14,84,103). With extensive input from a national committee and technical review group, the National Center for Healthy Housing (NCHH) and the American Public Health Association (APHA) issued the 2014 National Healthy Housing Standard (92). These standards incorporate many elements of the physical environment that convey injury risk, such as electrical hazards that can cause fires and sources of carbon monoxide poisoning.

Home injuries result from interactions between individuals and their physical and social environments, which is why there are natural synergies among social determinants of health, environmental health, and injury prevention. With more than 30,000 home injury deaths annually in the U.S. (75), the growing support for and interest in comprehensive and collaborative efforts to prevent home injuries is warranted. Moreover, for every home injury death many more non-fatal home injuries occur; from 1997-2001 there were, on average, 12.4 million non-fatal home injuries annually (100). These injuries were estimated to cost $222 billion annually in medical care alone (100). Fortunately, many of these injuries are preventable through the use of injury prevention countermeasures and principles of practice, as we will show.

AIMS

The aims of this paper are to 1) describe the epidemiology of home injuries; and 2) summarize the evidence on prevention strategies that address the groups most at risk for four of the leading causes of home injury -- infant sleep-related deaths, house fires and burns, poisonings, and falls. A robust body of literature provides evidence for the preventability of many of these injuries, and we draw on existing reviews of it, including the Cochrane Collaboration Reviews (e.g., 45, 58, 71, 126, 127), national level policy recommendations (e.g., 23, 34, 90, 95). We categorize the prevention strategies as follows:

Strong evidence: prevention strategy has been extensively documented with empirical research and/or Cochrane Reviews.

Promising evidence: prevention strategy has some positive evaluation data to support it.

Recommended practice: prevention strategy has no or very limited research evidence, but it is by relevant professional organizations and/or national policy documents.

Epidemiology of Home Injuries

In 2002 the Home Safety Council commissioned the first comprehensive study of home injuries in the United States; this study was updated in 2004 (55, 100). These landmark reports compiled national data from multiple sources to document the prevalence of and risk factors for fatal and nonfatal home injuries, as well as the use of safety products and behaviors to reduce those risks. The national experts contributing to these reports concluded with a strong set of recommendations (see sidebar, Home Safety) to address what they showed to be a large and substantially preventable problem, despite having limited surveillance data that detail the location of injury incident. Even today, there are issues related to obtaining data on the location of the injury incident. The Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project provides extensive data on hospitalizations and emergency department visits, but because the coding is done for billing purposes, codes with no financial incentive, such as the location of injury incident, are usually underreported (62). Even for injury deaths, Mack et al. (77) found that the location of injury incident was missing for 31% of the death certificates they reviewed from 2000 to 2008. The National Health Interview Surveys (26), however, include detailed questions about injuries that required medical attention as well as the cause and the location of the injury incident, specifying inside the home or outside the home (e.g., porches). In the next sections, we present currently available data on fatal and nonfatal home injuries.

Home Safety

Following are recommendations from the 2004 report, *The State of Home Safety in America: Facts About Unintentional Injuries in the Home* (excerpted from 100, pp. 13–15).

1. Multiple organizations should commit to a collaborative national effort to address the home safety problem.
2. Congress should allocate increased resources to support injury prevention efforts.
3. Federal agencies responsible for injury data should examine how to improve the quality and completeness of data about injury in the home environment.
4. Injury researchers and practitioners should work together to develop research priorities to better understand the nature and magnitude of injury in the home environment; Congress should fund initiatives to address these priorities.
5. Designers, architects, and engineers as well as policy makers need to be supported in applying existing knowledge to the development of new interventions, with particular attention to improvements in the design, manufacture, and marketing of safe consumer products; development and enforcement of improved regulatory standards for home safety design, construction, and maintenance, including monitoring of adherence to standards at the time homes are sold or rented; universally applied safety standards, as well as allowance for enhanced measures appropriate to address specific geographic and population needs; laws and social norms that relate to intervention acceptance and success; and strategies to modify human behaviors to be more conducive to home safety.
6. Funding agencies and organizations should require well-designed evaluations as an essential component of funding intervention efforts.
7. Funding agencies and organizations should support development of more effective ways to disseminate information about home safety to the general population as well as to decision makers.

Fatalities

From 2000 to 2008, an average of 30,569 home injury deaths occurred annually (Table 1). Adults made up the largest proportion of these deaths; 21.9% occurred among those 80 years of age and older, who also had the highest death rates by an enormous margin (65.3/100,000) (many of these deaths are due to falls, as discussed below). Infants experienced home injury deaths at the next highest rate of 17.7 per 100,000; the most common cause of injury death in this age group is due to unsafe sleep environments (discussed below). The male–female ratio of home injury deaths was consistently higher in males than in females, with the largest discrepancy among those 15–29 years of age.

Table 1. Average Annual Unintentional Home Injury Deaths by Age Group and Ratio of Males to Females: United States, 2000-2008

Age group (years)	Total			Rate ratio Male: Female
	#	Percent	Rate (95% CI)	
<1	725	2.4	17.7 (17.2, 18.1)	1.3
1-4	688	2.3	4.3 (4.2, 4.4)	1.6
5-9	254	0.8	1.3 (1.2, 1.3)	1.4
10-14	203	0.7	1.0 (0.9, 1.0)	1.8
15-19	588	1.9	2.8 (2.7, 2.9)	3.2
20-29	2,729	8.9	6.8 (6.7, 6.8)	3.0
30-39	3,593	11.8	8.7 (8.6, 8.8)	2.1
40-49	5,778	18.9	13.0 (12.9, 13.1)	1.8
50-59	3,987	13.0	11.1 (11.0, 11.2)	1.8
60-69	2,161	7.1	9.5 (9.4, 9.6)	1.8
70-79	3,150	10.3	19.5 (19.3, 19.7)	1.6
≥80	6,708	21.9	65.3 (64.8, 65.8)	1.5
All[a]	30,569	100.0	10.4 (10.4, 10.5)	1.5

Note: Rate is crude rate per 100,000 people

[a] Age groups do not sum to total as age was missing for a small number of deaths (n=56). Data excerpted from: Mack, et al, 2013 and includes injuries occurring inside and outside the home

Nonfatal Injuries

In 2012, there were 19.4 million episodes of medically attended home injuries (Table 2), most of which happened inside the home (11.8 million). In contrast with the death data, more females than males experienced injuries inside the home. Similar to the death data, injury rates were highest among those 75 years of age and older. Rates differed by ethnicity, although for several groups the numbers were too small to have reliable estimates. Poverty status seems to be associated with higher rates, particularly for in-home injuries where the rate is 8.24 for those classified as poor, 6.95 for near-poor, and 2.90 for the nonpoor. Geographic variation was not striking, except that those in large metropolitan statistical areas and those in the south had the lowest rates of home injuries.

Table 2. Frequency and Age-Adjusted Rates of Medically Consulted Injury Episodes Occurring in the Home: United States, 2012 (2)

Selected characteristic	Total	Inside Home		Outside Home	
	# (thousands)	#	Rate (SE)	#	Rate (SE)
Total	19,420	11,816	37.35 (2.38)	7,604	24.17 (1.97)
Sex					
Male	8,509	4,455	29.93 (3.13)	4,054	27.39 (3.10)
Female	10,911	7,362	44.23 (3.43)	3,549	21.48 (2.41)
Age					
Under 12 years	2,825	1,721	35.25 (5.19)	1,104	22.62 (4.23)
12-17 years	1,203	602	24.25 (6.14)	601	24.20 (6.74)
18-44 years	5,089	3,060	27.56 (3.44)	2,029	18.28 (2.93)
45-64 years	6,150	3,732	45.50 (5.03)	2,418	29.49 (4.06)
65-74 years	2,060	1,370	57.63 (10.78)	690	29.05 (8.29)
75 years and over	2,093	1,332	73.70 (13.19)	761	42.07 (10.75)
Race					
One race	19,052	11,551	37.31 (2.41)	7,501	24.36 (2.01)
White	16,569	9,820	39.32 (2.81)	6,749	26.83 (2.41)
Black or African American	1,540	1,020	26.99 (4.65)	520	12.95 (3.15)
American Indian or Alaska Native	*528	*327	*164.74 (65.44)	*201	*65.79 (29.17)
Asian	*384	*384	*27.06 (8.95)	*	*
Native Hawaiian or Other Pacific Islander	-	-	-	-	-
Two or more races	*368	*266	*40.71 (16.04)	*102	*
Hispanic or Latino origin and race					
Hispanic or Latino	2,291	1,387	27.80 (4.68)	904	18.90 (3.62)
Not Hispanic or Latino	17,130	10,430	39.08 (2.69)	6,700	25.56 (2.31)
Education					
Less than a high school diploma	2,054	1,459	52.36 (9.19)	595	21.35 (5.60)
High school diploma or GED	3,684	2,623	43.30 (5.70)	1,061	18.84 (3.90)
Some college	5,000	2,662	47.39 (6.63)	2,338	41.13 (6.48)
Bachelor's degree or higher	3,299	1,869	32.18 (5.24)	1,430	23.85 (4.77)
Family income					
Less than $35,000	7,999	5,439	58.14 (5.45)	2,560	26.93 (3.26)
$35,000 or more	10,088	5,703	30.68 (2.85)	4,385	23.16 (2.69)
$35,000-$49,999	2,489	1,114	27.49 (5.38)	1,375	36.56 (8.32)
$50,000-$74,999	2,235	1,436	28.70 (4.99)	799	15.68 (3.53)
$75,000-$99,999	2,087	1,103	36.64 (8.33)	984	26.34 (6.07)
$100,000 or more	3,278	2,051	31.13 (5.20)	1,227	19.35 (4.17)

Selected characteristic	Total	Inside Home		Outside Home	
	# (thousands)	#	Rate (SE)	#	Rate (SE)
Poverty status					
Poor	3,981	2,800	69.62 (8.24)	1,181	28.59 (4.80)
Near poor	3,591	2,159	43.85 (6.95)	1,432	28.49 (5.09)
Not poor	9,856	5,727	30.81 (2.90)	4,129	22.67 (2.72)
Place of residence					
Large MSA	9,090	5,779	34.51 (3.13)	3,311	19.81 (2.57)
Small MSA	6,617	3,815	39.43 (4.70)	2,802	28.78 (3.97)
Not in MSA	3,713	2,222	43.11 (5.91)	1,491	29.70 (4.74)
Region					
Northeast	3,136	2,132	37.47 (6.25)	1,004	18.89 (4.90)
Midwest	4,665	2,652	39.06 (5.17)	2,013	28.31 (4.68)
South	6,975	3,899	32.99 (3.54)	3,076	26.15 (3.37)
West	4,643	3,133	43.17 (5.15)	1,510	21.14 (2.98)

Note: #s are in thousands, rates are per 100,000 population
*Estimates are considered unreliable. Data preceded by an asterisk have a relative standard error (RSE) greater than 30% and less than or equal to 50% and should be used with caution. Data not shown have an RSE greater than 50%.
- Quantity zero.
Data excerpted from Vital and Health Statistics, Series 10(259), December 2013 and come from CDC/NCHS, National Health Interview Survey, 2012.

Causes of Home Injuries

Poisonings, at 43.1%, make up the largest proportion of fatal home injuries (Table 3); falls are second, at 33.9%. At 41.2%, falls also cause the largest proportion of nonfatal home injuries. Fires and burns, at 9.3%, are the third highest cause of fatal injuries, whereas nonfatal home injuries are more likely due to being struck by/against, cut/pierce, or overexertion.

Table 3. Percentage Distribution of Causes for Fatal and Non-fatal Home Injuries

Cause of Injury	Non-fatal, 1997-2001[1] N=12,395,864 (%)	Fatal, 2000-2008[2] N=30,569 (%)
Fall	41.2	33.9
Struck By/Against	11.8	1.0
Cut/Pierce	11.3	0.2
Overexertion	10.2	0.0
Poisoning	5.9	43.1
Natural/Environmental	4.7	1.6
Miscellaneous/Not elsewhere	4.5	0.9
Unspecified	3.8	0.8
Fire/Burn	2.1	9.3
Pedal Cyclist, Other	1.4	n/a
Transport, Other	1.1	n/a
Machinery	1.0	0.4
Motor Vehicle	0.7	n/a
Pedestrian, Other	0.2	n/a
Choking/Suffocation	0.1	5.0
Firearm	0.1	1.1
Near-Drowning/Submersion	<0.1	2.7
Total	100.0	100.0

[1] State of Home Safety, 2004 [2]Mack et al, 2013

Prevention of Home Injuries

In the next sections, we briefly describe the epidemiology of specific injury causes: sleep-related deaths in infants, fires and burns, falls in children, falls in older adults, and poisoning. We also summarize the evidence supporting selected prevention strategies for each of these causes. Table 4 lists the prevention strategy, whether the outcomes evaluated are injuries or safety behaviors, and the strength of the evidence according to the definitions presented previously (strong evidence, promising evidence, recommended practice).

Table 4. Prevention strategies for home injuries by type of injury, outcomes studied, and level of evidence

Prevention strategies	Outcomes studied[a] (%)	Level of Evidence
Safe sleep		
National Back to Sleep Campaign	Injury	Promising
Crib distribution program	Behavior	Recommended practice
Parent/caregiver education	Behavior	Promising
Poisoning	Behavior	Promising
Fires and burns		
Working smoke alarms	Injury	Strong
Smoke alarm installation and education programs	Behavior	Strong
Residential sprinkler technology	Injury	Strong
Sprinkler mandates for new home construction	Behavior	Promising
Reduced ignition propensity cigarettes	Injury	Promising
Fire escape planning interventions	Behavior	Strong
Interventions for safe storage of matches	Behavior	Recommended practice
Child-resistant cigarette lighters	Injury	Promising
Interventions for safe hot water temperature	Behavior	Strong
Interventions for keeping hot drinks and foods out of reach	Behavior	Recommended practice
Falls (children)		
Mandated redesign of baby walkers	Injury	Promising
Reduction of baby walker possession and use	Behavior	Strong
Stair gate education and distribution	Behavior	Strong
Window guard mandates	Injury	Strong
Falls (older adults)		
Medication review	Falls	Strong
Strength and balance exercise programs	Falls	Strong
Home modification	Falls	Strong
Yearly vision screening	Falls	Promising
Multicomponent interventions	Falls	Strong
Poisoning (children)		
Safe storage of medication away from children	Behavior	Strong
Child-resistant and sublethal dose packaging	Injury	Strong
Poison control centers	Injury	Strong
Poisoning (adults)		
Safe storage, use, and disposal of opioid pain relievers	Behavior	Recommended
Control of supply and dispensing of opioid pain relievers	Injury	Promising
Carbon monoxide alarms	Behavior	Recommended

[a] Outcomes studied were classified as the reduction of injury or falls, or improved injury risk behavior.

Sleep Related Deaths in Infants

Who is at risk, and how do these injuries occur?
Sleep-related deaths, for the purpose of this section, include sudden unexpected infant death (SUID), accidental suffocation and strangulation in bed (ASSB), sudden infant death syndrome (SIDS), and other unknown causes. Protocols for distinguishing among these deaths are improving; the resulting diagnostic shift may explain the recent decrease in SIDS and the increase in ASSB (86). Unfortunately, strict adherence to classification definitions is not yet universal. Therefore, this section has been framed as sleep-related deaths and not just suffocation.

Sleep-related deaths are higher in nonwhites compared with whites. According to the most recent data, 3,610 SUID occurred in 2010, 15% of all deaths in children younger than one year of age (44). Compared with non-Hispanic whites (0.94 per 100,000 live births), American Indian/Alaska Natives (2.14 per 100,000 live births) and non-Hispanic blacks (1.92 per 100,000 live births) have higher mortality rates (44). The high-risk age group is infants three months and younger (15, 107, 111). Modifiable risk factors include parental smoking (76), maternal alcohol and drug consumption (18), low birth weight or premature birth (79), sleeping in an adult bed (15, 75, 105, 107, 109), soft or excess bedding (87, 98, 105), bed sharing (especially on a couch) (121), and non-supine sleep position (51, 74).

In the search to understand the cause of SIDS and other sleep-related deaths, Filiano & Kinney (50) offer the “triple risk model,” which posits that death results when risk factors converge from three areas: a vulnerable infant (e.g., premature or low birth weight), outside stressors (e.g., prone sleep position), and a critical development period (e.g., 1–4 months). The exact mechanisms that lead to respiratory and cardiac distress and ultimately death are not yet fully understood. However, the model suggests that interrupting or removing any of the modifiable risk factor areas could be protective of infants during sleep.

Prevention Strategies – Sleep Related Deaths

National sleep campaign (promising evidence).
The American Academy of Pediatrics (AAP) first linked sleep position and infant death in 1992 (122). Owing to the strength of the research demonstrating this association, the AAP and the National Institute of Child Health and Human Development, along with other partners, initiated the Back to Sleep campaign in 1994 (http://www.nichd.nih.gov.ezp.welch.jhmi.edu/sts/campaign/moments/Pages/default.aspx). Annual surveys of infant care practices were used to monitor the impact of the campaign; they found that between 1992 and 2001 supine sleep position increased from 13% to 72%, and SIDS rates declined 53%.

Since then, rates of supine sleep position seem to have plateaued (123). The Academy strengthened recommendations in 2005 and 2011 to further emphasize supine sleep position and other environmental factors to protect against sleep-related deaths, such as room sharing but not bed sharing; ensuring a firm sleep surface that is free of soft objects; and avoiding alcohol, illicit drugs, and smoke (122). How best to translate and to disseminate these recommendations so that all babies benefit from safe sleep practices has been studied, albeit not through any randomized controlled trials (RCTs) that we could identify. Results from other types of studies are categorized in Table 4 and described below.

Crib distribution programs (recommended practice).

Level A Recommendations for Safe Infant Sleeping by the American Academy of Pediatrics
Task Force on Sudden Infant Death Syndrome
Full Report Available at:
http://pediatrics.aappublications.org/content/128/5/e1341.full

1. Back to sleep for every sleep
2. Use firm sleep surface
3. Room-sharing without bed sharing is recommended
4. Keep soft objects and loose bedding out of the crib
5. Pregnant women should receive regular prenatal care
6. Avoid smoke exposure to during pregnancy and after birth
7. Avoid alcohol and illicit drugs during pregnancy and after birth
8. Breastfeeding is recommended
9. Consider offering a pacifier at nap time and bedtime
10. Avoid overheating infant
11. Do not use home cardiorespiratory monitors as strategy to reduce SIDS
12. Expand the national campaign to reduce the risk of SIDS to include a major focus on the safe sleep environment and ways to reduce the risks of all sleep-related infant deaths, including SIDS, suffocation, and other accidental deaths; pediatricians, family physicians and other primary

A review of the literature revealed no examples of evaluated crib distribution programs despite the existence of various programs across the country. Medical societies, government agencies, and safety advocate organizations encourage the use of cribs that meet the newest safety standards (39) or other approved sleep spaces, such as bassinets, playpens, portable cribs, or play yards. Having

a safe crib is necessary but insufficient to ensure safe sleep practices: Li (75) reported that a crib was found in homes of 90% of infants who died in Maryland while co-sleeping; Brixey (15) found a crib in the home of more than half (55%) of all infant suffocation deaths.

Parent/caregiver education (promising evidence).
A review of the literature revealed one RCT to test the best methods for educating parents of newborns about safe sleep. Goetter & Stepans (59) found that using a single nurse educator to review safe sleep education systematically with first-time mothers during the postpartum recovery period compared with usual (non-standardized) discharge instructions resulted in significantly higher rates of reported supine sleeping during the first week after discharge but no difference 6–7 weeks postpartum. In a quasi-experimental evaluation of a 15-min health educator–led session on safe sleep practices for groups of 3–10 parents attending a Women, Infants and Children clinic, Moon et al. (88) found pre- to posttest improvements in self-reported safe sleep behaviors and knowledge immediately after the session and at six months, when compared with an untreated comparison group, although there was substantial attrition. Using a historical control group, Colson & Joslin (32) found that training nursing staff to deliver safe sleep education prior to discharge resulted in significant increases in reported safe sleep behaviors at the time of the infant's two-week pediatric visit.

Health care settings model safe sleep (promising evidence).
We found two studies that used quality-improvement strategies to enhance safe sleep practices in the hospital setting, one that involved seven hospitals in Michigan (110) and another that focused on a neonatal intensive care unit in Texas (54). Both used nurse in-service trainings, crib audit forms, and parent surveys to measure change, and both found some significant improvements in safe sleep of the infants in the hospital setting.

Fire and Burn Injuries - Who is at risk and how do these injuries occur?

Who Is at Risk, and How Do These Injuries Occur?
Home fire deaths were at their peak in 1978 with 6,015 deaths, but since 2001 they have ranged between 2,380 and 3,200 (67). Despite the decline, in 2012 a death occurred every 221 minutes and an injury every 41 minutes owing to a fire in the home (67). Various other non-fire events also lead to burn-related death and injury in the home, including contact with electricity, scalding liquids, or hot surfaces. Fire and burn deaths are usually combined because deaths from burns in fires cannot always be distinguished from deaths from toxic smoke or other nonburn causes (1). Injury results either from respiratory distress or thermal injury to the skin. During a house fire, noxious gases—most notably CO—are released and reduce available oxygen levels, either by consuming the oxygen or by

displacing it with these toxicants (93). Thermal injury to the skin, a burn, results when an external heat source raises the temperature of the skin and causes either tissue cell death or charring (68).

Injury and deaths from house fires vary by sex, race, and age. Males compared with females face increased risk: 29% higher risk of death and 16% higher risk of injury. Black individuals compared with whites and Hispanics are at higher risk for home fire deaths. The risk of death is highest among the very old and the very young. Compared with the general population average, children younger than 5 years old are ~1.5 times more likely to die from a residential fire; adults 75 years and older are 3 times more likely; and those 85 years and older are 3.5 times more likely (52). Burns caused by cooking are 50% more likely to occur among young adults ages 20–24 compared with the general population average for all ages (52).

Fire and burn injuries appear to be overrepresented among communities with low education, poverty, and high unemployment. Those who live in older homes (63) and rental properties are at an increased risk for fire and burn injuries (112). Manufactured homes, most especially single detached mobile homes, have been linked to higher fire death rates than other types of one- and two-story family homes (91). Those who live in the Midwest and the South face the highest regional home fire death rates; rural communities compared with suburban and urban areas also have increased risk (52).

Smoking causes most home fire fatalities, and cooking is responsible for the most home fires (3). Other common fire and burn causes are matches and lighters (72, 117), faulty electrical equipment (52), candles, stoves and microwave ovens, wood burning stoves, and fireplaces (47). One study found that kitchen-related items and household electrical appliances combined were responsible for 54% of all burn-related injuries to individuals ages 0–20 (41). Both children and adults have been burned by hot grease from cooking (49) and from soup (96). Water and other liquids that reach temperatures above 125°F can produce a serious burn in less than two minutes; thus setting water heater thermostats to temperatures at or below 120°F is important (113). Other causes of burns to children and adults in the home include friction burns from treadmills (31, 78) and hair curling irons (35). Among older adults with home burn injuries, most occurred in the kitchen or bathroom (43).

Prevention Strategies

Working smoke alarms and installation/education programs (strong evidence). Working, residential smoke alarms are a cost-effective way to reduce fire-related injury, and door-to-door distribution programs are an effective way to get them into homes (45, 97, 120, 126). Kendrick and colleagues' (71) review of home safety education and provision of safety products found 17 studies that promoted

smoke alarm use among 5,107 participants. Across the studies, families who received interventions compared with controls were significantly more likely to possess a working smoke alarm [odds ratio (OR) 1.81, 95% confidence interval (CI) 1.30–2.52], and the effect size was generally larger when smoke alarms were provided. The Centers for Disease Control and Prevention (CDC)-sponsored Smoke Alarm Installation and Fire Safety Education program recommends the installation of lithium-battery smoke alarms with a hush feature for high-risk households (6, 64). DiGuiseppi and colleagues (46) found that families who had their smoke alarm directly installed were much more likely to have a functioning alarm six months later as compared with families who received a voucher for a free smoke alarm. More recently, Gielen and colleagues reported higher rates of participation in a fire department home-visiting program when community health workers provided advanced notice to residents about the upcoming visits (56).

Residential sprinkler technology (strong evidence) and sprinkler mandates for new home construction (promising evidence).
Data have shown that sprinklers reduce fire fatalities by 100% and property damage by 72% (17). The International Residential Code includes a provision for requiring sprinklers in new one- and two-family homes, although some states have adopted laws excluding this provision. Research is still needed to better understand ways to facilitate adoption of residential sprinkler policies across the United States, as well as to encourage retrofitting in existing homes.

Reduced ignition propensity cigarettes (RIPC) (promising evidence).
All 50 states have adopted laws requiring all cigarettes sold in their state to be RIPC, known more commonly as fire-safe cigarettes. New York, whose law was effective June 2004, reported experiencing a 35% reduction in fire deaths in the first year the law was enacted. Although it may take a decade to see the full benefits of the legislation on fire-related deaths, one published evaluation demonstrated a 28% reduction in house fires but no statistically significant reduction in injuries (4).

Fire escape planning interventions (strong evidence).
Despite recommendations to develop and practice residential fire escape plans so that all household members will know how to react in a house fire, only 52% of homes report having a fire escape plan, and only 16% of them report practicing it every 6 months (7). Remembering When is a program developed by the CDC and the National Fire Protection Association (NFPA) for older adult home safety; two of their eight key fire prevention messages relate to fire escape planning, including developing the plan around the abilities of the older adult and practicing it (94). Kendrick et al.'s 2012 meta-analysis of home safety education and provision of safety equipment included four studies that promoted fire escape plans, and it found that the interventions were successful in increasing the

proportion of families with such plans (OR 2.01, 95% CI 1.45–2.77) (71). Although these studies demonstrate changes in behavioral outcomes, we could find no studies of the impact of fire escape planning on injury or death in the event of a fire.

Interventions for safe storage of matches (recommended practice).
Using a combination of self-reported and observed definitions of "storing matches out of reach," six studies were included in Kendrick et al.'s meta-analysis of home safety interventions (71). Analysis revealed a lack of evidence that home safety interventions were effective in achieving this outcome.

Child-resistant cigarette lighters (promising evidence).
The Consumer Product Safety Commission (CPSC) safety standard requires that cigarette lighters be inoperable by children younger than age 5; this standard, when applied to national fire loss data, was credited with preventing an estimated 3,300 fires, 100 deaths, 660 injuries, and $52.5 million in property loss in 1998 (117).

Interventions for safe hot water temperatures (strong evidence).
According to Kendrick et al.'s 2012 meta-analysis (71), 16 studies included a safe hot water focus with 3,727 subjects. Although the studies varied in terms of study setting, definition of safe temperature, distribution of thermometers to test water, and follow-up period, families in the home safety intervention arms were significantly more likely to have safe hot water temperatures (OR 1.41, 95% CI 1.07–1.86). Whether having the temperature set at 49°C/120°F can effectively reduce scald burns is an open question, and recent data from home observations found substantial discrepancies between the thermostat settings and the actual tap water temperatures (113).
Interventions for keeping hot drinks and food out of reach of children (recommended practice).

The six studies on this topic in Kendrick et al.'s review (71) defined "keeping hot food and drinks out of reach" differently, and no statistically significant differences were found between families in the intervention and those in the control groups.

Falls - Who is at risk and how do these injuries happen?

Who Is at Risk and How Do These Injuries Happen?
A fall is an event that results in a person coming to rest inadvertently on the ground or on the floor or other low level. Falls can occur on the same level, for example, when an older adult trips or loses his/her balance, and falls can occur from one level to another, for example when a child falls from a window, down the stairs, or off furniture (81, 129). When these events result in the need to seek medical care or are fatal, they are coded as fall injuries. The degree to which an

injury results from a fall depends on many factors, most importantly the distance of the fall and the landing surface (9). Shorter distances and more energy-absorbing surfaces typically result in less severe injury. Individual differences in anatomy also affect fall injuries. Bone structure and fat composition affect injury severity and depend in part on the individual's age. For instance, an infant's head is proportionally larger relative to his body than is an adult's, and his bones are still soft. These contribute to making an infant particularly susceptible both to falling over and to suffering head injury as a result (27, 33, 132).

Falls are a leading cause of unintentional morbidity and mortality in the United States (25). Most unintentional fall deaths occur in homes (102). Of all home-related injuries, falls are a leading cause of emergency department visits; children under 18 and adults over 65 are at increased risk (101). Because of the different etiologies and intervention strategies for falls in children and older adults, we examine each age group separately.

Falls in children.

Unintentional falls are the number one cause of nonfatal injury for children (23). Most serious falls happen at home (12). In 2010, 127 children in the United States died from a fall-related injury. Boys are at an increased risk for both fatal and nonfatal falls (23). Children of low socioeconomic status and ethnic minorities are at increased risk (12). Falls are also a significant cause of morbidity in children. In 2011, falls accounted for 2.8 million pediatric emergency room visits (23). Children's age, size, and stage of development are all associated with risk. Children under age 4 account for 39% of all fall-related injuries in children (23). Falls down stairs are a significant contributor to falls in the home. Some of the most dangerous falls down stairs involve baby walkers (116). Though less common, falls from windows are particularly dangerous owing to the height of the fall. More than 3,000 children fall from windows annually in the United States (40). Window falls occur more frequently in large urban areas and low-income neighborhoods (33, 119). Another contributor to fall-related injuries in the home is falls from furniture, which result from infants rolling over or older children climbing. Currently, no prevention strategy has been evaluated to reduce the incidence of these injuries, and adequate caregiver supervision is recommended.

Falls in older adults.

Falls are a leading cause of morbidity and mortality for older adults (20). Each year ~2.3 million older adults are treated in the hospital for a fall. In 2010, 21,000 older adults died as the result of a fall (25). Beyond the risk of morbidity and mortality, falls are the leading contributor to loss of independence in older adults. Fears of falling and of losing independence contribute to decreased mobility and physical activity in older adults, which in turn increase the risk of falls (13, 106). Falls among older adults are an expensive contributor to health care costs. Using data from falls in 2010, direct medical costs were estimated to total $0.2 billion

for fatal injuries and $19 billion for nonfatal injuries (20). Multiple factors contribute to older adult fall risks, including tripping hazards within the home, lack of grab bars in the bathroom, use of medications that can cause dizziness or hypotension, and diminished eyesight and physical strength. The interaction of these risk factors is thought to contribute to an older adult's risk of falling (58, 90).

Prevention Strategies: Children

Mandated redesign of baby walkers (promising evidence).
The CPSC has taken the lead to reduce the risk of falls associated with baby walkers by issuing regulations mandating the redesign of the product. The voluntary standard is credited with an 88% reduction in baby walker–associated falls between 1994 and 2008 (38).

Reducing baby walker possession and use (strong evidence).
A cluster RCT involving 64 general practices and 1,174 expectant mothers in the United Kingdom sought to evaluate the effectiveness of an educational package in reducing baby walker possession and use. The intervention significantly reduced both possession and use of baby walkers and positively influenced knowledge and attitudes about them (70).

Stair gate education and distribution (strong evidence).
Home safety interventions have proven effective at increasing the use of fitted stair gates in homes, which are a recommended practice; the pooled result of 12 studies showed that families participating in home safety observations were 61% more likely to use stair gates than were nonparticipating families (71). These educational interventions have been most effective when combined with a physician recommendation and access to the product through a clinic-based safety center (28). No studies of the impact of increasing the use of stair gates in populations on injury rates were found.

Window guard mandates (strong evidence).
Mandating the use of window guards is an example of an effective policy intervention to reduce falls from windows. In response to injury incidence data, the New York City Board of Health passed a law requiring property owners of multiple-story buildings to provide window guards for all dwellings with children under 10 years of age. This effort resulted in a 96% reduction in hospital admissions for falls from windows (99). Window guards are recommended for windows on the first floor over 12 feet high and on all windows above the first story.

Prevention Strategies: Older Adults

Medication review (strong evidence).
Medication review by a physician or pharmacist is recommended to minimize interactions of both prescription and over-the-counter medication that may contribute to falls by causing dizziness or changes in blood pressure. Reductions in the rate of falls have been demonstrated with particular attention to psychotropic medication and prescription modification programs (90).

Strength and balance exercise programs (strong evidence).
Exercises, such as multiple-component group exercise (16 trials; 3,622 participants) and home exercise (7 trials; 951 participants), significantly reduced the rate of falls. Strength and balance training, particularly tai chi, has been effective in decreasing falls in older adults (6 trials; 1,625 participants). It is important that programs focus on increasing leg strength and that programs are made more challenging over time (58, 90).

Home modification (strong evidence).
Home safety assessment and modification interventions to reduce trip hazards and to install grab bars in bathrooms are recommended and have reduced both the risk (7 trials; 4,051 participants) and rate of falling (6 trials; 4,208 participants) (58).

Yearly vision screening (promising evidence).
Vision screening is recommended yearly to maximize vision with particular attention to wearers of multifocal glasses and those in need of cataract surgery (58). The provision of new glasses (single lens distance glasses) for older adults showed a significant reduction of falls among the more physically active subgroup of the intervention group (61).

Multicomponent interventions (strong evidence).
Comprehensive interventions incorporating multiple prevention strategies are perhaps the most promising, compared with interventions that focus on only a single strategy. A systematic review examined the effects of multiple interventions to prevent falls in older adults (60) and found that multicomponent interventions that were not tailored to individual risk factors were effective at reducing both the number of people who fell (pooled rate ratio = 0.85, 95% CI 0.80–0.91) as well as their rate of falls (pooled rate ratio = 0.80, 95% CI 0.72–0.89). This review presented the results of 17 trials with 5,034 participants.

Poisoning - Who is at risk and how do these injuries happen?

Who Is at Risk, and How Do These Injuries Happen?

A poison exposure is defined as an ingestion of or contact with a substance that can produce toxic effects (21). In the absence of any universally agreed on definition of a poisoning from either a clinical or epidemiological perspective (34), we define a poisoning as the result of “either a brief or long-term exposure to a chemical agent” that results in physical harm (21). Physical harm can range in severity from mild to fatal, and the physical effects of nonfatal injuries caused by poisonings can be temporary in nature or can result in lifelong disability. The sources of poisonings differ by age group, and here we address common poisonings in children and adults, as well as CO poisoning, which can affect all members of a household.

Among children, 90% of the poisoning exposures occur in the home (22). More than half of all calls to poison control centers are for children younger than six years old (16). Children account for the highest rates of nonfatal poisonings owing to their high exposure to common household products such as personal care products, household cleaners, pesticides, and medications (16). The most common household product associated with a potentially toxic exposure is bleach, and the most common method of exposure is a spray bottle (82). In addition, 150 pesticides that may be used in the home were implicated in calls to poison control centers in a 2-year period (118). Forty percent of pediatric calls to poison control centers resulted from children's exposure to medications (16), and one study found that medications were involved in almost 60% of pediatric emergency department visits for a poisoning exposure (53). In another study of children younger than 2 years old, the most common types of medications responsible for fatal poisonings were prescription medications for asthma, heart disease, and psychiatric problems (8).

Unintentional poisonings, mostly due to prescription drug overdose, have been rising steadily, and in 2010 they were the leading cause of injury death in the United States for adults ages 25–64 (24). In 2011, 1.4 million adult emergency room visits were attributed to prescription pain medication misuse and abuse (104). Prescription drugs were associated with more than 22,000 overdose deaths in 2010, 75% of deaths involved opioid pain relievers, and 30% involved benzodiazepines (66). People who died of overdose often had a combination of opioid pain relievers and benzodiazepines in their bodies. The annual cost of prescription medication abuse is estimated at $57 billion, which includes costs associated with loss of work productivity, criminal justice costs, and health care costs (10).

CO is a colorless, odorless gas produced from the incomplete combustion of carbon-containing substances. In addition to being present during house fires, common sources of CO include wood-burning or gas fireplaces that are

improperly vented, car exhaust, and malfunctioning furnaces, gas space heaters, and stoves (134). CO exposure has also occurred during periods of power failure when people use generators that are not properly ventilated. CO is absorbed through the lungs and displaces oxygen in the body. Depending on the amount and duration of exposure to CO, symptoms can range from headache and dizziness to convulsions, loss of consciousness, and, in severe cases, loss of life. Annually, CO exposure results in 400 deaths, 20,000 emergency room visits, and more than 4,000 hospitalizations. Fatality is highest among adults 65 and older (19).

Prevention Strategies: Children

Safe storage of medications away from children (strong evidence).
Childproof locks can be installed on cabinets or drawers, or families can use a lock box. Home safety interventions have been effective at increasing the correct storage of household products and medications. A systematic review showed that families participating in home safety interventions were 53% more likely to store medicines safely (13 studies) and 55% more likely to store cleaning products safely (15 studies) than were nonparticipating families (71). We could find no studies demonstrating the relationship between safe storage practices and reduced rates of poisoning or exposures.

Child-resistant packaging and sublethal dose packaging (strong evidence).
The United States Poison Prevention Packaging Act of 1970 required certain household chemicals and medicines to be packaged in a way that is difficult for children under age 5 to open. Although this legislation was originally limited to aspirin, other prescription medicines, over-the-counter drug products, and household chemicals have been added over time (11, 124, 36, 37, 128). Utilization of childproof caps on medications has resulted in a decrease in pediatric medication ingestions (83). Limiting the number of tablets per bottle to a nonlethal dose, when combined with improved packaging and education, was successful in reducing deaths from baby aspirin (30).

Poison control centers (strong evidence).
In the United States, poison control center staff are available 24 hours per day at an emergency hotline to dispense information and treatment advice. Poison control centers have effectively reduced medical utilization costs due to poisonings (73). Recognizing the importance of poison control centers, the Institute of Medicine (IOM) outlined 12 specific recommendations to improve the system, including that all poison control centers should perform a core set of functions, be better integrated into the public health system, and be supported by sufficient and stable funding to fulfill their mission (34). Miller & Lestina (85) conducted a cost–benefit analysis showing that the average public call to a

poison control center prevented $175 in other medical spending. Overall, data have indicated that the poison control system saves more than $1.8 billion per year in the United States, reducing costs by avoiding medical utilization, reducing the lengths of hospital stays, and reducing work-loss days (73). Caregivers should be educated about poison control centers so they know what to do in the event of an accidental poisoning. Kelly and colleagues (69) created a nine-minute videotape (available in both English and Spanish) that improved the knowledge, attitudes, behaviors, and behavioral intentions regarding the use of poison control centers.

Prevention Strategies: Adults

Safe storage, use, and disposal (recommended practice).
Increasing attention is being paid to adults' use of opioid pain relievers (OPRs) for the reasons described above. The CDC recommends that patients who are prescribed OPRs be counseled against sharing medications, about proper storage and disposal, and about compliance with use according to the prescribing physician's instructions (22). A nonrandomized pilot intervention demonstrated promising results at improving knowledge around storage and disposal as well as self-reported misuse behaviors at one-month follow-up (80).

Controlling the supply and dispensing of opioid pain relievers (promising evidence).
Numerous efforts are under way to control the supply of OPRs and improve physicians' prescribing practices (78, 125, 131). One major initiative undertaken to tackle the supply of OPRs is the state-level prescription drug monitoring program (PDMP), now in effect in nearly every US state. Preliminary evaluations are under way in several states. Early evaluations demonstrate that these programs have been effective at reducing the diversion of controlled substances (29, 42, 89, 133). For example, policy changes in Florida from 2010 to 2012, which resulted in the shutdown of pain clinics and prescribing dispensers statewide, resulted in a significant decrease in deaths resulting from prescription drug overdoses (65). In addition, PDMPs have been credited with improving clinical decision making by providing clinicians with timely information about their patients (5, 48). Other efforts using a computerized decision support system have successfully improved prescribing practices by making patient-specific guidance-based recommendations available in real time during a clinic visit (125).

Carbon monoxide alarms (recommended practice).
CO alarms are designed to provide an early warning alerting occupants to when CO accumulates in a home. CO alarms are recommended on each level where people sleep and have been mandated by legislation in some jurisdictions (93). Proper maintenance of potential sources of CO in the home is the best way to

avoid CO exposure (93). Proper maintenance includes routine servicing of appliances and ensuring that CO-producing appliances are properly vented. Although no formal evaluations have been completed on the effects of CO alarm distribution programs on health, we know that CO alarms provide the only possible protection from a CO leak in a home. We found no studies that explored the most effective strategies to increase the use of CO alarms in homes.

CONCLUSION

We have demonstrated the extent to which injuries that occur in the home continue to be a significant public health problem across the life span, with particular importance to young children and older adults. Home injury surveillance, intervention development, and evaluation are still hampered by insufficient data. Better data would allow for more in-depth understanding of the myriad factors that contribute to home injuries and better ability to prioritize the development and delivery of evidence-based solutions to the populations that need them.

Even in the absence of adequate surveillance data, research has identified numerous preventive strategies: for instance, supine sleeping for infants, working smoke alarms, residential sprinkler technology, reduced ignition propensity cigarettes, child-resistant packaging of cigarette lighters and medications, fall prevention programs for older adults. A remaining challenge is to ensure more widespread adoption of proven effective strategies. We need to find effective ways to reach those who do not have access to or do not fully embrace the behavior changes required to utilize the behaviorally focused prevention strategies. Doing so will require putting in place programs that effectively deliver safety products and safety information using evidence-based approaches to health promotion programming (57, 115). We also need to identify effective strategies to increase uptake of the technological and policy strategies that have shown promise (e.g., residential sprinklers and mandates). Public health and injury prevention professionals will need to work with new partners (e.g., home builders and code developers) and learn new advocacy and policy development skills. As this review shows, another challenge is the variability in the outcomes that have been assessed across the various prevention strategies. In some cases, we still need evidence beyond how to change safety behaviors to demonstrate impacts on injuries (e.g., fire escape planning), and in other cases, we need to find effective strategies to increase adoption of proven prevention strategies (e.g., window guards).

The current interest in public health circles in the role of housing in health offers unparalleled opportunities for injury prevention professionals who are concerned with home injuries. Collaborating with our environmental health and healthy

housing colleagues is one important approach to reducing home injuries. Their access to homes and ability to influence housing policy can play significant roles in reducing home injuries. Sharing the science of injury prevention (114) with the wide array of professionals who create home environments and who interact with people in their homes (e.g., architects, home builders, home visiting programs, fire and emergency medical service providers) could be a useful approach. As originally recommended in 2004 (100), we believe there continues to be an urgent need for multiple organizations committing to a collaborative national effort to reduce the burden of home injuries in the United States.

REFERENCES

1. 1.ABA (Am. Burn Assoc.). 2013. Burn Incidence and Treatment in the United States: 2013. Chicago, IL: ABA. http://www.ameriburn.org/resources_factsheet.php
2. Adams PF, Kirzinger WK, Martinez ME. 2013. Summary health statistics for the U.S. population: National Health Interview Survey, 2012. National Center for Health Statistics. Vital Health Stat. 10:1–94
3. Ahrens M. 2013. Home Structure Fires. Quincy, MA: Natl. Fire Prot. Assoc. (NFPA), Fire Anal. Res.
   Div. http://www.nfpa.org/~/media/Files/Research/NFPA%20reports/Occupancies/oshomes.pdf
4. Alpert HR, Christiana DC, Orav J, Dockery DW, Connolly GN. 2014. Effectiveness of the cigarette ignition propensity standard in preventing unintentional residential fires in Massachusetts. Am. J. Public Health 104:e56–61
5. Baehren DF, Marco CA, Droz DE, Sinha S, Callan EM, Akpunonu P. 2010. A statewide prescription monitoring program affects emergency department prescribing behaviors. Ann. Emerg. Med. 58:19–23
6. Ballesteros MF, Jackson ML, Martin MW. 2005. Working toward the elimination of residential fire deaths: The Centers for Disease Control and Prevention's Smoke Alarm Installation and Fire Safety Education (SAIFE) program. J. Burn Care Rehabil. 26:434–39
7. Ballesteros MF, Kresnow MJ. 2007. Prevalence of residential smoke alarms and fire escape plans in the U.S.: results from the Second Injury Control and Risk Survey (ICARIS-2). Public Health Rep. 122:224–31
8. Bar-Oz B, Levichek Z, Koren G. 2004. Medications that can be fatal for a toddler with one tablet or teaspoonful: a 2004 update. Paediatr. Drugs6:123–26
9. Barlow B, Niermirska N, Gandhi RP, LeBlanc W. 1983. Ten years of experience with falls from a height in children. J. Pediatr. Surg. 18:509–11
10. Birnbaum HG, White AG, Schiller M, Waldman T, Cleveland JM, Roland CL. 2011. Societal costs of prescription opioid abuse, dependence, and misuse in the United States. Pain Med. 12:657–67
11. Blumenthal D. 1989. Artificial nail remover poses poisoning risk. FDA Consum. 23:22
12. Borse N, Sleet DA. 2009. CDC Childhood Injury Report: patterns of unintentional injuries among 0- to 19-year olds in the United States, 2000–2006. Fam. Community Health 32:189
13. Boyd R, Stevens JA. 2009. Falls and fear of falling: burden, beliefs and behaviours. Age Ageing 38:423–28
14. Breysse P, Farr N, Galke W, Lanphear B, Morley R, Bergofsky L. 2004. The relationship between housing and health: children at risk. Environ. Health Perspect. 112:1583–88
15. Brixey SN, Kopp BC, Schlotthauer AE, Collier A, Corden TE. 2011. Use of child death review to inform sudden unexplained infant deaths occurring in a large urban setting. Inj. Prev. 17(Suppl. 1):i23–27
16. Bronstein AC, Spyker DA, Cantilena LR Jr., Green JL, Rumack BH, Giffin SL. 2009. 2008 annual report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 26th annual report. Clin. Toxicol. 47:911–1084
17. Butry DT. 2012. Comparing the performance of residential fire sprinklers with other life-safety technologies. Accid. Anal. Prev. 48:480–94
18. Carpenter RG, Irgens LM, England PD, Fleming P, Huber K, et al. 2004. Sudden unexplained infant death in 20 regions in Europe: case control study. Lancet 363:185–91
19. CDC (Cent. Dis. Control Prev.). 2013. Carbon monoxide poisoning. Updated July 23. CDC, Atlanta. http://www.cdc.gov.ezp.welch.jhmi.edu/co/faqs.htm
20. CDC (Cent. Dis. Control Prev.). 2014. Costs of falls among older adults. Updated March 5. CDC, Atlanta. http://www.cdc.gov.ezp.welch.jhmi.edu/homeandrecreationalsafety/falls/fallcost.html
21. CDC (Cent. Dis. Control Prev.). 2014. Poisoning prevention. Updated May 19. CDC, Atlanta. http://www.cdc.gov.ezp.welch.jhmi.edu/healthyhomes/bytopic/poisoning.html

22. CDC (Cent. Dis. Control Prev.). 2013. Tips to prevent poisonings. Updated July 2. CDC, Atlanta. http://www.cdc.gov.ezp.welch.jhmi.edu/HomeandRecreationalSafety/Poisoning/preventiontips.htm
23. CDC (Cent. Dis. Control Prev.), Natl. Action Plan Child Inj. Prev. 2013. A national action plan for child injury prevention: reducing fall-related injuries in children. Updated July 2. CDC, Atlanta. http://www.cdc.gov.ezp.welch.jhmi.edu/safechild/NAP/overviews/falls.html
24. CDC (Cent. Dis. Control Prev.), NCHS (Natl. Cent. Health Stat.), Natl. Vital Stat. Syst. 2010. 10 leading causes of injury deaths by age group highlighting unintentional injury deaths, United States—2010. Hyattsville, MD: NCHS. http://www.cdc.gov.ezp.welch.jhmi.edu/injury/wisqars/pdf/10LCID_Unintentional_Deaths_2010-a.pdf
25. CDC (Cent. Dis. Control Prev.), Natl. Cent. Inj. Prev. Control. 2014. Injury prevention and control: data & statistics (WISQARS). Updated July 10. CDC, Atlanta. http://www.cdc.gov.ezp.welch.jhmi.edu/injury/wisqars/index.html
26. 26. Chen LH, Warner M, Fingerhut L, Makuc D. 2009. Injury episodes and circumstances: National Health Interview Survey, 1997–2007. Vital Health Stat. 10(241)
27. 27. Chiaviello CT, Christoph RA, Bond GR. 1994. Infant walker-related injuries: a prospective study of severity and incidence. Pediatrics 93:974–76
28. 28. Clamp M, Kendrick D. 1998. A randomized controlled trial of general practitioner safety advice for families with children under 5 years. BMJ316:1576–79
29. Clark T, Eadie J, Kreiner P, Strickler G. 2012. Prescription Drug Monitoring Programs: An Assessment of the Evidence for Best Practices. Waltham, MA: Prescr. Drug Monit. Progr. Cent. Excel., Heller Sch. Soc. Policy Manag., Brandeis Univ. http://www.pdmpexcellence.org/sites/all/pdfs/Brandeis_PDMP_Report_final.pdf
30. Clarke A, Walton WW. 1979. Effect of safety packaging on aspirin ingestion by children. Pediatrics 63:687–93
31. 31. Collier ML, Ward RS, Saffle JR, Edelman LS, Morris SE, Lundy C. 2004. Home treadmill friction injuries: a five-year review. J. Burn Care Rehabil.25:441–44
32. 32. Colson ER, Joslin SC. 2002. Changing nursery practice gets inner-city infants in the supine position for sleep. Arch. Pediatr. Adolesc. Med.156:717–20
33. 33. Comm. Inj. Poison Prev. 2001. Falls from heights: windows, roofs, and balconies. Pediatrics 107:1188–91
34. Comm. Poison Prev. Control, Board of Health Promot. Dis. Prev., Inst. Med. (IOM). 2004. Forging a Poison Prevention and Control System. Washington, DC: Natl. Acad. Press
35. CPSC (US Consum. Prod. Saf. Comm.). 1990. Young Children and Teens Burned By Hair Curling Irons: Safety Alert. Washington, DC: CPSC. https://catalog.swem.wm.edu/Record/962393/Details
36. 36. CPSC (US Consum. Prod. Saf. Comm.). 2001. Title 16 Code of Federal Regulations, Part 1700. Child-resistant packaging for certain over-the-counter drug products. Fed. Regist. 66:40111–16
37. 37. CPSC (US Consum. Prod. Saf. Comm.). 2002. Title 16 Code of Federal Regulations, Part 1700. Poisoning prevention packaging requirements; exemption of hormone replacement therapy products. Fed. Regist. 67:66550–52
38. 38. CPSC (US Consum. Prod. Saf. Comm.). 2010. CPSC issues final mandatory rule on infant baby walkers. CPSC News Release 10-247, May 27. http://www.cpsc.gov/en/Newsroom/News-Releases/2010/CPSC-Issues-Final-Mandatory-Rule-on-Infant-Baby-Walkers/
39. CPSC (US Consum. Prod. Saf. Comm.). 2010. Title 16 Code of Federal Regulations, Parts 1219, 1220, 1500, et al. Full-size baby cribs and non-full size baby cribs: safety standards; revocation of requirements; third party testing for certain children's products; final rules. Fed. Regist. 75:81766–87
40. 40 CPSC (US Consum. Prod. Saf. Comm.). 2011. CPSC: parents, caregivers should consider safety before opening windows. CPSC News Release 11-192, April 8. http://www.cpsc.gov/en/

Newsroom/News-Releases/2011/CPSC-Parents-Caregivers-Should-Consider-Safety-Before-Opening-Windows/

41. D'Souza AL, Nelson NG, McKenzie LB. 2009. Pediatric burn injuries treated in US emergency departments between 1990–2006. Pediatrics124:1424–30
42. 42. Darves B. 2012. Tracking Rx misuse: state programs making gains. Sept. 4. iHealthBeat, Calif. HealthCare Found. Oakland, CA. http://www.ihealthbeat.org/insight/2012/tracking-rx-misuse-state-programs-making-gains
43. 43. Davidge K, Fish J. 2008. Older adults and burns. Geriatr. Aging 11:270–75
44. 44. DHHS (US Dep. Health Hum. Serv.), HRSA (Health Resour. Serv. Adm.), MCH (Matern. Child Health Bur.). 2013. Child Health USA 2013. Rockville, MD: DHHS.http://mchb.hrsa.gov.ezp.welch.jhmi.edu/chusa13/dl/pdf/chusa13.pdf
45. 45. DiGuiseppi C, Goss CW, Higgins JP. 2001. Interventions for promoting smoke alarm ownership and function. Cochrane Database Syst. Rev.2:CD002246
46. DiGuiseppi C, Roberts I, Wade A, Sculpher M, Edwards P, et al. 2002. Incidence of fires and related injuries after giving out free smoke alarms: cluster randomized controlled trial. BMJ 325:995–97
47. 47. Dunst CM, Scott EC, Kraatz JJ, Anderson PM, Twomey JA, Peltier GL. 2004. Contact palm burns in toddlers from glass enclosed fireplaces. J. Burn Care Rehabil. 25:67–70
48. 48. Feldman L, Williams KS, Knox M, Coates J. 2012. Influencing controlled substance prescribing: attending and resident physician use of a state prescription monitoring program. Pain Med. 13:908–14
49. 49. Fiebiger B, Whittmire F, Law E, Still JM. 2004. Causes and treatment of burns from grease. J. Burn Care Rehabil. 25:374–76
50. 50. Filiano JJ, Kinney HC. 1994. A perspective on neurologic findings in victims of the sudden infant death syndrome: the triple-risk model. Biol. Neonate 65:194–97
51. 51. Fleming PJ, Blair PS, Bacon C, Bensley D, Smith I, et al. 1996. Environment of infants during sleep and risk of the sudden infant death syndrome: results of 1993–5 case-control study for confidential inquiry into stillbirths and deaths in infancy. Br. Med. J. 313:191–95
52. 52. Flynn JD. 2010. Characteristics of Home Fire Victims. Quincy, MA: Natl. Fire Prot. Assoc. (NFPA), Fire Anal. Res. Div. http://www.nfpa.org/~/media/Files/Research/NFPA%20reports/Victim%20Patterns/oshomevictims.pdf
53. 53. Franklin RL, Rodgers GB. 2008. Unintentional child poisonings treated in United States hospital emergency departments: national estimates of incident cases, population-based poisoning rates, and product involvement. Pediatrics 122:1244–51
54. 54. Gelfer P, Cameron R, Masters K, Kennedy KA. 2013. Integrating “Back to Sleep” recommendations into neonatal ICU practice. Pediatrics131:e1264–70
55. 55. Gielen AC. 2005. Unintentional home injuries: the work of the Home Safety Council. Am. J. Prev. Med. 28:72
56. 56. Gielen AC, Shields W, Frattaroli S, McDonald E, Jones V, et al. 2013. Enhancing fire department home visiting programs: results of a community intervention trial. J. Burn Care Res. 34:e250–56
57. 57. Gielen AC, Sleet D, DiClemente R, eds. 2006. Injury and Violence Prevention: Behavioral Science Theories, Methods, and Applications. San Francisco, CA: Jossey-Bass
58. 58. Gillespie LD, Robertson MC, Gillespie WH, Sherrington C, Gates S, et al. 2012. Interventions for preventing falls in older people living in the community. Cochrane Database Syst. Rev. 9:CD007146
59. 59. Goetter MC, Stepans MBF. 2005. First-time mothers' selection of infant supine sleep positioning. J. Perinat. Educ. 14:16–23
60. Goodwin VA, Abbott RA, Whear R, Bethel A, Ukoumunne OC, et al. 2014. Multiple component interventions for preventing falls and fall-related injuries among older people: systematic review and meta-analysis. BMC Geriatr. 14:15
61. 61. Haran MJ, Cameron ID, Ivers RQ, Simpson JM, Lee BB, et al. 2010. Effect on falls of providing single lens distance vision glasses to multifocal glasses wearers: VISIBLE randomized controlled trial. BMJ 340:c2265

62. Haut ER, Pronovost PJ, Schneider EB. 2012. Limitations of administrative databases. JAMA 307(24):2589–90
63. 63. Istre GR, McCoy MA, Osborn L, Barnard JJ, Bolton A. 2001. Deaths and injuries from house fires. N. Engl. J. Med. 344:1911–16
64. Jackson M, Wilson J, Akoto J, Dixon S, Jacobs DE, Ballesteros MF. 2010. Evaluation of fire-safety programs that use 10-year smoke alarms. J. Community Health 35:543–48
65. Johnson H, Paulozzi L, Porucznik C, Mack K, Herter B. 2014. Decline in drug overdose deaths after state policy changes—Florida, 2010–2012. MMWR 63:569–74
66. 66. Jones CM, Mack KA, Paulozzi LJ. 2013. Pharmaceutical overdose deaths, United States, 2010. JAMA 309:657–59
67. 67. Karter MJ. 2013. Fire loss in the United States during 2012. Quincy, MA: Natl. Fire Prot. Assoc. (NFPA), Fire Anal. Res. Div. http://www.nfpa.org/~/media/FD0144A044C84FC5BAF90C05C04890B7.ashx
68. Katcher ML. 1981. Scald burns from hot tap water. JAMA 246:219–22
69. Kelly NR, Huffman LC, Mendoza FS, Robinson TN. 2003. Effects of a videotape to increase use of poison control centers by low-income and Spanish-speaking families: a randomized, controlled trial. Pediatrics 111:21–26
70. Kendrick D, Illingworth R, Woods A, Watts K, Collier J, et al. 2005. Promoting child safety in primary care: a cluster randomized controlled trial to reduce baby walker use. Br. J. Gen. Pract. 55:582–88
71. 71. Kendrick D, Young B, Mason-Jones AJ, Ilyas N, Achana FA, et al. 2012. Home safety education and provision of safety equipment for injury prevention. Cochrane Database Syst.
72. 72. Leistikow BN, Martin DC, Milano CE. 2000. Fire injuries, disasters, and costs from cigarettes and cigarette lights: a global overview. Prev. Med.31:91–99
73. Lewin Group. 2012. Final Report on the Value of the Poison Center System. Falls Church, VA: Lewin Group. https://aapcc-s3-amazonaws-com.ezp.welch.jhmi.edu/files/library/Value_of_the_Poison_Center_System_FINAL_9_26_2012_–_FINAL_FINAL_FINAL.pdf
74. Li DK, Petitti DB, Willinger M, McMahon R, Odouli R, et al. 2003. Infant sleeping position and the risk of sudden infant death syndrome in California, 1997–2000. Am. J. Epidemiol. 157:446–55
75. 75. Li L, Zhang Y, Zielke RH, Ping Y, Fowler DR. 2009. Observations on increased accidental asphyxia deaths in infancy while co-sleeping in the state of Maryland. Am. J. Forensic Med. Pathol. 30:318–21
76. 76. Liebrechts-Akkerman G, Lao O, Liu F, van Sleuwen BE, Engleberts AC, et al. 2011. Postnatal parental smoking: an important risk factor for SIDS. Eur. J. Pediatr. 170:1281–91
77. Mack KA, Rudd RA, Mickalide AD, Ballesteros MF. 2013. Fatal unintentional injuries in the home in the U.S., 2000–2008. Am. J. Prev. Med. 44:239–46
78. 78. Maguiña P, Palmeiri TL, Greenhalgh DG. 2004. Treadmills: a preventable source of pediatric friction burn injuries. J. Burn Care Rehabil. 25:201–4
79. Malloy MH, Freeman DH. 2004. Age at death, season, and day of death as indicators of the effect of the Back to Sleep program on sudden infant death syndrome in the United States, 1992–1999. Arch. Pediatr. Adolesc. Med. 158:359–65
80. McCauly JL, Back SE, Brady KT. 2013. Pilot of a brief, web-based educational intervention targeting safe storage and disposal of prescription opioids. Addict. Behav. 38:2230–35
81. 81. McDonald EM, Girasek D, Gielen AC. 2006. Home injuries. In Injury Prevention for Children and Adolescents: Research, Practice and Advocacy, ed. KD Liller, pp. 149–87. Washington, DC: Am. Public Health Assoc. Press
82. 82. McKenzie LB, Ahir N, Stolz U, Nelson NG. 2010. Household cleaning product-related injuries treated in US emergency departments in 1990–2006. Pediatrics 126:108–516
83. 83. Merck Man. for Health Care Prof. 2013. General Principles of Poisoning. Whitehouse Station,
NJ: Merck. http://www.merckmanuals.com/professional/injuries_poisoning/poisoning/general_principles_of_poisoning.html

84. 84. Mickalide AD, Baldwin G. 2010. Principles of healthy housing: safe. In Healthy & Safe Homes: Research, Practices, & Policy, ed. RL Morley, AD Mickalide, KA Mack, pp. 53–72. Washington, DC: Am. Public Health Assoc.
85. 85. Miller TR, Lestina DC. 1997. Costs of poisoning in the United States and saving from poison control centers: a benefit-cost analysis. Ann. Emerg. Med. 29:246–47
86. Mitchell EA. 2009. SIDS: past, present, future. Acta Paediatr. 98:1712–19
87. Mitchell EA, Thompson JMD, Ford RPK, Taylor BJ, Members of the New Zealand Cot Death Study Group. 1998. Sheepskin bedding and the sudden infant death syndrome. J. Pediatr. 133:701–4
88. Moon RY, Oden RP, Grady KC. 2004. Back to Sleep: an educational intervention with women, infants and children program clients. Pediatrics113:542–47
89. 89. Morgan L, Weaver M, Sayeed Z, Orr R. 2013. The use of prescription monitoring programs to reduce opioid diversion and improve patient safety. J. Pain Palliat. Care Pharmacother. 27:4–9
90. Moyer VA, US Prev. Serv. Task Force. 2012. Prevention of falls in community-dwelling older adults: U.S. Preventive Services Task Force recommendation statement. Ann. Intern. Med. 157:197–204
91. Mullins RF, Alarm B, Huq Mian MA, Samples JM, Friedman BC, et al. 2009. Burns in mobile home fires—descriptive study at a regional burn center. J. Burn Care Res. 30:694–99
92. 92. NCHH (Natl. Cent. for Healthy Hous.), APHA (Am. Public Health Assoc.). 2014. National Healthy Housing Standard. Columbia, MD: NCHH. http://www.nchh.org/Portals/0/Contents/NHHS_Full_Doc.pdf
93. 93. NFPA (Natl. Fire Prot. Assoc.). 2008. Carbon monoxide safety tips. NFPA, Quincy, MA. http://www.nfpa.org/safety-information/for-consumers/fire-and-safety-equipment/carbon-monoxide/carbon-monoxide-safety-tips
94. 94. NFPA (Natl. Fire Prot. Assoc.). 2014. Remembering when. Quincy, MA: NFPA. http://www.nfpa.org/safety-information/for-public-educators/education-programs/remembering-when
95. 95. NIH (Natl. Inst. Health), NICHD (Eunice Kennedy Shriver Natl. Inst. Child Health Dev.). 2013. Key moments in Safe to Sleep®history. Updated Sept. 23. NIH, Rockville, MD. http://www.nichd.nih.gov.ezp.welch.jhmi.edu/sts/campaign/moments/Pages/default.aspx
96. 96. Palmieri TL, Anderson TS, Ison D, O'Mara MS, Sharma R, et al. 2008. Pediatric soup scald burn injury: etiology and prevention. J. Burn Care Res.29:114–18
97. 97. Parmer JE, Corso PS, Ballesteros MF. 2006. A cost analysis of a smoke alarm installation and fire safety education program. J. Saf. Res. 37:367–73
98. 98. Ponsonby AL, Dwyer T, Couper D, Cochrane J. 1998. Association between use of a quilt and sudden infant death syndrome: case control study. BMJ 316:195–96
99. 99. Pressley JC, Barlow B. 2005. Child and adolescent injury as a result of falls from buildings and structures. Inj. Prev. 11:267–73
100. 100. Runyan CW, Casteel C, eds. 2004. The State of Home Safety in America: Facts About Unintentional Injuries in the Home. Washington, DC: Home Safety Counc. 2nd ed.http://www.iccsafe.org/cs/CTC/Documents/guards/resource/guards_Moss_SOHSIA-2004report.pdf
101. Runyan CW, Casteel C, Perkis D, Black C, Marshall SW, et al. 2005. Unintentional injuries in the home in the United States Part I: mortality. Am. J. Prev. Med. 28:73–79
102. Runyan CW, Perkis D, Marshall SW, Johnson RM, Coyne-Beasley T, et al. 2005. Unintentional injuries in the home in the United States Part II: morbidity. Am. J. Prev. Med. 28:80–87
103. Saegert SC, Klitzman S, Freudenberg N, Cooperman-Mroczek J, Nassar S. 2003. Healthy housing: a structured review of published evaluations of US interventions to improve health by modifying housing in the United States, 1990–2001. Am. J. Public Health 93:1471–77
104. SAMHSA (Subst. Abuse Ment. Health Serv. Adm.). 2013. The DAWN report: highlights of the 2011 Drug Abuse Warning Network (DAWN) findings on drug-related emergency department visits. Updated Feb. 18. US DHHS, SAMHSA, Rockville, MD. http://www.samhsa.gov.ezp.welch.jhmi.edu/data/2k13/DAWN127/sr127-DAWN-highlights.htm

105. Scheers NJ, Dayton CM, Kemp JS. 1998. Sudden infant death with external airways covered: case-comparison study of 206 deaths in the United States. Arch. Pediatr. Adolesc. Med. 152:540–47
106. Scheffer AC, Schuurmans MJ, van Dijk N, van der Hooft T, de Rooij SE. 2008. Fear of falling: measurement strategy, prevalence, risk factors and consequences among older persons. Age Ageing 37:19–24
107. Schnitzer PG, Covington TM, Dykstra HK. 2012. Sudden unexpected infant deaths: sleep environment and circumstances. Am. J. Public Health102:1204–12
108. Secr. Advis. Comm. Natl. Health Promot. Dis. Prev. Object. 2020. 2010. Healthy People 2020: an opportunity to address societal determinants of health in the United States. Revis. Oct. 26. US Dep. Health Hum. Serv. (DHHS), Washington, DC. http://www.healthypeople.gov/sites/default/files/SocietalDeterminantsHealth.pdf
109. Senter L, Sackoff J, Landi K, Boyd L. 2011. Studying sudden and unexpected infant deaths in a time of changing death certification and investigation practices: evaluating sleep-related risk factors for infant death in New York City. Matern. Child Health J. 15:242–48
110. Shaefer SJM, Herman SE, Frank SJ, Adkins M, Terhaar M. 2010. Translating infant safe sleep evidence into nursing practice. J. Obstet. Gynecol. Neonatal Nurs. 39:618–26
111. Shapiro-Mendoza CK, Kimball M, Tomashek KM, Anderson RN, Blanding S. 2009. US infant mortality trends attributable to accidental suffocation and strangulation in bed from 1984 through 2004: Are rates increasing? Pediatrics 123:533–39
112. Shenassa ED, Stubbendick A, Brown MJ. 2004. Social disparities in housing and related pediatric injury: a multilevel study. Am. J. Public Health94:633–39
113. Shields WC, McDonald E, Frattaroli S, Perry EC, Zhu J, Gielen AC. 2013. Still too hot: examination of water temperature and water heater characteristics 24 years after manufacturers adopt voluntary temperature setting. J. Burn Care Res. 34:281–87
114. Sleet D, Gielen AC. 2004. Developing injury interventions: the role of behavioral science. In The Scientific Basis of Injury Prevention and Control, ed. R McClure, M Stevenson, S McEvoy, pp. 214–32. Melbourne, Aust.: IP Commun.
115. Sleet D, Gielen AC. 2006. Health promotion and injury prevention. In Health Promotion Handbook, ed. SS Gorin, J Arnold, pp. 247–75. St. Louis, MO: Mosby-Year. 2nd ed.
116. Smith GA, Bowman MJ, Luria JW, Shields BJ. 1997. Babywalker-related injuries continue despite warning labels and public education. Pediatrics 100:e1–5
117. Smith LE, Greene MA, Singh HA. 2002. Study of the effectiveness of the US safety standard for child resistant cigarette lighters. Inj. Prev. 8:192–96
118. Spann MF, Blondell JM, Hunting KL. 2000. Acute hazards to young children from residential pesticide exposures. Am. J. Public Health 90:971–73
119. 119. Stone KE, Lanphear BP, Pomerantz WJ, Khoury J. 2000. Childhood injuries and deaths due to falls from windows. J. Urban Health 77:26–33
120. Ta VM, Frattaroli S, Bergen C, Gielen AC. 2006. Evaluated community fire safety interventions in the United States: a review of current literature. J. Community Health 31:176–97
121. Tappin D, Ecob R, Brooke H. 2005. Bedsharing, room sharing, and sudden infant death syndrome in Scotland: a case control study. J. Pediatr.147:32–37
122. Task Force on Sudden Infant Death Syndr. 2011. Policy statement: SIDS and other sleep-related infant deaths: expansion of recommendations for a safe infant sleeping environment. Pediatrics 128:1030–39
123. Task Force on Sudd. Infant Death Syndr. 2011. Technical report: SIDS and other sleep-related infant deaths: expansion of recommendations for a safe infant sleeping environment. Pediatrics 128:e1341–67
124. Tech. Advis. Comm. 1971. Poison Prevention Packaging Act of 1970. Bull. Natl. Clgh. Poison Control Cent. May–June:1–2
125. Trafton J, Martins S, Michel M, Lewis E, Wang D, et al. 2010. Evaluation of the acceptability and usability of a decision support system to encourage safe and effective use of opioid therapy for chronic, noncancer pain by primary care providers. Pain Med. 11:575–85

126. Turner C, Spinks A, McClure R, Nixon J. 2004. Community-based interventions for the prevention of burns and scalds in children. Cochrane Database Syst. Rev. 3:CD004335
127. Turner S, Arthur G, Lyons RA, Weightman AL, Mann MK, et al. 2011. Modification of the home environment for the reduction of injuries. Cochrane Database Syst. Rev. 2:CD003600
128. Walton WW. 1982. An evaluation of the Poison Prevention Packaging Act. Pediatrics 69:363–70
129. WHO (World Health Organ.). 2007. WHO Global Report on Falls Prevention in Older Age. Geneva: WHO. http://www.who.int.ezp.welch.jhmi.edu/violence_injury_prevention/publications/other_injury/falls_prevention.pdf?ua=1
130. WHO (World Health Organ.). 2013. Social determinants of health, key concepts. WHO, Geneva. http://www.who.int.ezp.welch.jhmi.edu/social_determinants/thecommission/finalreport/key_concepts/en
131. Wiedemer NL, Harden PS, Arndt IO, Gallagher RM. 2007. The opioid renewal clinic: a primary care, managed approach to opioid therapy in chronic pain patients at risk for substance abuse. Pain Med. 8:573–84
132. 132. Wilson MH, Baker SP, Teret SP, Shock S, Garbarino J. 1991. Saving Children: A Guide to Injury Prevention. New York: Oxford Univ. Press
133. Worley J. 2012. Prescription drug monitoring programs, a response to doctor shopping: purpose, effectiveness, and directions for future research. Issues Ment. Health Nurs. 33:319–28
134. 134. Zimmerman SS, Tuxal B. 1981. Carbon monoxide poisoning. Pediatrics 68:215–33

Chapter 11

Child Housing Assessment for a Safe Environment (CHASE): a new tool for injury prevention inside the home

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In Review Injury Prevention

ABSTRACT

Objective: To develop a tool to assess the safety of the home environment that could produce valid measures of a child's risk of suffering an injury.

Methods

Tool Development

A four-step process was utilized to develop the CHASE tool, including: 1) a literature scan 2) reviewing of existing housing inspection tools 3) key informants interviews 4) reviewing the National Electronic Injury Surveillance System to determine the leading housing elements associated with pediatric injury.

Retrospective Case Control Study to Validate CHASE Tool

Recruitment included case (injured) and control (sick but not injured) children and their families from a large, urban pediatric emergency department (PED) in Baltimore, Maryland in 2012. Trained inspectors applied both the well-known Home Quality Score (HQS) and the CHASE tool to each enrollee's home and we compared scores on individual and summary items between cases and controls.

Results

Twenty-five items organized around twelve subdomains were included on the CHASE tool. 71 matched pairs were enrolled and included in the analytic sample. Comparisons between cases and controls revealed statistically significant differences in scores on individual items of the CHASE tool as well as on the overall score with the cases systematically having worse scores. No differences were found between groups on the HQS measures.

Conclusion

Programs conducting housing inspections in the homes of children should consider including the CHASE Tool as part of their inspection measures. Future study of the CHASE Inspection tool in a prospective trial would help assess its efficacy in preventing injuries and reducing medical costs.

INTRODUCTION

Children experience injuries in their home environments at unacceptably high rates: an average of 1,870 children younger than 15 die in a home injury annually in the United States.[1] An additional estimated 2.8 million children younger than 12 experience non-fatal home injuries every year. For every death, there are almost 1,600 nonfatal home injuries.[2] The World Health Organization recognizes unintentional injuries as a leading cause of death to children and identify their reduction as a priority. [3] The poor and certain minority populations are disproportionately affected by home injuries, though racial disparities seen in injury rates most likely have more to do with living in unhealthy environments and a host of social disparities rather than race or ethnicity.[4-8] Housing conditions in low-income neighborhoods (e.g., poor-quality structures, faulty electrical wiring) likely contribute to low-income families' increased risk for home injury. [9-11]Residents of substandard housing are at increased risk for fire, electrical injuries, lead poisoning, falls, rat bites, and other injuries.[12-16] Several studies in the USA, UK and Europe have found that children living in socioeconomically disadvantaged neighborhoods are at increased risk of home injury, even after accounting for individual-level background factors.[9, 11,17-18] Moreover, a case-control study in New Zealand [19] measured the association between home injury hazards and home injury. With each additional injury hazard observed in the homes, there was a 22% increase in the odds of injury occurrence, suggesting that addressing injury hazards in the home may be effective in reducing home injury.

Decades of research and practice have led to an extensive body of evidence about effective home safety modifications [20,21] (e.g., smoke alarms cut the risk of death in a house fire in half).[22-23] Studies of smoke alarm canvassing and installation programs provide successful examples of modifying the home environment to reduce home injury risk to children.[24-27] Another widely cited example of successfully modifying housing conditions to reduce child injury is New York City's "Children Can't Fly" program[28] which installed window guards on high-rise apartments and is credited with significant reductions in morbidity and mortality due to falls from windows. The success of the program resulted in a legislative change that required landlords to provide window guards and further reductions in falls from windows where achieved.[28]

The benefits of home safety modifications have not reached all segments of society. Socio-economic inequalities have been documented in the adoption and use of specific home safety products (i.e. smoke alarms and stair gates). [7] Low-income families face many barriers including limited access to safety products and injury prevention information, along with the poverty-related housing conditions described above can be significant barriers to child safety. [29-32] Data from our own observations in low income areas of East Baltimore found presence

of at least one working smoke alarm ranged from 55% to 82%[33,34], 41% of homes had unsafe water temperatures[35] and only 10% of families with young children kept any of their poisonous substances locked[29, 34]. Almost all (97%) of families in one study reported keeping their prescription medications unlocked.[36]

Housing programs provide a promising opportunity to deliver evidence-based home safety modifications. The U.S. Department of Housing and Urban Development (HUD) is the largest provider of housing assistance in the United States with approximately 5 million subsidized units available.[37] HUD's primary mission is to "create strong, sustainable, inclusive communities and quality affordable homes for all".[38] Since 1999 HUD has been transitioning from a focus on lead hazard control to a more comprehensive approach aimed at reducing multiple environmental hazards in homes including lead, mold, asthma and injury risks. This transition was marked by an expansion of the name to the Office of Healthy Homes and Lead Hazard Control. This office (still known as "HUD") ensures homes have acceptable indoor air quality, and do not expose occupants to toxic chemicals, biologic contaminants, and injury hazards which are known to affect the health and safety of residents.

Despite this understanding of the burden of injuries in the home environment and the evidence base for reducing injury risks via modifications, the housing inspection tools used by HUD have few items related to injury. Housing inspections are a required component for homes to qualify as rental assistance properties. The largest of HUD's housing assistance programs is the Housing Choice Voucher Program ("Section 8" housing) with 2.2 million properties [39] The Housing Choice Voucher Program provides financial assistance in the form of a monthly voucher to assist with the rental payments. In order to qualify for rental assistance, properties must be deemed "decent, safe and sanitary" according to HUD's housing quality standards as determined by their inspection system. The form used to guide inspections is the HOME Housing Quality Standards (HQS) Inspection Form and trained housing inspectors are certified to complete annual assessments.[40] The 120 HQS items focus primarily on structural housing elements and some neighborhood features, along with a few injury prevention measures. We undertook a study to improve the HQS (and other similar housing hazard assessment tools) to systematically identify and remediate child injury hazards in the home, something that has not been previously reported in the peer reviewed literature.

This paper reports on the development and utilization of the CHASE (Child Housing Assessment for a Safer Environment) housing inspection tool designed to reduce injury risks in the homes of children. In a small retrospective study, we assessed the ability of the CHASE and HQS tools to discriminate between homes that are associated with a child injury vs. not. In section one we describe the development of the CHASE tool. In section two we describe the methods and the results of the case control study s in a sample of low income, urban households

with children. We tested the null hypothesis that both the new CHASE tool and the existing HQS tool would have similar capability to distinguish homes where there had been a recent injury vs. homes where there had not. This study was approved by the Johns Hopkins Bloomberg School of Public Health Institutional Review Board.

METHODS

Tool Development

We developed the CHASE tool through a four-step process: 1) a scan of the currently available literature to determine the epidemiology and risk factors for the leading causes of unintentional home injury and death among children; 2) a review of existing housing inspection tools to identify items for inclusion on the CHASE housing inspection tool; 3) phone and in-person interviews with key informants in the healthy housing and housing inspection community to determine how items were chosen for inclusion on their inspections tools; and 4)a review of the housing elements in the National Electronic Injury Surveillance System to determine the leading housing elements associated with child injury emergency department visits and hospitalizations.[29] The investigators then developed an inspection protocol for each of the items selected for inclusion on the CHASE tool and a training program for inspectors (data collectors). Finally, cost estimates for each CHASE item were determined by searching online for product prices and discussing labor costs with home maintenance professionals.

Prospective Case Control Study

Study Population

We recruited children from a large, urban pediatric emergency department (PED) in Baltimore, Maryland. Families were enrolled between January and December 2012 if they met the following enrollment criteria: (1) child aged from birth to 7 years, (2) child had a PED visit that was not a follow-up visit, (3) child was discharged home, (4) home address in Baltimore City or County, (5) parent/guardian spoke English, (6) child lived with the parent/guardian most of the time, and (7) the injury occurred in the home where the child lived most of the time (cases). Controls met all of the above inclusion criteria except that their chief complaint for the PED visit was for illness-related symptoms, not an injury. Participants were matched on variables associated with injury risk including, age, gender race, and type of housing during recruitment.

Recruitment

We recruited parents in person in the PED or by mail or phone if the child visited the PED during hours when study staff were not available or were discharged before study staff approached the parent. In the PED, potentially eligible children were identified by reviewing the PED tracking board. Parents of age-eligible children were approached if the child presented with a chief complaint consistent with a home injury and one of the following four injury categories: 1) fall; 2) struck by/against; 3) fire/burn; or 4) cut/pierce or one of the following illness-related chief complaints: 1) fever; 2) wheezing; 3) vomiting; 4) seizure; 5) ear pain; 6) difficulty breathing; 7) cough; 8) rash; 9) abdominal pain; or 10) congestion. For parents who were missed in the PED, potentially eligible children were identified by reviewing patient discharge records. A child was excluded from the study if suspicion of abuse was noted on the tracking board or in child's medical record.

CHASE Tool Training and Inspection Protocol

Data collectors were trained to inspect and code items according to a standardized inspection protocol for both CHASE and HQS. A field inspection guide was developed with pictures to demonstrate the pass and fail criteria. Data collectors completed human subjects training, standard data collection training, and ten hours of training in conducting the home inspection protocol. Data collectors were observed completing the inspection protocol by the research team prior to being eligible to complete it on their own.

In-Home Data Collection Protocol

A team of two data collectors completed the home visits within one to eight weeks following the PED visit. The home visit included an interview with the parent/guardian who accompanied the child to the PED and an inspection of the home with the CHASE tool. Parents were informed about the study at the time of initial contact and written informed consent was obtained from the parent/guardian at the time of the home visit. The inspection involved completing both the HQS and the CHASE by observing each floor of the household, including specifically selected rooms: kitchen, living room, (or room where the child spent the most time), child's bedroom, and bathroom most often used by the child. Data collectors also looked for (and tested) smoke alarms on every floor, including attics and basements whenever possible.

Measures

Socio-Demographics

The in-home parent interview assessed demographic information, including parent self-reported race and ethnicity, parent education level, and estimated household income. We classified families as being above or below the Federal Poverty Level (FPL) based on the reported household income and the number of people supported with that income.

Household Characteristics

The home was classified based on parent self-report during the recruitment process into one of four housing categories: (1) row house, town house, or duplex, (2) detached single family home, (3) apartment in a house, (4) apartment in a building.

Housing Inspection Measures

Data collectors were kept blinded about the case/control status of enrollee households. When they reached the homes, they were instructed not to ask about the child's case/control status. Each data collector completed both HUD's Housing Quality Standards (HQS) inspection form,[40] and the CHASE tool. A total of 20 HUD HQS sub-domains were included. HQS subdomains cover a comprehensive group of measures related to the adequacy and structural integrity of the home including an inspection of the condition of windows, floors, walls, ceiling, plumbing, stairs, cooking facilities etc. HQS subdomains also include examination for electrical hazards, lead based paint, security risks and smoke alarms. Exterior items (I.e. roof, gutters, chimney) from the HQS were not included in our inspection because our focus was on in-home injuries. A total of 25 CHASE items within 12 sub-domains were also inspected. HQS and CHASE items were coded as pass or fail based on the study protocol and the existing HQS standards. Failing any item within a subdomain resulted in a failure on that subdomain (e.g., failing on a book case, entertainment center hazard resulted in failing the sub-domain "tipping hazards" on the CHASE; any broken window resulted in failing the corresponding sub-domain "window condition" subdomain on the HQS).

Statistical Analysis

All statistical analyses were performed using SPSS statistical software version 25. Frequency distributions were used to report on the pass/fail rate on the CHASE and HQS. Univariate comparisons of sociodemographic characteristics between the cases (injured) and controls (sick, not injured) were made using the chi-square statistic for categorical variables. The primary analyses were the comparison between the cases and controls of the CHASE sub-domain and the HQS sub-domain score, using the average pass rate across all sub-domains.

Children were matched on age, gender and type of housing. Matched conditional logistic regression was performed in SPSS, which is analogous to a paired t-test. Each estimated beta coefficient is interpreted as a standard regression estimate. Separate models were run for the CHASE sub-domains and the HQS sub-domains. The matched logistic regression models were adjusted by including education level, poverty status, and rental status, such that the resulting regression estimate accounts for these key covariates.

RESULTS

CHASE Housing Inspection Tool Development

Twenty-five items organized around twelve subdomains were included on the CHASE tool. Pass criteria, inspection protocol, inspection recommendations, supporting literature and cost estimates were provided for each CHASE item. Consistent with the organization of the HQS, the CHASE items were similarly organized around the sub-domains of different injury causes: household water temperature (1 item), bathroom fall hazards (2 items), fire escape (3 items), electrical safety concerns (4 items), electrical tripping hazards (1 item), protruding nails (1 item), tipping hazards (5 items), carbon monoxide alarms (1 item), poison storage (2 items), interior stair safety (2 items), window fall safety (2 items), and smoke alarms (1 item). (see supplemental file)

Sample

A total of 1023 families were invited to participate in the study; 176 families were enrolled and completed the home visit. Of the non-participants, 97 were screened eligible but did not complete the home visit, 162 were ineligible, 191 refused screening, and 397 were never reached. Among the 176 families enrolled, 71 matched pairs were identified for inclusion in the analytic sample; 34 families (2 cases, 32 controls) were not included because a suitable match was not identified. Children included in the analytic sample were predominately African American (82.9%) boys (60.6%), with a mean age of 2.5 years. The majority of parents/guardians were unmarried (64.3%), women (93%), with a high school education or greater (74.6%), lived above the federal poverty level (55.6%), in rented (81%) row houses (78.2%). No significant differences were found between the cases and controls on demographic factors. (see Table 1)

Table 1. Demographics

Variable	Non Injured Group (N=71)		Injury Group (N=71)	
Child Age (years)	Mean 2.54	SD 1.75	Mean 2.51	SD 1.69
	Frequency	Percent	Frequency	Percent
Child Gender				
Boy	43	60.6%	43	60.6%
Girl	28	39.4%	28	39.4%
Respondent Education				
Less than high school	12	16.9%	23	32.4%
High school graduate	24	33.8%	15	21.1%
More than high school	34	47.9%	33	46.5%
Poverty				
Yes	29	40.8%	36	50.7%
Rental Status				
Rent	56	78.8%	59	83.1%
Own/Pay Mortgage	13	18.3%	12	16.9%
Marital Status				
Single	49	69.0%	41	57.7%
Married	20	28.2%	30	42.3
Race				
AA	59	83.1%	57	80.3%
Other	10	14.1%	14	19.7%

Note. No significant differences were found between demographic variables among the injured and sick groups.

CHASE Tool

Individual item pass rates varied greatly across CHASE items, from 0% having medication locked and 13% having window guards to 88% being free of furniture crowding and 87% having proper exits. The majority of households had safe water temperatures (54%), and CO alarms (68%). However, most households also had failure rates greater than 50% for bathroom fall hazards (89%), furniture and TV tipping hazards (99%), lack of a secure place to store medications and household poisons (100%), issues with stair safety (80%), window fall risks (85%), and window choking hazards (61%). The overall percent of subdomains passed was 54% for cases, 59% for controls. (See Table 2)

Table 2. CHASE Sub-Domain total and individual variables

	Controls (Sick)		Cases (Injured)			Total	
CHASE Sub-Domain (CSD)	Frequency	% pass	Frequency	% pass	*p*-value	Frequency	% pass
CSD 1.1: fire hazard	64	90.1	65	91.5	0.419	129	90.8
CSD 1.2: breaker	43	60.6	52	73.2	0.903	95	66.9
SD 1.3 overload	54	76.1	41	57.7	0.039	95	66.90
CSD 1.4: UL or FM	44	62.0	51	71.8	0.427	95	66.9
CSD 2.1: Emergency exits	64	90.1	59	83.1	0.584	123	86.6
CSD 3.1: Window Blind Cord	37	52.1	19	26.8	0.057	56	39.4
CSD 3.2: Window Guard	8	11.3	11	15.5	0.612	19	13.4
CSD 4.1: Protruding Nail	41	57.7	32	45.1	0.107	73	51.5
CSD 5.1: Bookcase tip	49	69.0	47	66.2	0.494	96	67.6
CSD 5.2: Entertain center Tip	45	63.4	44	62.0	0.104	89	62.7
CSD 5.3: Flat TV Tip	33	46.5	27	38.0	0.715	60	42.3
CSD 5.4: Stove & Oven	37	52.1	41	57.7	0.516	78	54.9
CSD 5.5: Tube TV	25	35.2	31	43.7	0.701	56	39.4
CSD 6.1: Crowding	61	85.9	64	90.1	0.564	125	88.0
CSD 6.2: furniture crowd	56	78.9	61	88.7	0.584	117	82.4
CSD 7.1: Medicine Lock	0	0	0	0	na	0	0
CSD 7.2: Household lock	52	73.2	54	76.1	0.280	106	74.6
CSD 7.3: Childproof caps	47	66.2	41	57.7	0.520	88	62.0
CSD 8.1: Hot water	39	54.9	38	53.5	0.323	77	54.2
CSD 9.1 Bath tub grab bar	13	18.3	9	12.7	0.662	22	15.5
CSD 9.2: Non-slip	33	46.5	34	47.9	0.776	67	47.2
CSD 10.1: Handrail	46	64.8	33	46.5	0.050	79	55.6
CSD 10.2: Safe steps	27	38.0	13	18.3	0.020	40	28.2
CSD 11.1: CO alarm	47	66.2	49	69.0	0.596	96	67.6
CSD 12.1: Electric tripping	56	78.9	50	70.4	0.027	106	74.6
	Avg. % Sub-domains passed		Avg. % Sub-domains passed			Avg. % Sub-domains passed	
Chase Sub-Domain Score	59%		54%		0.034	57%	

†Adjusted paired regression analysis included education level, poverty status, and rental status.

HQS Tool

Individual item pass rates ranged from a low of 61% having a working smoke alarm on all levels to a high of 98% being free of signs of garbage. Pass rates on the HQS measures were generally high with 91% on average of subdomains passed for the total group (90% for cases, 92% for controls). (see Table 3)

Table 3. HQS Sub-Domain total and individual variables

	Controls (Sick)		Cases (Injured)			Total	
HQS Sub-Domain (HSD)	Frequency	% pass	Frequency	% pass	*p*-value	Frequency	% pass
HSD 1.1: Electrical Hazards	55	77.5%	46	64.8%	0.049	101	71.1
HSD 1.2: Electrical	63	88.7%	66	93.0%	0.904	129	90.8
HSD 2.1: Ceiling	64	90.1%	60	84.5%	0.058	124	87.3
HSD 2.2: Floor	59	83.1%	67	94.4%	0.066	126	88.7
HSD 2.3: Walls	65	91.5%	66	93.0%	0.507	131	92.3
HSD 3.1: Bathroom Present	71	100%	71	100%	na	142	100
HSD 3.2: Bathroom Sink	64	90.1%	66	93%	0.317	130	91.5
HSD 3.3: Toilet	67	94.4%	65	91.5%	0.200	132	93.0
HSD 3.4: Bathroom Tub	67	94.4%	67	94.4%	0.969	134	94.4
HSD 3.5: Bathroom Ventilation	61	85.9%	63	88.7%	0.435	124	87.3
HSD 3.6: Kitchen Stove	65	91.5%	64	90.1%	0.914	129	90.8
HSD 3.7: Kitchen Present	71	100%	71	100%	na	142	100
HSD 3.8: Kitchen Refrigerator	70	98.6%	69	97.2%	0.951	139	97.9
HSD 3.9: Kitchen Sink	67	94.4%	68	95.8%	0.686	135	95.1
HSD 3.10: Kitchen Storage	71	100%	70	98.6%	na	141	99.3
HSD 4.1: Fire Exists	71	100%	69	97.2%	0.953	140	98.6
HSD 4.2 Signs of garbage	69	97.2%	70	98.6%	0.936	139	97.9
HSD 4.3: Evidence of Infestation	57	80.3%	59	83.1%	0.888	116	81.7
HSD 4.4: Security	62	87.3%	62	87.3%	0.850	124	87.3
HSD 4.5: Smoke Detectors	45	63.4%	41	57.7%	0.545	86	60.6
HSD 4.6: Stairs	66	93.0%	63	88.7%	0.220	129	90.8
HSD 4.7: Windows	60	84.5%	57	80.3%	0.334	117	82.4
HSD 5.1: Heating	50	70.4%	52	73.2%	0.778	102	71.8
	Avg. % Sub-domains passed		Avg. % Sub-domains passed			Avg. % Sub-domains passed	
HQS Sub- Domain Score	92.03%		90.10%		0.249	91.1%	

Comparison Between Cases and Controls

Significant differences in pass rates were found between the cases and controls on the following CHASE items: overloaded electrical outlets (58% vs 76%), inadequate or missing handrails (47% vs 65%), unsafe steps (18% vs 38%), and electrical tripping hazards 70% vs 79% with the cases being significantly less likely to pass. No differences were found between groups on the HQS measures. In the adjusted paired regression analysis of the overall average pass rates, case status was significantly associated with the CHASE sub-domains such that cases compared to controls were significantly less likely to pass -4.527 (2.13)(p=034)

(see Table 4) The HQS subdomain model analyses suggest no difference in scores between cases and controls. (see Table 4)

Table 4. Chase & HQS Sub-Domain Pass Rates

	Non-Injured	Injured	Unadjusted paired Regression	Adjusted paired regression†
	Avg. % Sub-domains passed	Avg. % Sub-domains passed	Beta (S.E.), p-value	Beta (S.E.), p-value
Chase Sub- Domain Score	59%	54%	-3.315 (1.48), p=.025	-4.527 (2.13), p=.034
HQS Sub- Domain Score	92.03%	90.10%	-.033 (.023), p=.153	-.031 (.027), p=.249

†Adjusted paired regression analysis included education level, poverty status, and rental status.

DISCUSSION

These results add to the literature by demonstrating the potential of an improved home inspection tool to contribute to child injury prevention.[41]Our findings also demonstrate that not all tools are equal in terms of identifying injury hazards and injury risk. The CHASE tool was statistically significantly more likely to result in a non-passing score in homes of injured children compared to homes of matched non-injured controls. The CHASE tool differs from the HQS in that it explores areas which are specifically related to housing conditions that are hazardous to children i.e. securing furniture tipping hazards and locking medicines. The authors believe that assisting parents by addressing injury measure with the same attention as the HQS is used to address failures in measures of structural housing condition would greatly reduce injury risks in homes. Our findings in the current study are consistent with our own previous work as well as the work of others. Data from our own observations in low income areas of East Baltimore found that 41% of homes had unsafe water temperatures and only 10% of families with young children kept any of their poisonous substances locked.[34,32] Almost all (97%) of families in one study reported keeping their prescription medications unlocked which is consistent with the finding in the current study which found that no families were storing their medicines in a locked place.[35]

While the results offer important insights about home inspection tools and identifying injury risks, they should be interpreted in the context of several limitations. The proportion of those recruited and enrolled was low (17%). Reasons for refusal and differences between those who enrolled and those who did not is unknown. Resources limited our control sample to one per case; having multiple controls per case would have strengthened our findings. We included children with four types of injuries and did not attempt to associate type of injury

with specific inspection failures. Findings suggest an overall association, which may be due to other unmeasured factors. Even though the multivariate analysis controlled for household economic status there may be other unmeasured confounders that correlate with both injury and items on the CHASE tool. For instance, the intensity of parental monitoring is known to correlate with child injury and may also be associated with a lack of vigilance against household hazards. It cannot be assumed that structural hazard correction will also ameliorate parental monitoring. Findings from this study are based on a sample of homes in an urban environment. The extent these to which these results are generalizable to other environments (e.g. rural, newer construction etc.) is unknown. An additional consideration is the fact that we used non-injured patients as controls. This allowed us to explore the hypothesis that injury status could be associated with household injury measures which was a strength of the design. However, it may be the case that there are inherent differences between families of children seeking non-urgent health care in the emergency department and families of injured children which were not fully anticipated or controlled for with our study design. Future work with a larger sample might be able to examine associations between the types of injury in relation to explanatory hazards in the home.

The recognition of the relationship between housing and health and the existence of home inspection programs offers opportunities for injury prevention professionals concerned with home injuries to collaborate with the growing healthy housing community to reduce home injuries. Housing professionals' access to and knowledge about homes, and their ability to inform housing policy complements injury prevention professionals' understanding of injury and associated risks. Broad dissemination and use of the CHASE tool has the potential to decrease injury risk in homes served by existing inspection programs that are not currently addressing injury hazards in the home.

CONCLUSION

Programs conducting housing inspections in the homes of children should consider including the CHASE Tool as part of their inspection measures. Future research should utilize the CHASE Inspection tool in a prospective sample of homes to determine its efficacy in preventing injuries and reducing medical costs.

REFERENCES

1. Gielen A.C., McDonald E.M., Shields W. Unintentional Home Injuries Across the Life Span: Problems and Solutions. Annu Rev Public Health. 2015;36(1):231-253. doi:10.1146/annurev-publhealth-031914-122722.
2. Runyan C., Casteel C. The State of Home Safety in America: Facts about Unintentional Injuries in the Home. Washington, DC; 2004.
3. Shenassa E.D., Stubbendick A., Brown M.J. Social disparities in housing and related pediatric injury: a multilevel study. Am J Public Health. 2004;94(4):633-639.
4. Fallat M.E., Costich J, Pollack S. The impact of disparities in pediatric trauma on injury-prevention initiatives. J Trauma. 2006;60(2):452-454. doi:10.1097/01.ta.0000196936.72357.2e.
5. Bernard S.J., Paulozzi L.J., Wallace D.L.J., Centers for Disease Control and Prevention (CDC). Fatal injuries among children by race and ethnicity--United States, 1999-2002. MMWR Surveill Summ. 2007;56(5):1-16.
6. Kendrick D., Mulvaney C., Watson M. Does targeting injury prevention towards families in disadvantaged areas reduce inequalities in safety practices? Health Educ Res. 2009;24(1):32-41. doi:10.1093/her/cym083.
7. Bishai D., McCauley J., Trifiletti L.B., McDonald E.M., Reeb B., Ashman R., & Geilen A.C. The Burden of Injury in Preschool Children in an Urban Medicaid Managed Care Organization. Ambul Pediatr. 2002;2(4):279-283. doi:10.1367/1539-4409(2002)002 <0279:TBOIIP>2.0.CO;2.
8. Reading R., Langford I.H., Haynes R., Lovett A. Accidents to preschool children: comparing family and neighbourhood risk factors. Soc Sci Med. 1999;48(3):321-330.
9. Lyons R.A., Newcombe R.G., Jones S.J., Patterson J., Palmer S.R., Jones P. Injuries in homes with certain built forms. Am J Prev Med. 2006;30(6):513-520. doi:10.1016/ j.amepre.2006.02.007.
10. Haynes R., Reading R., Gale S. Household and neighbourhood risks for injury to 5-14 year old children. Soc Sci Med. 2003;57(4):625-636.
11. Krieger J, Higgins DL.Housing and health: time again for public health action.Am J Public Health. 2002 May;92(5):758-68. Review.
12. United States Department of Health and Human Services. Tracking Healthy People 2010. Washington, DC; 2000.
13. Aherns M. Characteristics of Home Fire Victims. Quincy, MA; 2014. http://www.nfpa.org/ news-and-research/fire-statistics-and-reports/fire-statistics/demographics-and-victim-patterns/characteristics-of-home-fire-victims.
14. An Overview of the U.S. Fire Problem. Quincy, MA; 2017. http://www.nfpa.org/news-and-research/fire-statistics-and-reports/fire-statistics/fires-in-the-us.
15. Campbell R. Electrical Fires. Quincy, MA; 2017.
16. Durkin M.S., Davidson L.L., Kuhn L, O'Connor P, Barlow B. Low-income neighborhoods and the risk of severe pediatric injury: a small-area analysis in northern Manhattan. Am J Public Health. 1994;84(4):587-592.
17. O'Campo P., Rao R.P., Gielen A.C., Royalty W., Wilson M. Injury-producing events among children in low-income communities: the role of community characteristics. J Urban Health. 2000;77(1):34-49. doi:10.1007/BF02350961.
18. Reimers A., Laflamme L. Neighbourhood social and socio-economic composition and injury risks. Acta Paediatr. 2005;94(10):1488-1494.
19. Keall M.D., Baker M., Howden-Chapman P., Cunningham M. Association between the number of home injury hazards and home injury. Accid Anal Prev. 2008;40(3):887-893. doi:10.1016/j.aap.2007.10.003.
20. Watson M C and Errington G. Preventing unintentional injuries in children: successful approaches. Paediatrics and Child Health. 2016; 26(5), 194-199.
21. Hemenway D. While We Were Sleeping. Success Stories in Injury and Violence, Berkeley: University of California Press, 2009
22. Runyan CW, Bangdiwala SI, Linzer MA, et al. Risk factors for fatal residential fires. N Engl J Med 1992;327:859–63.

23. Hall JR Jr. The U.S. experience with smoke detectors: Who has them, How well do they work?When don't they work? NFPA J 1994:36–46.
24. Gielen A.C., Shields W., Frattaroli S., McDonald E., Jones V., Bishai D., O'Brocki R., Perry E.C., Bates-Hopkins B, Tracey P & Parsons S. Enhancing fire department home visiting programs: results of a community intervention trial. J Burn Care Res. 2013;34(4):e250-6. doi:10.1097/BCR.0b013e3182685b3a.
25. Ta V.M., Frattaroli S., Bergen G., Gielen A.C. Evaluated community fire safety interventions in the United States: a review of current literature. J Community Health. 2006;31(3):176-197.
26. Ballesteros M.F., Jackson M.L., Martin M.W. Working toward the elimination of residential fire deaths: the Centers for Disease Control and Prevention's Smoke Alarm Installation and Fire Safety Education (SAIFE) program. J Burn Care Rehabil. 2005;26(5):434-439.
27. Cooper N.J., Kendrick D., Achana F., Dhiman P., Zhimin H., Wynn P., Le Cozannet E., Saramago P. & Sutton A.J. Network meta-analysis to evaluate the effectiveness of interventions to increase the uptake of smoke alarms. Epidemiol Rev. 2012;34(1):32-45. doi:10.1093/epirev/mxr015.
28. Spiegel C.N., Lindaman F.C. Children can't fly: a program to prevent childhood morbidity and mortality from window falls. 1977. Inj Prev. 1995;1(3):194-198.
29. Gielen A.C., Wilson M.E., Faden R.R., Wissow L., Harvilchuck J.D. In-home injury prevention practices for infants and toddlers: the role of parental beliefs, barriers, and housing quality. Health Educ Q. 1995;22(1):85-95.
30. Cubbin C., Smith G.S. Socioeconomic inequalities in injury: critical issues in design and analysis. Annu Rev Public Health. 2002;23(1):349-375. doi:10.1146/annurev.publhealth. 23.100901.140548.
31. LeBlanc J.C., Pless I.B., King W.J., Bawden H., Bernard-Bonnin A.C., Klassen T. & Tenenbein M. Home safety measures and the risk of unintentional injury among young children: a multicentre case-control study. CMAJ. 2006;175(8):883-887. doi:10.1503/ cmaj.050592.
32. Kendrick D., Mulvaney C., Burton P., Watson M. Relationships between child, family and neighbourhood characteristics and childhood injury: A cohort study. Soc Sci Med. 2005;61(9):1905-1915. doi:10.1016/j.socscimed.2005.04.003.
33. Gielen A.C., McDonald E.M., Wilson M.E.H., Hwang W.T., Serwint J.R., Andrews J.S. & Wang M.C. Effects of improved access to safety counseling, products, and home visits on parents' safety practices: results of a randomized trial.
34. Chen L-H., Gielen A.C., McDonald E.M. Validity of self reported home safety practices. Inj Prev. 2003;9(1):73-75.
35. Shields, W.C., McDonald, E., Frattaroli, S., Perry, E.C., Zhu, J., & Gielen, A.C. Still too hot: Examination of water temperature and water heater characteristics 24 years after manufacturers adopt voluntary temperature setting. Journal of Burn Care Research, 2013 Mar-Apr;34(2):281-7
36. Frattaroli S., Shields W., Omaki E., Molloy M., Gielen A.C. How Are Prescription Medications Stored in Urban Homes Where Children Live? Opportunities for Poisoning Prevention. Clin Pediatr (Phila). September 2016. doi:10.1177/0009922816668631.
37. Housing Choice Voucher Program Guidebook. Chapter 10: housing quality standards. US Department of Housing and Urban Development Web Site. Available at: https://www. hud.gov/sites/documents/DOC_35620.PDF Accessed October 25, 2018.
38. United States Department of Housing and Urban Development. Healthy Home Rating System. Retrived from https://www.hud.gov/program_offices/healthy_homes/hhrs Accessed October 25, 2018.
39. https://www.cbpp.org/housing-choice-voucher-fact-sheets Accessed October 25, 2018.
40. United States Department of Housing and Urban Development. (2018, April 30). Housing Choice Voucher Program Inspection Form. https://www.hud.gov/sites/documents/52580-A.PDF Accessed October 25, 2018.
41. R. L. Morley, R. L., Mickalide, A. D. & Mack, K. A. (Eds.) (2011). Healthy and safe homes: Research, practice, and policy Washington, DC: American Public Health Association Press.

Appendix 1. Chase Tool

Subdomain [population of interest]	Pass Criteria	Statistics about Hazards	Housing inspection recommendation	Cost	
				Product	Labor
Hot water [All]	Hot water is 120 degrees Fahrenheit and below.	According to the U.S. Consumer Product Safety Commission, nearly 3,800 injuries and over 30 deaths occur in the home each year due to hot water burns.[3,4] In the United States, the annual cost for scald burn deaths and injuries from all causes among children 14 years and younger is about $44 million. Children younger than 5 years old contribute to 90% of this cost.[5]	Test, adjust, and retest water to ensure water temperature is not above 120 degrees Fahrenheit. Consider installing scald prevention devices.	Thermostatic Mixing Valve (>$100 per valve)[1] Bathtub thermometer (~$12)[1] Candy thermometer (~$5)[1]	TMV installation ($150)[2]
Bathroom Fall Hazards [Seniors]	Having a permanently affixed non-slip treads/ material, non-slip mat, or non-slip decals in the tub/shower Having a grab bar in the tub/shower	More than 43,000 children younger than 18 years old are treated in an emergency room each year after a bathroom or shower related injury. Slipping and falling caused 81 percent of all injuries.[6] For people aged 15 years old or greater, falls are responsible for 81% of all bathroom injuries.[7] The bathroom was found to be the most hazardous room in the home for falls (previously thought to be second behind the kitchen).[8]	Install a grab bar and non-slip surface in all tubs/showers.	$40[1]	
Fire Escape [All]	Having at least two exits in the room	80.7% of all fire deaths, occurred in the home, this is an increase of 6.8% compared to 2015.[9]	Make sure that every room in the home has at least 2 exits.	N/A	
Crowding [All]	No furniture in the room or placement/ amount of items		Adjust furniture placement so that no	N/A	

Subdomain [population of interest]	Pass Criteria	Statistics about Hazards	Housing inspection recommendation	Cost	
				Product	Labor
	allows for freedom of movement Furniture and other items in the living room are arranged in such a way that you can easily enter/ exit the room	There was a civilian fire death every 2 hours and 35 minutes and a civilian fire injury every 35 minutes 54 seconds in 2016. [9] In 2016, there were an estimated 352,000 reported home structure fires and 2,735 associated civilian deaths, and 14,650 civilian injuries in the United States.[9] Fire and burn injuries cost about $7.5 billion each year.[10]	furniture would restrict one from moving around and entering/ exiting the room.		
Electrical Safety Concerns [All]	Power strip has a UL or FM label Power strip has a toggle/ switch, breaker or fuse Electrical outlets are not overloaded No electrical or extension cords are a fire hazard	Between 2010 and 2014, U.S. municipal fire departments responded to an average of 45,210 home structure fires involving electrical failure or malfunction. These fires caused annual averages of 420 civilian deaths, 1,370 civilian injuries, and $1.4 billion in direct property damage.[11] Roughly half (57%) of home electrical failure fires from 2010-2014 involved electrical distribution or lighting equipment. Of 31,960 non-confined home structure fires involving electrical distribution or lighting equipment, there were 400 civilian deaths, 1,180 civilian injuries, and $1.2 billion in direct property damage per year.[11]	Make sure that all electrical outlets and power strips are not presenting any fire hazards, are not overloaded, and have a proper switch and label.	$10-25/strip $15-25/outlet[2]	$10-25/strip $50-75/ outlet (or more)[2]
Electrical Tripping Hazards [All]	No electrical or extension cords are a tripping hazard	An estimated 3,300 residential fires originate from extension cords each year, killing and injuring over 300 people.12 More than half of the injuries from tripping over extension cords involved fractures, lacerations, contusions, or sprains.13	Reposition/ rerun electrical cords so they are no longer a tripping hazard.	$20-60/2	$40-75/2

Subdomain [population of interest]	Pass Criteria	Statistics about Hazards	Housing inspection recommendation	Cost	
				Product	Labor
Protruding Nails [All]	No protruding nails/screws in the walls and floors that could cause someone to cut themselves	A query of 2008 NEISS data for children under 18 indicated that there were 31,243 annual injuries associated with protruding nails.14	Remove and replace (or hammer in) all protruding nails.	$0-15/ area2	$20-100/ area2
Tipping Hazards [Children]	No entertainment center 4 feet above the ground is present in the room or if present in this room, it is secured to the wall No bookcases are present in the room or if present in this room, it is secured to the wall No flat screen TVs are present in the room or if present in this room, it is secured to the wall No traditional TVs are present in the room or if present in this room, it is secured to the wall Stove must be secured to wall or cabinet/counter	An average of 30,700 “falling furniture” injuries are reported annually, 52% involved children.15 Each day, more than 40 children younger than 18 years old visit the emergency department for injuries from furniture tip-overs.15	Move entertainment centers, bookcases, and TVs to places where they are less than 4 feet above the ground. Secure stove to the wall or cabinet.	Furniture Wall Straps- 2 pack ($10.00)1 Too variable to price2	Too variable to price2
Carbon Monoxide Alarm [All]	Having at least one working CO alarm in the home	An average of 439 people died annually during 1999-2004 from unintentional, non-fire related CO poisoning.[16] The CDC estimated an average of 20,636 nonfatal, unintentional, and non-fire related CO exposures were seen in the ER each year from 2004-2006.[17]	Check/install carbon monoxide alarms in the home.	CO alarm (battery operated) ($15)[1]	$25-40[2]

Subdomain [population of interest]	Pass Criteria	Statistics about Hazards	Housing inspection recommendation	Cost	
				Product	Labor
		CO alarms are one of the most important protective devices for preventing CO exposure and poisoning in the homes.[18]			
Poison Storage [Children]	All prescription medicines, over-the-counter medicines and household products are locked away All prescription and over-the-counter medicines have childproof caps	In 2008, over 41,000 people died as a result of poisoning.[19] It was noted that in 2008, the number of poisoning deaths exceeded the number of motor vehicle traffic deaths for the first time since at least 1980. Poisoning is now the leading cause of death from injuries in the US, increasing from 3.0 per 100,000 in 1979 to 13.1 per 100,000 in 2012. [20] 91% of unintentional poisoning deaths are caused by drugs, mainly opioid pain medicaitons.[20] 46.4% of the 2.159 million calls to Poison Help Number in 2016 involved children ages 5 and younger. 85.1% of poisonings occur at home without a visit to the ER or physician.[20]	Check medicine cabinet to make sure all medicines are locked and closed with childproof caps.	Cabinet slide lock ($2.00 per lock)[1]	
Interior Stairs Safety [All]	Stairs are perfect and safe. There are no loose or broken steps, damages or uneven surfaces, disrepair or other safety threats? The risers are not greater than 7.75" in height and are consistent. The treads are not less than 10" in depth & are consistent. Both risers & treads are free from defect. If	An estimated 931,886 children aged less than 5 years old were treated for stair-related injuries from 1999 through 2008, averaging 93,189 injuries per year and 46.5 injuries per 10,000 population annually.[21] About a third of seniors 65 and older fall annually.[22]	Repair any loose, damaged, or uneven steps. Install handrails/ guardrails for the staircase. Consider stair gates in homes with young children.	Stairs are almost never even. Repair defects- $50-150. Wall rails $85-175/ Open rails $150-250/	$65-300. $90-175. $125-200[2]

Subdomain [population of interest]	Pass Criteria	Statistics about Hazards	Housing inspection recommendation	Cost	
				Product	Labor
	a runner or carpet covers stairs, it's free from defect. At the bottom of the staircase, the right or the left side has an open handrail only or an open with handrail and baluster (guardrails, spindles). The openings of the guardrail are not greater than 4". The Baluster and spindles is secure. The handrail is secure.			All unfinished[2]	
Window Safety [Children]	A window stop or guard was present The blind/curtain was cordless, cord protected, or cord unprotected but inaccessible to the child	Every year since 1983, an average of 12 children have been killed by window blind cords. There has not been a significant decrease in deaths since. Many more have suffered permanent brain damage.24 From 1990-2015, there were about 16,827 window blind related injuries, about 647 per year.25 In 2009, the CPSC recalled over 5 million Roman shades and blinds, it was largest product recall in the CPSC's history.26	Remove any curtains with cords, and install a window stop/guard.	Window Lock ($1.25 per lock)1 Window blind cord wind-ups 2 pack ($2.50)1 Cordless window shade ($30-$100)1	
Smoke Alarm [All]	At least one smoke detector must be present and working on each level of the unit. Including the basement, but not the crawl spaces and unfinished attic	In 2016, 81% of all U.S. civilian fire deaths occurred in the home.9 In 2016, there were roughly 352,000 reported home structure fires in the US and 2,735associated civilian death.9		Smoke alarms $8-$251	$30-$50 per home 2

Subdomain [population of interest]	Pass Criteria	Statistics about Hazards	Housing inspection recommendation	Cost	
				Product	Labor
Sprinkler	Working Sprinkler system	In 2016, 10.6 billion in property damage was caused by structure fires.9 Based on 2016 US data, there is about one structure fire reported every 66 seconds. The same data shows that a civilian fire injury happens roughly every 36 minutes and a civilian fire death occurs every 2 hours and 35 minutes.9	Inspect sprinkler systems in home with existing systems. Consider retrofitting homes without existing sprinkler systems.	The cost of installing home fire sprinklers is about $1.35 per sprinklered square foot27	

REFERENCES APPENDIX 1

1. Estimate from amazon.com prices
2. Estimate from professional
3. Underlying Cause of Death 1999-2016 on CDC WONDER Online Database. Centers for Disease Control and Prevention, National Center for Health Statistics Web site. http://wonder.cdc.gov/ucd-icd10.html. Published December 2017. Accessed January 5, 2018.
4. Shields W, Omaki E, Frattaroli S, Shields M, Hielen. Still too many scald injuries: An analysis of tap water scalds from the NEISS data set 30 years after the adoption of a voluntary water heater standard. Paper presented at: American Public Health Association; October 2016; Denver, CO.
5. Shields WC, McDonald EM, Pfisterer K, Gielen AC. Scald burns in children under 3 years: An analysis of NEISS narratives to inform a scald burn prevention program. *Injury prevention*. 2015:041559.
6. Mao SJ, McKenzie LB, Xiang H, Smith GA. Injuries associated with bathtubs and showers among children in the united states. *Pediatrics*. 2009;124(2):541-547.
7. Stevens JA, Haas EN, Haileyesus T. Nonfatal bathroom injuries among persons aged ≥ 15years—United states, 2008. *J Saf Res*. 2011;42(4):311-315.
8. Feldman F, Chaudhury H. Falls and the physical environment: A review and a new multifactorial falls-risk conceptual framework. *Canadian Journal of Occupational Therapy*. 2008;75(2):82-95.
9. Haynes J.G. H. Fire loss in the United States during 2016. *NFPA Journal*. 2017.
10. Finkelstein EA, Corso PS, Miller TR. Incidence and economic burden of injuries in the United States. *American Journal of Preventive Medicine*. 2007;32(3):256. doi: 10.1016/j.amepre.2006.11.010.
11. Campbell R. *Electrical fires.* Quincy, MA: National Fire Protection Association; 2017. http://gateway.proquest.com/openurl?url_ver=Z39.88-2004&res_dat=xri:c19index-us&rft_dat=xri:c19index:NSTC:st12_009698.
12. Electrical Safety Foundation International. Extension cord safety virtual demonstration. https://www.esfi.org/resource/extension-cord-safety-virtual-demonstration-214. Updated 2015. Accessed October 26,2018
13. US Consumer Product Safety Commission. Extension cords fact sheet http://www.dataspan.com/uploads/pdf/us-consumer-protection-extension-cord-safety-fact-sheet.pdf. Updated 2010. Accessed October 26,2018
14. Shields W, McDonald E, Frattaroli S, Bishai D, Ma X, Gielen A. Structural housing elements associated with home injuries in children. *Injury prevention: Journal of the International Society for Child and Adolescent Injury Prevention*. 2016;22(2):105-109. 10.1136/injuryprev-2015-041621.
15. Suchy A. Product instability or tip-over injuries and fatalities associated with televisions, furniture, and appliances: 2016 report: Consumer product safety commission injury and death reports;2017 ASI 9166-7.167. *US Consumer Product Safety Commission*. 2016.
16. M King, C Bailey. Carbon monoxide-related deaths — United States, 1999–2004. *Morbidity and Mortality Weekly Report*. 2007;56(50):1309-1312.
17. J Clower, F Yip, J Annest, et al. Nonfatal, unintentional, Non–Fire-related carbon monoxide exposures — United States, 2004–2006. *Morbidity and Mortality Weekly Report*. 2008;57(33):896-899.
18. Krenzelok EP, Roth R, Full R. Carbon monoxide… the silent killer with an audible solution. *American Journal of Emergency Medicine*. 1996;14(5):484-486.
19. Warner M, Chen LH, Makuc DM, Anderson RN, Miniño AM. Drug poisoning deaths in the United States, 1980–2008. *NCHS data brief.* 2011(81):1-8.
20. American Association of Poison Control Centers. Reports to U.S. poison control centers. Poison Statistics National Data 2016 Web site. https://www.poison.org/poison-statistics-national. Accessed October 26,2018
21. Ashley E Zielinski, Lynne M Rochette, Gary A Smith. Stair-related injuries to young children treated in US emergency departments, 1999-2008. *Pediatrics*. 2012;129(4):721-727.

22. Stevens JA, Ballesteros MF, Mack KA, Rudd RA, DeCaro E, Adler G. Gender differences in seeking care for falls in the aged Medicare population. *American journal of preventive medicine*. 2012;43(1):59.
23. Parents for Window Blind Safety. Window coverings standard press release. https://consumerfed.org/pdfs/WindowCoveringsStandardPressRelease.pdf. Updated 2011. Accessed October 26,2018
24. Onders B, Kim EH, Chounthirath T, Hodges N, Smith G. Pediatric injuries related to window blinds, shades, and cords. *Pediatrics*. 2018;141.
25. CPSC announces voluntary recalls to repair millions of roman shades and roll up blinds by multiple firms. US Consumer Product Safety Commission Web site. https://www.cpsc.gov/th/node/19955. Published January 2010. Accessed October 26,2018
26. Newport Partners LLC. *Home fire sprinkler cost assessment.* 1st ed. New York, NY. Springer-Verlag New York. 2014.

Chapter 12

General Discussion

This thesis aims to demonstrate the relevance of the public health approach for addressing the burden of home injuries. This thesis aim to enhance our understanding of the burden of injuries, risk and protective factors associated with home injuries. This thesis additionally reports on the evaluation of the Johns Hopkins Home Safety Project; community intervention trial aimed at reducing safety risks in the homes. Finally, this these provides strategies to improve the implementation of home safety measures. In four subsequent parts, the following research questions are studied:

For part 1: Examining the burden of home Injuries

1. What is the burden of home injuries from scalds and housing elements in the USA? (Chapter 2-3)

For part 2: Risk and protective factors regarding safety in the home

2. What are the main risk and protective factors for burn injuries and from housing elements in the homes of low-income families? (Chapter 4-7)

For part 3: Evaluation of a community Intervention to reduce safety risks in the home

3. How effective was the Johns Hopkins Home Safety Project at increasing home safety practices? (Chapter 8-9)

For part 4: Strategies to improve the implementation of home safety measures

4. Which strategies can be used to improve adoption of home safety measures? (Chapter 10-11)

In this chapter, the main findings are summarized, and the results are discussed and linked to current research to highlight new insights. Additionally, the strengths and limitations of the studies are discussed. Finally, implications for practice and future studies are discussed.

MAIN FINDINGS AND INTERPRETATION

Question 1. What is the burden of home injuries from scalds and housing elements in the USA? (Chapters 2-3)
In chapters 2-3 the National Electronic Injury Surveillance System (NEISS) of the Consumer Product Safety Commission was utilized to explore the burden of injuries from scalds and housing elements in the United States.

An analysis of the NEISS was conducted to determine the incidence of pediatric scald burns for children under 3 years of age who were treated in US hospital emergency departments (Chapter 2). The analysis also quantified injury patterns associated with scald burns to inform prevention recommendation messaging.

The NEISS query identified 2104 scald burn cases between 2009 and 2012, yielding a national estimate of 11,028 scald burns in children younger than 3 years old annually in the USA. The analysis of the case narratives resulted in the identification of precipitating and/or contributing factors including cooking, bathing, and consuming hot liquids. Our findings are similar to previous work, which identified hot water (from bathing) and hot liquids, such as coffee, as significant contributors to scald burns. [1-4] The available information on precipitating and/or contributing factors suggests that caretakers should test the temperature of their water heaters, test the bath water before bathing children, and be made aware of risk of scalds from hot liquids so that they exercise close supervision of children.

A second study utilized the NEISS system to quantify unintentional injuries associated with housing elements among children less than 18 years old treated in US hospital emergency departments. Injury risk has previously been associated with housing condition. [5-9] Chapter three identified twelve housing elements (bathtub, cabinet, carpet, ceiling/wall, counter, door, fence, floor, nail, porch, stairs and window) as the leading causes of injuries resulting in hospitalizations or emergency department visits. A list of potential interventions (i.e. the use of anti-slip surfaces in the bathroom; removal of protruding nails, & door stops to prevent finger entrapment) was generated based on the review of the case histories. Suggested changes for NEISS coding system, including and expansion of the narrative text field, were also offered to enhance future prevention research.

The NEISS database is a valuable national resource which has demonstrated real-world utility since its inception. The examination and presentation of NEISS data have led to product recalls (e.g., lawn darts, high-powered magnet sets), [10,11] creation of voluntary standards (e.g., window blind cords), [12] and even awareness of injury sources, leading to the development of new, safer equipment (e.g., tractor rollover protective structures). [13] It has had a significant impact in recreational, household, and occupational products, which affect people daily. Injury surveillance systems are employed in other countries though none have been as extensively utilized for reporting in the peer-reviewed literature as in the NEISS system. This thesis demonstrates the utility of NEISS for exploring the both the burden and circumstances associated with home injury. It has specifically demonstrated its utility for exploring pediatric scald burns and injuries to children from housing elements.

Chapter 2 demonstrated that an estimated 11,028 children younger than 3 years old experience a scald burn annually in the USA. By examining the precipitating and/or contributing factors we were able to recommend prevention strategies for caretakers of children including that they should test the temperature of their water heaters, test the bath water before bathing children, and be made aware of risk of scalds from hot liquids so that they exercise close supervision of children.

By utilizing the NEISS system to examine housing elements associated with home injury in Chapter 3 we were able to identify 12 housing elements associated with the most emergency department visits and hospitalizations. In addition to identifying these housing elements we provided guidance for remediating these injury risks via a list of prevention recommendations.

Question 2. What are the main risk and protective factors for burn injuries and from housing elements in the homes of low-income families? (Chapter 4-7)

In chapters 4-7 a variety of methods including questionnaire design, home observations, and qualitative interviews were utilized to improve understanding of risk and protective factors for injuries from burns and housing elements.

To determine the potential benefit of an extended questionnaire to improve reporting of smoke alarm coverage parents of children who were treated in an urban emergency department were recruited into a study.(Chapter 4) Parents were randomized to receive an intervention to improve their fire safety behaviors or car set behaviors. Education was delivered via a smartphone app. Respondents completed a baseline assessment of their safety behavior and related beliefs. Data for this analysis come from the baseline assessment of the fire safety arm of the study. As part of the assessment, respondents were first asked two questions which constituted the Brief Form. Later in the assessment, they answered an Extended Form, which asked them to identify the number of levels in their home, and then were prompted for each of those levels to report whether a smoke alarm was present, if it was working, and how they knew it was working. Answers were summarized to create two variables comparable to the items assessed on the Brief Form: any working smoke alarm and a working smoke alarm on every level. Responses from the Brief and Extended Forms were compared using a Kuder-Richardson test, a measure of internal consistency for binomial data. Comparing responses between the two forms demonstrated that respondents reported more working alarms (96% vs 85%) and more working smoke alarms on all levels (92% vs 73%) on the Brief Form compared to the Extended Form. Our results show that question phrasing and quantity changed respondents' answers to smoke alarm questions, presumably for more accurate reporting of smoke alarm presence and functionality. Our findings are valuable in light of previous work which has demonstrated discrepancies between self-reported and observed smoke alarm functionality with positive predictive values ranging from 26% to 90%. [14] Additional work by Stepnitz et. all demonstrated that when answering commonly used questions to assess smoke alarm status, the general public over-reports because they may not consider all levels of the home and because they may be unaware of indicators of alarm functionality . [14] These finding demonstrate the need to consider potential ways to improve accurate reporting including the use of improved questions. [15]

An observational study was conducted to examine the association between living in substandard housing and fire and burn risks in families living in a low-income urban environments in Baltimore Maryland, USA. (Chapter 5) The purposes of this study was 1) to describe the frequency and characteristics of substandard housing in urban homes with young children and 2) to explore the hypothesis that better housing quality is associated with a greater likelihood of having working smoke alarms and safe hot water temperatures. A total 246 caregivers of children ages 0-7 years were recruited from a pediatric emergency department and a well child-clinic. In-home observations were completed using 46 items from the Housing and Urban Development's Housing Quality Standards. The observation study found that virtually all homes (99%) failed the housing quality measure. Items with the highest failure rates were those related to heating and cooling; walls, ceilings, and floors; and sanitation and safety domains. 82% of the observed homes had only one working smoke alarm. 42% had one on every level, and 62% had safe hot water temperatures. For every increase of 1 item in the number of housing quality items passed, the odds of having any working smoke alarm increased by 10%, the odds of having one on every level by 18%, and the odds of having safe hot water temperatures by 8%. Many children may be at heightened risk for fire and scald burns by virtue of their home environment. Stronger collaboration between housing, health care, and injury prevention professionals is urgently needed to maximize opportunities to improve home safety. Our finding supports the recommendations of a systematic review of interventions by DiGuiseppi et al addressing injury-related structural deficiencies in housing. The review noted the absence of research on improving the implementation of safety-related building and housing codes. [16] Given that smoke alarm standards are part of safety related housing codes, our finding supports the need for improving implementation and enforcement. [17]

Another observation study was conducted as formative work to prepare the Johns Hopkins Home Safety Project community intervention trial. The formative work allowed us to observe water heaters and household characteristics and water temperature and report results in relation to the water heater manufacturers voluntary standard which was adopted in 1980 in the USA. The voluntary standard required water heaters thermostats to pre-set to 49°C/120°F (Chapter 6). This study reports on water temperatures in 976 urban homes and identifies water heater and household characteristics associated with having safe temperatures. This study found that hot water temperature was unsafe in 41% of homes. Homeowners were more likely to have safer hot water temperature ($\leq$ 49°C/120°F) than renters (63% vs. 54%; $p<0.01$). For 11% of gas water heaters, the water temperature was $\geq$ 49°C/54°F although the gauge was set at less than 75% of its maximum setting. In a multivariate logistic regression, electric water heaters were more likely to have safe hot water temperatures than gas water heaters (OR=4.99; $p<0.01$). Water heaters with more gallons per person in the household were more likely to be at or to be below the recommended 49°C/120°F.

These results suggest that hot water temperatures remain dangerously high for a substantial proportion of urban homes in low income areas despite the adoption of voluntary standards to preset temperature settings by manufacturers. This research highlights the need for improved prevention strategies such as installing thermostatic mixing valves to ensure a safer temperature and also for the recommendation that the importance of household size be stressed as part of the purchasing process. Although hot water temperature is generally correlated with the water heater setting, we have evidence that this is not always the case, [18] and the International Residential Code for 1- and 2-family dwellings recommends thermostatic mixing valves that regulate the water temperature at the faucet. [19] [20] The results presented in this thesis support the recommendation of the International Residential Code. [19] Edwards et al. quantified the positive effects of a thermostatic control system on the prevalence of dangerous water temperatures in a cluster randomized controlled trial in London. [21] A study in Ontario demonstrated a positive effect of legislation requiring a mixing valve with the installation of all new water heaters on the scald burn incidence. [22]

The risk factors identified by these observation studies were unsafe water temperatures and insufficient smoke alarm coverage. Tap water temperatures were too hot in 38% and 41% of homes respectively in the two observation studies. Smoke alarms were not present in in 18% of homes and insufficient smoke alarm coverage was observed in 58% of homes. Smoke alarm coverage and unsafe water temperature were both associated with overall housing quality.

A qualitative study conducted with parents of injured children examines parents' self-reported perceptions of protective measures which could have prevented injury as well as actions taken to avert future injuries by making changes to the home environment. (Chapter 7) Previous work has demonstrated that medical attention for an injury can increase parents' perception of their child's susceptibility to injury. [23] Understanding subsequent parental actions to avert future injuries can inform prevention efforts. In this study, we describe the children's injured body part and parents' reports of: 1) the cause of the injury; 2) what could have prevented it; and 3) changes made afterwards. This study examined the medical records and conducted qualitative interviews with one hundred three parents of injured children. In all but two cases parents identified an item as contributing to the injury: 35% involved a house feature; 33% house furnishings, 11% food/beverage, and 8% toys. Most parents identified at least one prevention strategy (82%). Of the 110 suggested prevention strategies, 40% indicated a recommendation to improve the safety of the environment (e.g., store hazardous product), 31% recommended a modification to the child's behavior (e.g., new rules), and 29% recommended increased supervision. Only fifty-nine parents (57%) reported making changes post injury, 51% modified the environment; 27% got rid of/replaced items; and 10% increased supervision

This study additionally explored how parents changed their homes after a medically-attended injury to prevent reoccurrence. Most parents identified a prevention strategy, commonly an environmental modification (e.g., storing hazard), however only 57% made modifications. Safety changes reported by parents to prevent reoccurrence of medically-attended home injuries can inform future prevention efforts that are more likely to be adopted in the future by other parents.

Chapter four demonstrated the potential to improve parents' report of risks in the home via the utilization of an extended questionnaire about smoke alarm. Chapter five demonstrated an association between housing quality and the presence of smoke alarms and safe water temperature indicating that substandard housing is a risk factor for injury from fire and burns. Chapter six identified risk and protective factors associated with safe household water temperature. We learned that electric water heaters were protective compared to gas water heaters and that an increased number of household members per gallon on water in the water heater was associated with unsafe water temperature. In chapter six we used qualitative methods to interview parents of injured children to identify prevention strategies. Parents recommended environmental changes to the environment, eliminating risk items that had been associated with their child's injury and greater supervision as potential protective factors which may have prevented their child's injury.

Question 3. How effective was the Johns Hopkins Home Safety Project at increasing home safety practices? (Chapter 8-9)
In chapter 8-9 the Johns Hopkins Home Safety Project was evaluated to examine its effect on smoke alarm installations and hot water safety at the 6-month follow-up visit.

The Johns Hopkins Home Safety Project was a community intervention trial which evaluated the impact of an enhanced fire department home visiting programs on community participation and installation of 10-year lithium battery smoke alarms. Chapter 8 describes the rate of fire and burn hazards observed in homes. Communities were randomly assigned to receive either a standard or enhanced home visiting program. During a one-year intervention period, 171 fire department home visit events took place with 8,080 homes. Households in the enhanced area received pre-notification about an impending visit from the Baltimore City Fire Department to install smoke alarms. Fire department personnel visited homes in the standard community without pre-notification. At baseline, 60% of homes did not have working smoke alarms on every level of their homes; 44% had unsafe water temperatures; and 72% did not have carbon monoxide alarms. Residents in the enhanced community, relative to those in the standard community, were significantly more likely to let the fire fighters into their homes (75% vs 62%). Among entered homes, those in the enhanced community were significantly more likely to agree to have smoke alarms installed (95% vs

92%), to be left with a working smoke alarm on every level of the home (84% vs 78%), and to have more smoke alarms installed per home visited (1.89 vs 1.74). Previously reported, smoke alarm distribution programs have used various combinations of community volunteers, paid staff, and fire personnel with mixed results [24-26] . Our study is most similar to the earlier work by Schwarz et al, [24] who hired community liaisons to engage community members at the block level in advance of having safety inspectors go door-to-door. Similar to Schwarz's work, we too found that advance notice, provided by a recognized community representative, resulted in increased access to homes. We were surprised, however, that the advance notice did not result in more residents being home on the day of the event; how to address the 60% of residents who were not home remains a challenge. Prior smoke alarm distribution programs that have evaluated their impact on fire deaths have had mixed results, [25,26] Programs evaluating the impact of home visiting and installation of 10-year lithium battery alarms have demonstrated their benefit as compared to typical 9-volt alarms. [28]

The Johns Hopkins Home Safety Project also provided an opportunity to test an intervention aimed at decreasing risks from scald burns by educating families about unsafe water temperatures during an enhanced home safety visit. (Chapter 9) We aimed to determine whether households who participated in an enhanced home safety visit demonstrated improved safety behaviors about hot water compared to homes receiving a standard home visit. Hot water temperature and self-reported prevention behaviors were recorded at a baseline visit and retested 6-9 months later in sub sample of homes who agreed to participate in the follow-up visit. At baseline families in the enhanced group received a tailored educational message aimed at having them retest and adjust the water heater gage when an unsafe water temperature had been observed. Families in the standard group were informed of their water temperature but were not provided with a tailored educational message. Residents whose hot water temperatures remained at an unsafe temperature were asked why they did not adjust the temperatures. Demographic data were also recorded. A total of 708 households participated in both the baseline and follow-up visits. No significant difference emerged between the two study groups in the proportion of households observed to have adjusted their hot water temperature to safe levels between the baseline and follow-up visits ($t = 1.24$; $P = 0.22$). Residents who received the enhanced education were more likely to report testing their water temperature (27% vs 11%; $P < .01$) and turning their hot water temperature below 49°C/120°F (43% vs 32%; $P = .08$). Among those who had unsafe temperature levels and did not reduce the water temperature, the most common reason (26%) offered was that they "liked it hot." These results demonstrate that water temperatures are unsafe in many urban homes. The effect of educational interventions may be mitigated by personal preferences of hot water temperature. Our work supports the results of Babul et al which demonstrated that families receiving a home safety intervention

were two times more likely to adjust their hot water temperature to safe levels than families who did not receive a home safety intervention [29] .

This evaluation further supported our recommendation of the need for the thermostatic mixing valve as an engineering solution for the water heater. An intervention by Kendrick et al demonstrated that installing thermostatic mixing valve anti-scald devices at the tap have shown promise in protecting people from scalding water. [30] Kendrick et al has demonstrated a decrease in scald burns after utilizing this passive intervention [30] .This recommendation should be considered concurrently with the risk from legionnaires disease in water storage tanks. There were 6,100 cases of Legionnaires' disease reported by US health departments in 2016 [31] . Legionnaires disease outbreaks are commonly associated with water systems in large buildings with complex water systems. [32] The work of Alary et al [32] examined residential water heaters in Quebec Canada and found no risk of legionella in gas and furnace powered water heaters and minimal risk in electric water heaters. In contrast the observations we have conducted demonstrates the risk of hot tap water scalds burns in 40% of homes in Baltimore . [18] The proposed engineering solution, a thermostatic mixing valve; allows water to be stored at higher temperature in the tanks before it is mixed with colder water upon leaving the tank prior to exiting faucets where residents would be exposed to it. The engineering solution decreases the risk of both legionella at hot tap water scald burn injuries and is already required in part of the plumbing code in Australia as well as in Ontario, Canada. [33,22]

The Johns Hopkins Home Safety project was effective at increasing smoke alarm coverage for both the standard and enhanced groups in the community interventional trial. The enhanced group had significantly better outcomes for allowing fire personnel into their homes and allowing alarms to be installed. The Johns Hopkins Home Safety Project was also successful at improving water testing and adjusting behavior in the enhanced group but was not successful at reducing unsafe water temperatures.

Question 4. Which strategies can be used to improve adoption of home safety measures? (Chapter 10-11)
Chapters 10-11 provide guidance for improving the adoption of home safety measures.

Chapter 10 describes the epidemiology of home injuries; and summarizes the available evidence on prevention strategies that address the groups most at risk for four of the leading causes of home injury -- infant sleep-related deaths, house fires and burns, poisonings, and falls. Effective prevention strategies have been identified to reduce injury or mitigate risk behaviors. The evidence is summarized by the strength of the evidence for selected prevention strategies for each of these injury causes. Strong evidence was found to support recommendations for burn prevention, pediatric and older adult falls, and pediatric poisoning

prevention. Strong evidence indicates that next steps for these evidence-based recommendations is the dissemination of these recommended strategies to the target populations. Table 1 presents a summary of the evidence. Recommendations for the prevention of adult poisoning and infant safe sleep were limited to recommended and promising categories indicating that further evaluative work is needed to determine the effectiveness of these recommendations.

Table 1. Prevention strategies for home injuries by type of injury, outcomes studied, and level of evidence

Prevention strategies	Outcomes studied[a] (%)	Level of Evidence
Safe sleep		
National Back to Sleep Campaign	Injury	Promising
Crib distribution program	Behavior	Recommended practice
Parent/caregiver education	Behavior	Promising
Poisoning	Behavior	Promising
Fires and burns		
Working smoke alarms	Injury	Strong
Smoke alarm installation and education programs	Behavior	Strong
Residential sprinkler technology	Injury	Strong
Sprinkler mandates for new home construction	Behavior	Promising
Reduced ignition propensity cigarettes	Injury	Promising
Fire escape planning interventions	Behavior	Strong
Interventions for safe storage of matches	Behavior	Recommended practice
Child-resistant cigarette lighters	Injury	Promising
Interventions for safe hot water temperature	Behavior	Strong
Interventions for keeping hot drinks and foods out of reach	Behavior	Recommended practice
Falls (children)		
Mandated redesign of baby walkers	Injury	Promising
Reduction of baby walker possession and use	Behavior	Strong
Stair gate education and distribution	Behavior	Strong
Window guard mandates	Injury	Strong
Falls (older adults)		
Medication review	Falls	Strong
Strength and balance exercise programs	Falls	Strong
Home modification	Falls	Strong
Yearly vision screening	Falls	Promising
Multicomponent interventions	Falls	Strong
Poisoning (children)		
Safe storage of medication away from children	Behavior	Strong
Child-resistant and sublethal dose packaging	Injury	Strong
Poison control centers	Injury	Strong

Prevention strategies	Outcomes studied[a] (%)	Level of Evidence
Poisoning (adults)		
Safe storage, use, and disposal of opioid pain relievers	Behavior	Recommended
Control of supply and dispensing of opioid pain relievers	Injury	Promising
Carbon monoxide alarms	Behavior	Recommended

Chapter 10;Table 4 Gielen AC, McDonald EM, Shields WC. Unintentional Home Injuries across the Life Span: Problems and Solutions. *The Annual Review of Public Health*. 2015; 36:2.1-2.23

The Healthy Housing community, which has historically addressed lead poisoning and asthma in homes of affected children, is a new audience for injury prevention outreach. The CHASE Tool was developed and validated as a tool for use by this community. (Chapter 11) The CHASE tool which contains 14 injury subdomains, and 25 injury measures have been developed and validated to assist housing programs working in homes of children to identify and mediate injury risks. The majority of households had safe water temperature 56%, working smoke alarms on every level 62%, and CO alarms 70%. The overall passed percent of subdomains passed was 57% for the total group. Individual item pass rates varied greatly between CHASE items from a low of 0% having medication locked and 11% having window guards to highs of 90% having proper exits and 80% being free of furniture crowding. These results are important because they add to the literature demonstrating the need for injury prevention to be addressed as part of the healthy homes initiative. [34,35]The comparison between groups, which was done via an adjusted paired regression analysis, demonstrated that case status significantly predicted the CHASE sub-domain such that those who were in the injured group were significantly less likely to pass (b=-3.315, p=.025). This finding demonstrated that the CHASE Inspection tool could distinguish between injured and non-injured children. The current interest in public health circles in the role of housing in health offers unparalleled opportunities for injury prevention professionals concerned with home injuries. Collaborating with our environmental health and healthy housing colleagues is one important approach to reducing home injuries. Their access to homes and their ability to influence housing policy can play significant roles in reducing home injuries. Sharing the science of injury prevention [36] with the wide array of professionals who create home environments and interact with people in their homes (e.g., architects, home builders, home visiting programs, fire and EMS providers) could be a useful approach. The broad dissemination of the CHASE tool has the potential to decrease injury risk in homes served by the programs which previously were not addressed.

The strategies explored in chapters 10 and 11 provide guidance for clinical providers, injury preventions researchers, and the Healthy Housing Community to reduce injuries in the home. The guidance provided in these chapters has the potential to reduce home injuries if properly utilized and disseminated to specific

identified target audiences. Chapter 10 and 11 additionally provide insight into areas which are in need of additional evaluative work to determine the effectiveness of the recommended strategies before they can be deemed to be supported by strong evidence.

METHODOLIGICAL CONSIDERATIONS

National Electronic Injury Surveillance System (NEISS)

The NEISS-All Injury Program is used to produce national estimates of the number of consumer product-related injuries treated in hospital emergency departments in the USA . NEISS consists of a probability sample of hospital emergency departments (EDs) in the USA and its territories. The NEISS-All Injury Program (NEISS-AIP) uses data from a nationally representative sample of hospitals in the USA. The current NEISS sample includes approximately 100 hospitals grouped into five strata, four representing hospital emergency departments of differing sizes and a fifth representing emergency departments from children's hospitals. The hospitals included in the NEISS sample were selected as a probability sample of all 5,000+ U.S. hospitals with emergency departments. NIESS primarily functions as a surveillance system but it can also be used to identify cases for further investigation. The hospitals included in the sample were selected as a stratified probability sample of hospitals in the United States and territories with a minimum of six beds. The NEISS sample has been updated three times since its inception. The first update in 1990 expanded the universe of hospitals which the sample was drawn from, the second in 1991 expanded the sample from 65 to 91 hospitals. The last update in 1997 expanded the sample to 100 hospitals. The NEISS system is limited to producing estimates about injuries occurring in the United States and does not allow for comparisons between the US and other countries. [37]

Injury surveillance systems are employed in other countries though none have been as extensively utilized for reporting in the peer-reviewed literature as the NEISS system. A review of The Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP) data has shown great variance of sensitivity and systematic errors in data capture. [38] The National Injury Surveillance Unit of Australia has an acknowledged shortcoming in that it lacks a source of national quantitative data suitable for monitoring consumer product safety [39] . The Home and Leisure Accident Surveillance System (HASS/LASS) of the UK was discontinued in 2003. [40]

An additional consideration when interpreting results from the NEISS system is that the system relies on documentation from the emergency room clinicians and the details provided in the narratives description. The NEISS surveillance system was developed by the Consumer Product Safety Commission to track injuries

from consumer products. [41] It is unknown to what extent scald and injures from housing elements not associated with consumer products (i.e. a scald from hot tea) are missed by this surveillance system. Additionally, the NEISS system produces a sample of cases treated in hospital emergency departments. It is unknown to what extent cases treated in primary care or urgent care contribute to the burden of injuries from scald or housing element. Given that many scald burn patients bypass the regular emergency department for treatment at burn centers,[42] we hypothesize that our estimate under counts the burden of scald injuries.

The Johns Hopkins Home Safety Project

There are limitations to this study. Our findings were likely dampened by our decision to define the geographic areas using census tracts rather than natural borders that define neighborhoods. Using census tracts allowed us to access existing data and to select a comparable set of households. However, we were limited in our ability to create a robust community level campaign because our enhanced community was made up of portions of several neighborhoods. It was difficult for community partners to fully engage in promoting the program when their organizations encompassed areas that were part of the intervention and other areas that were not. Researchers designing community interventions will need to consider how best to define community in light of the implications for fully engaging community partners. Finally, something other than our intervention may have produced the observed effect. However, we know of no competing ongoing fire safety events in our study areas, and because both study areas were in Baltimore City, any major fire event or fire safety campaign would probably have affected both study areas equally.

Additionally, our study results are limited by having been conducted as part of a community intervention trial as opposed to a randomized controlled trial. Communities were randomly assigned to receive either a standard or enhanced home visiting program. To create comparable communities we used census variable, residential fire rate, and previous acceptance rates of fire department home visits. Prior to implementing the program, 603 household surveys were completed to determine comparability between the communities. Our outcomes may be dampened by our protocol to inform participants in both the standard and enhanced group about their smoke alarm and hot water temperature. Though the enhanced group intervention was more robust educationally, it may not have been different enough to effect change between groups.

CHASE Study

The CHASE study was a prospective case control study. An advantage of case control studies is that they are good for studying low incidence illness or events such as an injury [43] . A disadvantage of a case control study is that they are

subject to selection bias which may have had an effect on our results given that only 64% of eligible families participated. It is unknown how the participating families may have differed from the non-participating families. Our small sample also did not allow us to look at the CHASE score by the type of injury sustained by the case children.

An additional methodological consideration of the CHASE study is that there was little socio-economic variation in the population with 46% of families living below the poverty level and 82% living in rental properties. Poverty is a common risk factor for both substandard housing and for lower rates of smoke alarms and safe hot water temperatures [44,18]. Because our sample was predominantly low income, the independent effect of housing quality cannot be isolated. It is likely that a constellation of factors is associated with being able to implement safety behaviors and home modifications and that poor housing quality is a marker. Our results must be considered in light of the population which the tool was tested in.

Limited participation and Non-response bias

Limited participation is a limitation of multiple studies reported in this thesis. Limited participation causes concern about the possibility of the studies being affected by Non-response bias. [45] Non-response bias is the bias that results when participants differ in meaningful ways from non-participants. Given there was no data available from non-participants for comparison with participants in our studies it is not possible to ascertain if the finding would be different in non-participants. The safety behaviors and potential impact of the intervention of non-participating homes is unknown. The limited participation and possibility of non-response bias might limit the generalizability [45] of the results of the studies.

Limited Geographic and Social Economic Variation

Several studies presented in this thesis were conducted in Baltimore City. (Chapters 4,5,6,7,8,9,11) Participants in the Safety in Seconds Study (Chapter 4), the Johns Hopkins Home Safety Project (Chapter 6,8 & 9), and the CHASE studies (Chapter 5,7 & 11) were drawn from homes and families in Baltimore City. The limited geographic areas and concentration of participants from lower socio-economic groups limit the generalizability of the results to other more varied populations. An additional geographic limitation is that all studies and the National Electronic Injury Surveillance System draw from populations in the United States, limiting the generalizability to populations beyond the United States which decreases the external validity [45] of the findings in non-US populations.

Though the studies in this thesis and the National Electronic Injury Surveillance system all draw from populations in the United States the risk factor addressed, and the recommendations suggested are consistent with risks and recommendations in the European Union. Burns and scald risks which are

addressed in chapters 2,5 and 6 are the fourth leading cause of death to children in the European Union. [46] The risks from scalds demonstrated in chapter two parallels risk to young children in the European Union where children under the age of five are at the greatest risk of death from scald burns. [46]. Similarly; in the Netherlands, young children and seniors are at highest risk for burn injuries resulting in a hospital admission. [47] Of the children admitted to the hospital for burns in the Netherlands the majority (75%) were treated for a scald burn.[47] Recommendations to reduce burns from researchers and injury prevention organizations in the European Union, including limiting tap water to 50°C [48], increased supervision of children [47] ,and the promotion of smoke alarms [49] are consistent with the recommendations in this thesis in chapters 2,5,6,8, and 9. The Consumer Safety Institute of the Netherlands supports the policy statement from the European Child Safety Alliance recommending legislation requiring all homes have controlled bath water temperature not exceeding 50°C. [48] This policy aligns with the recommendations outlined in chapters 2,6 and 9 of this thesis. In addition to the parallels in risk and recommendations around burns there are similarities with other home injury risk between this thesis and the European Union injury prevention organizations. Recommendations from the European Child Safety Alliance, including safe storage of poisons[50]; promotion of baby walker alternatives[51]; and safe sleep recommendations [52], mirror the strategies highlighted in Chapters 10 and 11.

Measurement

An important strength of the thesis is that outcomes from multiple studies (Chapters 5,6,8,9,11) derive from home observations rather than self-report. Observation is not always possible in injury research therefore this adds strength to our findings, particularly in light of previous work which demonstrated evidence of parents' over-reporting certain safety practices. [53-56]

Our water temperature findings (Chapter 6 & 9) are based on a single water temperature reading and do not take into consideration possible fluctuations in the hot water temperature that may occur, throughout the course of the day.

Potential limitations of the of the qualitative interviews with parents reported chapter in 7 include how the parental self-report about the injury could be impacted by time that elapsed between the injury event and the interview and social desirability bias. [57]

FUTURE RESEARCH

The National Electronic Injury Surveillance System (NEISS) data base is a promising resource to explore the burden of home injuries in the USA. Though originally designed to explore injuries from consumer products, our work, as well

as the work of others [58-60], has demonstrated that the NEISS data base is a valuable tool to explore the epidemiology of injuries via injury type and location. The NEISS system should be further utilized to explore scald burn injury patterns to older children, adults and seniors. Though this thesis presents on the burden of tap water scald burns to the entire US population, an analysis of all scald burns (not limited to tap water) in the population may provide additional opportunities for prevention particularly in the older adult population which experiences scald burns at greater rates and worse outcomes compared to the adult population less than 65 years of age. [61] The NEISS system is being updated to expand the length of the narrative text field to enhance researchers' ability to understand circumstance of injury more fully. [62] This modification will help minimize the number of cases where the narrative text does not allow a sufficient understanding of the circumstances of the injury.

The methods utilized in this thesis demonstrate that NEISS could be utilized to expand our understanding of other homes injuries including suffocation, falls, and non-scald burns.

Utilizing surveillance systems from countries outside the United States, such as the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP)[38] and the Australian National Injury Surveillance System [39], may provide opportunities for comparison between countries. Unfortunately, the only system utilized in the European Union, The Home and Leisure Accident Surveillance System (HASS/LASS) of the UK, was discontinued in 2003. [40]

An analysis of the American Burns Associations national burn registry is an additional opportunity for understanding the burden of tap water scald burn. The National Burn Registry (NBR) represents ten years of cumulative data from burn centers in the USA, representing the largest resource on epidemiology of thermal injury for patients admitted to burn centers. [63] An examination of the NBR is necessary to understand the extent of patients missing from the estimates created using the NEISS system because it likely captures the injuries of patients whose burns severity causes them to bypass emergencies rooms.

Safety In Seconds Project

The extended smoke questionnaire evaluated in the Chapter 4 should be evaluated with home observations to validate the assumption that phrasing, and quantity improved the accuracy of respondents' reporting. Extended questionnaires should be tested with other injury behaviors particularly when being utilized to create tailored feedback as appropriate feedback is dependent on accurate reporting.

The Johns Hopkins Home Safety Project

The success of the JHHSP at increasing smoke alarm coverage suggests that fire department home visiting programs should take an "all hazards" approach to

expand services to reduce other home injuries risk. Future work is needed to develop an understanding of other areas risk areas which could be minimized by fire personnel.

Similarly, the success achieved by involving community health workers and other community partnerships to promote the fire department visits should be utilized to enhance other fire and life safety goals. Additional work is needed to understand how best to reach people who were not home during sweeps visit and what methods can be utilized to avail non-participating household of the life safety benefits of a home safety visit. An important unknown factor about fire department smoke alarm visits is how frequently homes that receive the alarms needs to be revisited. Future work is needed to understand the frequency of the need for a follow-up visit from the fire department.

Chapter 10 summarized the current evidence base for the prevention of home injuries. Chapter 10 also highlighted the need for future research in multiple areas. Additional work is needed to understand how to encourage parents' safe sleep practices in their home. Further work is needed to better understand ways to facilitate adoption of residential sprinkler policies across the U.S., as well as how to encourage retrofitting in existing homes. Additional work is needed understand the epidemiology of pediatric falls and to develop and test prevention strategies for these. Stair gates are a promising intervention to reduce falls on stairs, but to date their efficacy has not been validated in a randomized trial. Finally, much work is needed to better understand and address the current opioid epidemic. Interventions, which have previously been utilized to reduce exposure by children, such as lock boxes [64] , are being tested for utilization in the adult population where the sharing and theft of prescription medications has been associated with exposure and addiction.[65]

CHASE Housing Study

The CHASE housing tool (Chapter 11) should be further studied in a larger sample of homes to determine the cost of feasibility of the proposed modifications. Future research should utilize longitudinal analysis to examine the potential impact from the utilization of the CHASE tool and to create a recommendation on reducing the burden and cost of injuries. The measures introduced on the CHASE housing tool are suitable for utilization for researchers in the United States as well as other countries in the European Union, Australian, and Canada where housing research is active and/or where the international housing code is utilized. [19,20,21,30,64]

IMPLICATIONS FOR PRACTICE

Both step two; identifying risk & protective factors, and step three; developing prevention strategies, of the public health approach have implications for practice. This thesis provides multiple recommendations for improving the Practice of Injury Prevention. The recommendations have implications for practitioners in the United States as well as practitioners in other countries which have access to the families of children or with programs which assess the quality of homes.

Chapter 2 presents eighteen specific prevention messages to prevent scald burns in young children that were developed based on the analysis of precipitating and contributing factors. Educational content to effectively share these messages with parents is being developed and evaluated as part of our future work.

Chapter 6 presents the risk and protective factors for tap water scalds. The protective factors identified have practice implications. Specifically, these factors imply that enhanced education is needed to encourage the purchase of a properly sized water heater to match the gallons needed per person. Chapter 2, 6 & 9 demonstrate a need for the inclusion of the requirement for a thermostatic mixing value within housing and plumbing codes. Future work is needed to encourage the inclusion of this requirement in the relevant coding system. Practitioners should consider petitioning the Consumer Product Safety Commission to revisit the industry voluntary standard for consideration of the inclusion of thermostatic mixing valves on all water heaters sold in the United States based.

Practitioners working in homes of children need to consider the identification and remediation of a multiple home injury risks. Chapters 3, 5, and 11 describe risk factors and recommended practice solutions for programs doing modifications in the homes of children to reduce injury risk. Chapter 3 presented findings about the main housing elements associated with injuries to children. Chapter 7 provides insights from parents about protective measures which may have prevented their children's injuries. Chapter 11 described a housing tool that incorporated the housing elements from Chapter 3. This comprehensive housing assessment tool needs to be widely disseminated to practitioners working in the homes of children to ensure that their homes are free from known injury risks. Given that injury prevention is not currently comprehensively included in home assessments, efforts need to be made to inform the general community about the burden of home injuries and about the process for identifying and remediating home injury risks.

Chapter 8 provides recommendations for improving fire department smoke alarm canvassing programs. Our work supports using pre-notification of smoke alarm home visits to increase both entry into homes and the numbers of alarms

installed. Chapter 8 additionally supports the recommendation for public health academic centers to partner with the fire service to help generate evidence on program effectiveness that can inform decision making about resource allocation for prevention.

Finally, Chapter 10 presents the currently available evidence-based recommendations for practitioners to reduce injuries from suffocation, falls, burns, and poisonings. Practice recommendations endorsed are summarized in Table 1.

GENERAL CONCLUSION

Home injuries are a significant public health burden both in the United States and internationally. [66] The Public Health Approach is a valuable model to understand and address the burden of home injuries. Utilizing the Public Health Approach has provided valuable insight about the burden and risk factors associated with home injuries. Many of the injuries examined are preventable. A collaborative effort and coordination between multiple sectors including clinicians, home visitors, fire and life safety professionals and the housing community is needed to fully address the burden of injuries.

REFERENCES

5. Safe Kids Lee/Collier Counties. Burn Prevention. http://safekidsleecollier.org/safety/bunprevention/burnprevention.html
6. Baker SP, O'Neill B, Ginsburg MJ, et al. The injury fact book. New York, NY: Oxford University Press, Inc, 1992:169.
7. McLoughlin E, McGuire A. The causes, cost, and prevention of childhood burn injuries. Am J Dis Child 1990;144:677–83.
8. Feldman KW, Schaller RT, Feldman JA, et al. Tap water scald burns in children. Pediatrics 1978;62:1–7
9. Lyons R.A., Newcombe R.G., Jones S.J., Patterson J., Palmer S.R., Jones P. Injuries in homes with certain built forms. Am J Prev Med. 2006;30(6):513-520. doi:10.1016/j.amepre.2006.02.007.
10. Haynes R., Reading R., Gale S. Household and neighbourhood risks for injury to 5-14 year old children. Soc Sci Med. 2003;57(4):625-636.
11. Krieger J, Higgins DL. Housing and health: time again for public health action. Am J Public Health. 2002 May;92(5):758-68.
12. Campbell R. Electrical Fires. Quincy, MA; 2017.
13. Durkin M.S., Davidson L.L., Kuhn L, O'Connor P, Barlow B. Low-income neighborhoods and the risk of severe pediatric injury: a small-area analysis in northern Manhattan. Am J Public Health. 1994;84(4):587-592.
14. U.S. Consumer Product Safety Commission. Following Recent Injury CPSC Reissues Warning: Lawn Darts Are Banned and Should Be Destroyed. 1997.http://www.cpsc.gov/en/Newsroom/News-Releases/1997/Following-Recent-Injury-CPSC-Reissues-Warning-Lawn-Darts-Are-Banned-and-Should-Be-Destroyed/
15. U.S. Consumer Product Safety Commission. Buckyballs and Buckycubes High-Powered Magnet Sets Recalled Due to Ingestion Hazard; Craig Zucker To Fund A Recall Trust, Settles With CPSC. 2014. http://www.cpsc.gov/en/Newsroom/News-Releases/2014/Buckyballs-and-Buckycubes-High-Powered-Magnet-Sets-Recalled/
16. U.S. Consumer Product Safety Commission. Window Bling Cords Voluntary Standards Activities. 2013. http://www.cpsc.gov/en/Regulations-Laws--Standards/Voluntary-Standards/Window-Blind-Cords/
17. Reynolds S, Groves W. Effectiveness of roll-over protective structures in reducing farm tractor fatalities. Am J Prev Med. 2010. doi:10.1016/S0749-3797(00)00142-2
18. Stepnitz R, Shields W, McDonald E, et al. Validity of smoke alarm self-report measures and reasons for over-reporting. Inj Prev 2012;18:298–302.
19. Hatfield PM, Staresinic AG, Sorkness CA, et al. Validating self-reported home safety practices in a culturally diverse non-inner-city population. Inj Prev 2006;12:52e7.
20. DiGuiseppi C, Jacobs DE, Phelan KJ, et al. Housing interventions and control of injury- related structural deficiencies: a review of the evidence. J Pub Health Mngmnt Prac. 2010;16(5):S34–S43
21. https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=72
22. Shields WC, McDonald E, Frattaroli S, Perry EC, Zhu J, Gielen AC. Still too hot: examination of water temperature and water heater characteristics 24 years after manufacturers adopt voluntary temperature setting. J Burn Care Res. 2013 Mar-Apr;34(2):281-7.
23. International Code Council, Inc. International Residential Code for One- and Two-family Dwellings. Washington, DC: International Code Council, Inc; 2012
24. https://code.iccsafe.org/content/IRC2018/chapter-28-water-heaters
25. Edwards P, Durand MA, Hollister M, Green J, Lutchmun S, Kessel A, Roberts I. Scald risk in social housing can be reduced through thermostatic control system without increasing legionella risk: a cluster randomized trial. Arc Dis Child 2011;96:1097-1102.
26. Clouatre E, Pinto R, Banfield J,Jeschke MG. Incidence of hot tap water scalds after the introduction of regulations in Ontario.J Burn Care Res.2013 Mar-Apr;34(2):243-8.

27. Morrongiello BA, Howard AW, Rothman L, Sandomierski M, Once bitten, twice shy? Medically-attended injuries can sensitize parents to children's risk of injuries on playgrounds. Injury Prevention 2009;15:50–54.
28. Schwarz D, Grisso J, Miles C, et al. An injury prevention program in an urban African-American community. AJPH 1993; 83: 675-680.
29. DiGuiseppi C, Roberts I, Wade A, et al. Incidence of fires and related injuries after giving out free smoke alarms: cluster randomized controlled trial, BMJ, 2002;325(2): 1-4.
30. Mallonee S, Istre GR, Rosenberg M, et al. Surveillance and prevention of residential fire injuries, N Engl J Med 335:27-31, 1996.
31. DiGuiseppi C, Slater S, Roberts I, et al. The Let's Get Alarmed! Initiative: A smoke alarm giveaway programme, Injury Prevention, 1999;5:177-182.
32. Peek-Asa C, Yang J, Hamann C, Jones MP, Young T, Zwerling C. Smoke alarm and battery function 42 months after installation: a randomized trial.Am J Prev Med. 2010 Oct;39(4):368-71
33. Babul S, Olsen L, Janssen P, et al. A randomized trial to assess the effectiveness of an infant home safety programme. Int J Contr Saf Promot. 2007; 14(2): 109-17. PMid:17510847 http://dx.doi.org/10.1080/17457300701272474
34. Kendrick D, Stewart J, Coupland C, et al. Randomized controlled trial of thermostatic mixer valves in reducing bath hot tap water temperature in families with young children in social housing: A protocol. Trials. 2008; 9:14
35. Reported cases of notifiable diseases, by region and area – United States and U.S. territories, 2016.
36. Alary M, Joly JR.Risk factors for contamination of domestic hot water systems by legionellae. Appl Environ Microbiol. 1991 Aug;57(8):2360-7.
37. https://www.sa.gov.au/__data/assets/pdf_file/0010/294652/OTR-PAN-Heated-water-temperatures-140718.pdf
38. Morley RL, Mickalide AD, Mack KA. Healthy and Safe Homes Research, Practice, and Policy. Washington, DC: American Public Health Association; 2011
39. Centers for Disease Control and Prevention. CDC's health homes initiative: lead. https://www.cdc.gov/nceh/lead/publications/10_217029A_Walker_HealthyHomesBooklet_101310_UPDATED_WithCovers.pdf
40. Sleet D, Gielen AC. 2004. Developing injury interventions: the role of behavioral science. In The scientific basis of injury prevention and control, eds. McClure R, Stevenson M, McEvoy S. Melbourne, Australia: IP Communications
41. NEISS Sample Statistical Overviewhttps://www.cpsc.gov/Research--Statistics/NEISS-Injury-Data 6/
42. Butler M, Newton S, MacPhee S. The Canadian Injury Reporting and Prevention Program: Captured vs. uncaptured injuries for patients presenting at a peadiatric tertiary care centre. Paediatr Child Health. 2017 Jun;22(3):134-138
43. Harrison J. Australian Injury Surveillance Data Standards. Annals of Emergency Medicine. 2010 http://www.cdc.gov/nchs/data/ice/ice95v2/c04.pdf
44. The Royal Society for the Prevention of Accidents. HASS and LASS Home & Leisure Accident Surveillance System.http://www.hassandlass.org.uk/ Date Accessed: 6/1/2018
45. United States Consumer Product Safety Commission. National Electronic Injury Surveillance System (NEISS). http://www.cpsc.gov/en/Safety-Education/Safety-Guides/General-Information/National-Electronic-Injury-Surveillance-System-NEISS/; Internet.
46. https://www.miemss.org/home/Portals/0/Docs/Guidelines_Protocols/Protocols_2015_FULL_Web.pdf?ver=2015-04-09-133642-297 (pages 33,84)
47. Lewallen S, Courtright P.studies. Community Eye Health. 1998;11(28):57-8
48. Shenassa E.D., Stubbendick A., Brown M.J. Social disparities in housing and related pediatric injury: a multilevel study. Am J Public Health. 2004;94(4):633-639
49. Lavrakas, P.J. (2008) *Encyclopedia of survey research methods*. Sage Publications, Inc., Thousand Oaks
50. MacKay M, Vincenten J. How Safety Conscious are European countries towards children? European Summary for 31 Countries. European Child Safety Alliance, 2012.

51. den Hertog PC, Blankendaal FA, ten Hag SM.Burn injuries in The Netherlands. Accid Anal Prev. 2000 May;32(3):355-64.
52. https://www.childsafetyeurope.org/publications/positionstatements/info/tap-water-scalds-position-statement.pdf
53. https://www.childsafetyeurope.org/publications/info/factsheets/fires-in-the-home.pdf
54. https://www.childsafetyeurope.org/publications/info/factsheets/childhood-poisoning.pdf
55. https://www.childsafetyeurope.org/publications/positionstatements/info/baby-walkers-position-statement.pdf
56. https://www.childsafetyeurope.org/publications/info/factsheets/choking-strangulation-suffocation.pdf
57. Chen, L.H., Gielen, A.C., & McDonald, E.M. (2003). Validity of self-reported home safety practices. Injury Prevention, 9(1), 73–75. doi:10.1136/ip.9.1
58. Lee, L.K., Walia, T., Forbes, P.W., Osganian, S.K., Samuels, R., Cox, J.E., & Mooney, D.P. (2012). Home safety practices in an urban low-income population: Level of agreement between parental self-report and observed behaviors. Clinical Pediatrics, 51(12), 1119–1124.
59. Robertson, A.S., Rivara, F.P., Ebel, B.E., Lymp, J.F.,& Christakis, D.A. (2005). Validation of parent self-reported home safety practices. Injury Prevention, 11(4), 209–212.
60. Shields, W.C., McDonald, E.M., McKenzie, L., Wang, M.C., Walker, A.R., & Gielen, A.C. (2013). Using the pediatric emergency department to deliver tailored safety messages: Results of a randomized controlled trial. Pediatric Emergency Care, 29(5), 628–634.
61. Crowne, D. P., & Marlowe, D. (1960). A new scale of social desirability independent of psychopathology. Journal of Consulting Psychology, 24, 349-354. doi:10.1037/h0047358
62. Centers for Disease Control and Prevention (CDC). Nonfatal bathroom injuries among persons aged ≥15 years--United States, 2008.MMWR Morb Mortal Wkly Rep. 2011 Jun 10;60(22):729-33.
63. Centers for Disease Control and Prevention (CDC). Nonfatal scald-related burns among adults aged >/=65 years--United States, 2001-2006. MMWR Morb Mortal Wkly Rep. 2009 Sep 18;58(36):993-6.
64. Jennissen CA, Koos M, Denning G. Playground slide-related injuries in preschool children: increased risk of lower extremity injuries when riding on laps. Inj Epidemiol. 2018 Apr 10;5(Suppl 1):13
65. Rani M, Schwacha MG. Aging Dis. 2012 Apr;3(2):171-80. Epub 2011 Jul 4.
66. T. Schroeder, Consumer Product Safety Commission personal communication, April 2018
67. https://ameriburn.org/quality-care/registry-programs/
68. Kendrick D, Young B, Mason-Jones AJ, Ilyas N, Achana FA, et al. 2013. Home safety education and provision of safety equipment for injury prevention. Cochrane Database Syst. Rev. 9:CD005014
69. https://www.drugabuse.gov/publications/research-reports/relationship-between-prescription-drug-heroin-abuse/prescription-opioid-use-risk-factor-heroin-use
70. National Safety Council. Injury Facts®, 2015 Edition. Itasca, IL: Author. Library of Congress Catalog Card Number: 99-74142. 215.

Summary

The Burden of Home Injuries

Unintentional injuries account for significant mortality in the United States where they are the 4th leading cause of death. A substantial portion of unintentional injury deaths occur in the home each year, accounting for an estimated 74,600 deaths annually in the United States. The young and old experience home injuries at increased rates. Home injuries, burns and scalds in particular, disproportionately affect socioeconomically disadvantaged children. Fire and burns are a leading cause of home injuries morbidity and mortality.

The Public Health Approach

The public health approach as a conceptual model focuses on preventing health problems in a way that extends better care and safety to entire populations rather than to individuals. The public health approach is characterized by four steps: 1) define the problem, 2) identify risk and protective factors, 3) develop and test prevention strategies, and 4) assure widespread adoption of effective injury prevention principles and strategies. The World Health Organization and the Centers for Disease Control and Prevention recognize the utility of the public health approach for addressing injuries. The principles of the public health approach provide a useful framework for investigating and understanding the causes and consequences of unintentional home injuries and for preventing these injuries from occurring through primary prevention programs, policy interventions, and advocacy.

The thesis addresses 4 research questions; each research questions applies to one step in the above-mentioned public health approach.

1. What is the burden of home injuries from scalds and housing elements in the USA? (Refers to 'Step 1'; Chapter 2-3)
2. What are the main risk and protective factors for burn injuries and from housing elements in the homes of low-income families? (Refers to 'Step 2'; Chapter 4-7)
3. How effective was the Johns Hopkins Home Safety Project at increasing home safety practices? (Chapter 8-9)
4. Which strategies can be used to improve adoption of home safety measures? (Chapter 10-11)

Part one of this thesis utilizes the first step of the public health approach: defining the problem. In order to answer Question 1: What is the burden of home injuries from scalds and housing elements in the USA we must understand the problem. Prior to addressing an injury problem, we must understand both whom the problem affects and the magnitude of the problem in terms of morbidity and mortality as well as the circumstances of the injury events in order to understand

how the most dangerous injuries might be prevented. The National Electronic Injury Surveillance System (NEISS) of the Consumer Product Safety Commission (CPSC) is the primary tool for injury surveillance of consumer products in the US. In part one of this thesis, we utilize the NEISS system to explore the burden of injuries from scald burn and housing elements. (Chapter 2-3)

The NEISS query presented in Chapter 2 identified 2,104 scald burn cases between 2009 and 2012, yielding a national annual estimate of 11,028 scald burns in children younger than 3 years old in the USA. An analysis of the case narratives resulted in the identification of precipitating and/or contributing factors including cooking, bathing, and consuming hot liquids. Chapter 3 utilized the NEISS system to quantify unintentional injuries associated with housing elements among children less than 18 years old who were treated in US hospital emergency departments. This study identified twelve housing elements (bathtub, cabinet, carpet, ceiling/wall, counter, door, fence, floor, nail, porch, stairs and window) as the leading causes of injuries resulting in hospitalizations or emergency department visits.

Part two of this thesis utilizes the second step of the public health approach: identifying risk and protective factors to answer the Question 2: What are the main risk and protective factors for burn injuries and from housing elements in the homes of low-income families?

Chapter 4 reported on the potential benefit of an extended questionnaire to improve reporting of smoke alarm coverage by parents of children who were treated in an urban emergency department and recruited into a study. Respondents were first asked two questions which constituted the Brief Form. Later in the assessment, they answered an Extended Form, which asked them to identify the number of levels in their home, and then were prompted for each of those levels to report whether a smoke alarm was present, if it was working, and how they knew it was working. Answers were summarized to create two variables comparable to the items assessed on the Brief Form: any working smoke alarm and a working smoke alarm on every level. Responses from the Brief and Extended Forms were compared using a Kuder-Richardson test, a measure of internal consistency for binomial data. Comparing responses between the two forms demonstrated that respondents reported more working alarms (96% vs 85%) and more working smoke alarms on all levels (92% vs 73%) on the Brief Form compared to the Extended Form. Our results show that question phrasing and quantity changed respondents' answers to smoke alarm questions, presumably for more accurate reporting of smoke alarm presence and functionality.

Chapter 5 reports on an observational study conducted to examine the association between living in substandard housing and fire and burn risks in families living in low income urban environments. The observational study found

that virtually all homes (99%) failed the housing quality assessment and that there was an association between housing quality and burn risks. Chapter 6 expands our understanding of risks and protective factors for tap water scalds in urban homes via observational homes visits to collect data on water heater characteristics. This study in n=976 urban homes found that hot water temperature was unsafe in 41% of homes. Homeowners were more likely to have safer hot water temperature ($\leq$ 49°C/120°F) than renters (63% vs. 54%; $p<0.01$). These results suggest that hot water temperatures remain dangerously high for a substantial proportion of urban homes in low income areas despite the adoption of voluntary standards to preset temperature settings by manufacturers. Chapter 7 reports on a qualitative study conducted with parents of injured children which explored children injuries and parents self-reported perceptions of protective measures which could have prevented injury as well as actions taken to avert future injuries by making changes to the home environment. The most common injury mechanism was a fall (46%), and the most common body part injured was the head/neck/face area (62%). In all but two cases parents identified an item as contributing to the injury: 35% involved a house feature; 33% house furnishings, 11% food/beverage, and 8% toys. Parents identified prevention strategies. Of the 110 suggested prevention strategies, 40% indicated a recommendation to improve the safety of the environment (e.g., store hazardous product), 31% a modification to the child's behavior (e.g., new rules), and 29% for increased supervision. Fifty-nine parents (57%) reported making changes post injury, 51% modified the environment; 27% got rid of/replaced item; and 10% increased supervision. This study additionally explored how parents changed their homes after a medically-attended injury to prevent reoccurrence. Most parents identified a prevention strategy, commonly an environmental modification (e.g., storing hazard), however only 57% reported making a change to their home environment. Safety changes reported by parents to prevent reoccurrence of medically-attended home injuries can inform future prevention efforts that are more likely to be adopted in the future by other parents.

Part three of this thesis utilizes the third step of the public health approach: develop and test prevention strategies to answer Question 3: How effective was the Johns Hopkins Home Safety Project at increasing home safety practices? This section of the thesis presents the results of the Johns Hopkins Home Safety Project, a community intervention trial aimed at reducing risk from fire and burn in the homes of urban families in Baltimore. Chapter 8 reports on the effectiveness of the projects at increasing the acceptance of fire department installation visits by enhancing the fire departments with community health workers. At baseline, 60% of homes did not have working smoke alarms on every level of their homes; 44% had unsafe water temperatures; and 72% did not have carbon monoxide alarms. Residents in the enhanced community, relative to those in the standard community, were significantly more likely to let the fire fighters into their homes (75% vs 62%). Among entered homes, those in the enhanced

community were significantly more likely to be left with a working smoke alarm on every level of the home (84% vs 78%). Chapter 9 reports on the effect of adding in-home education about scald prevention to the Fire Department Home visit. We evaluated whether households which received in home safety education demonstrated improved safety behaviors about hot water compared to homes which did not receive the education. Hot water temperature and self-reported prevention behaviors were recorded at a baseline visit and retested 6-9 months later in a follow-up visit. No significant difference emerged between the two study groups in the proportion of households observed to have adjusted their hot water temperature to safe levels between the baseline and follow-up visits ($t = 1.24$; $P = 0.22$). Residents who received the enhanced education were more likely to report testing their water temperature (27% vs 11%; $P < .01$) and turning their hot water temperature below 49°C/120°F (43% vs 32%; $P = 0.08$). Among those who had unsafe temperature levels and did not reduce the water temperature, the most common reason (26%) offered was that they "liked it hot." These results demonstrate that water temperatures are unsafe in many urban homes.

Part four of this thesis focuses on the final step of the public health approach which is to share the knowledge learned through steps one-three with the broad audience in order to assure the adoption of the findings beyond the immediate community that was used to develop and test the interventions. Part four of this thesis aims to achieve the fourth step of the public health approach: by answering Question 4: Which strategies can be used to improve adoption of home safety measures? Chapters 10 and 11 present the knowledge we have gained via our utilization of the public health approach to a broad audience.

Chapter 10 describes the epidemiology of home injuries and summarizes the evidence on prevention strategies that addresses the groups most at risk for four of the leading causes of home injury -- infant sleep-related deaths, house fires and burns, poisonings, and falls. Effective prevention strategies have been identified to reduce injury or mitigate risk behaviors. The evidence is summarized by selected prevention strategies for each of these causes. Prevention strategies are organized by whether the outcomes evaluated are injuries or safety behaviors, and the strength of the evidence according to the definitions presented previously (strong evidence, promising evidence, recommended practice). Chapter 10 aims to assist injury prevention and health professionals in program planning.

Chapter 11 reports on the development and utilization of the CHASE housing assessment tool in a sample of 142 homes of children in Baltimore in a retrospective case control study. The CHASE tool development resulted in twenty-five injury items organized around twelve subdomains. When utilized in the sample of 142 homes the pass rates varied greatly across CHASE items, from 0% having medication locked and 11% having window guards to 90% having proper exits and 80% being free of furniture crowding. In the adjusted paired

regression analysis of the overall average pass rates, case status significantly predicted the CHASE sub-domains such that injured cases compared to non-injured controls were significantly less likely to pass (b=-3.315, p=.025). This finding demonstrated that the CHASE Inspection tool could distinguish between injured and non-injured children. The CHASE tool provides injury prevention measures, inspection protocol, risk remediation recommendations and cost estimates to aid with risk identification risk remediation planning.

Chapter 12 included a general discussion, including a description and interpretation of the main findings, methodological considerations, implications for policy and practice, and recommendations for future research.

All studies presented in this thesis and the National Electronic Injury Surveillance System draw from populations in the United States limiting the generalizability to populations beyond the United States. The literature cited in this thesis draws from injury literature based in the European Union, United Kingdom, Canada and Australia to more broadly reflect the evidence base on the prevention of home injuries internationally.

In conclusion, home injuries are a significant public health burden in the United States. The Public Health Approach is a valuable model to understand and address the burden of home injuries. Utilizing the Public Health Approach has provided valuable insight into the burden and risk factors associated with home injuries. Many of the injuries examined are preventable. A collaborative effort and coordination between multiple sectors including clinicians, home visitors, fire & life safety professionals and the housing community is needed to fully address the burden of injuries.

Samenvatting

De ziektelast van letsels door ongevallen in huis

Ongevalsletsels zorgen voor een aanzienlijke sterfte in de Verenigde Staten (VS), waar ze de 4e belangrijkste doodsoorzaak zijn. Een substantieel deel van deze sterfte komt door ongevallen in huis. Ongevallen in huis zijn in de VS verantwoordelijk voor naar schatting 74.600 sterfgevallen per jaar. Zowel jongeren als ouderen hebben een verhoogd risico om in huis gewond te raken. Letsels door ongevallen in huis – en met name brandwonden die zijn ontstaan door vuur of heet water- hebben een onevenredig grote invloed op sociaaleconomisch achtergestelde kinderen. Brandwonden zijn een belangrijke oorzaak van morbiditeit en mortaliteit ten gevolge van letsels door ongevallen in huis.

Het volksgezondheid perspectief

In deze thesis wordt de preventie van ongevallen in huis benaderd vanuit het perspectief van de volksgezondheid. Deze volksgezondheidbenadering is gericht op het voorkomen van gezondheidsproblemen bij hele bevolkingsgroepen in plaats van individuen. Deze aanpak wordt gekenmerkt door vier stappen: 1) definieer het probleem, 2) identificeer risicofactoren en beschermende factoren, 3) ontwikkel en evalueer preventiestrategieën, en 4) zorg voor brede toepassing van effectieve preventiestrategieën. De Wereldgezondheidsorganisatie (WHO) en het centrum voor ziektebestrijding en -preventie in de Verenigde Staten (CDC) erkennen het nut van de volksgezondheidbenadering voor het terugdringen van ongevalsletsels. De principes van deze aanpak bieden een bruikbaar kader voor het onderzoeken en begrijpen van de oorzaken en gevolgen van letsels door ongevallen in huis, voor het voorkomen van deze letsels door middel van primaire preventieprogramma's beleidsinterventies, en het op de kaart zetten van dit probleem.

Dit proefschrift behandelt 4 onderzoeksvragen; elke onderzoeksvraag sluit aan op één stap van de bovengenoemde volksgezondheidsbenadering.

1. Wat is de ziektelast van ongevalsletsels in huis door hete vloeistof verbrandingen en woonelementen in de Verenigde Staten
   (Verwijst naar 'Stap 1'; Hoofdstuk 2- 3)
2. Wat zijn de belangrijkste risicofactoren en beschermende factoren voor letsels door brandwonden en woonelementen in de huizen van gezinnen met een laag inkomen? (Verwijst naar 'Stap 2'; Hoofdstuk 4-7)
3. Hoe effectief was het “Johns Hopkins Home Safety Project” in het verbeteren van de veiligheid in huis? (Verwijst naar ‘Stap 3’; Hoofdstuk 8-9)

4. Welke strategieën kunnen worden gebruikt om de implementatie van maatregelen voor veiligheid in huis te verbeteren? (Verwijst naar 'Stap 4'; Hoofdstuk 10-11)

Deel één van dit proefschrift sluit aan bij de eerste stap van de volksgezondheidsbenadering: het probleem definiëren. Hiermee werd onderzoeksvraag 1 beantwoord: Wat is de ziektelast van ongevalsletsels in huis door hete vloeistof verbrandingen en woonelementen in de Verenigde Staten? Voordat we een letselprobleem kunnen aanpakken, moeten we zowel de oorzaken, als de omvang van het probleem alsmede de omstandigheden waarin de letsels plaats hebben gevonden identificeren. Hiermee begrijpen we beter hoe gevaarlijkste letsels kunnen worden voorkomen. Het National Electronic Injury Surveillance System (NEISS) van de Consumer Product Safety Commission (CPSC) is het primaire instrument voor de monitoring van letsels door consumentenproducten in de VS. In deel één van dit proefschrift gebruiken we het NEISS-systeem om de ziektelast van ongevalsletsels in huis door hete vloeistof verbrandingen en woonelementen (bijvoorbeeld deuren, spijkers en muren) te onderzoeken. (Hoofdstuk 2-3)

In hoofdstuk 2 werden met behulp van het NEISS-systeem 2.104 hete vloeistof verbrandingen tussen 2009 en 2012 geïdentificeerd. Dit resulteerde in een schatting van 11.028 hete vloeistof verbrandingen per jaar bij kinderen jonger dan 3 jaar oud in de VS. Een analyse van de casusbeschrijvingen resulteerde in de identificatie van hieraan bijdragende factoren, waaronder koken, in bad gaan en het drinken van hete vloeistoffen. In hoofdstuk 3 werd gebruik gemaakt van de data in het NEISS-systeem om ongevalsletsels die verband houden met woonelementen te kwantificeren bij kinderen jonger dan 18 jaar die werden behandeld op een spoedeisende hulp (SEH) afdeling van een Amerikaans ziekenhuis. Deze studie identificeerde twaalf woonelementen (badkuip, kast, tapijt, plafond/ muur, aanrecht, deur, hek, vloer, spijker, veranda, trap en raam) als de belangrijkste oorzaken van letsels die tot een bezoek aan de SEH en/of ziekenhuisopname leiden.

Het tweede deel van dit proefschrift maakt gebruik van de tweede stap van de volksgezondheidsbenadering: het identificeren van risico's en beschermende factoren. Hiermee werd onderzoeksvraag 2 beantwoord: wat zijn de belangrijkste risicofactoren en beschermende factoren voor letsels door brandwonden en woonelementen in de huizen van gezinnen met een laag inkomen?

Hoofdstuk 4 beschreef het potentiële voordeel van een uitgebreide vragenlijst om de rapportage van het gebruik van rookmelders te verbeteren. Respondenten waren ouders van kinderen die werden behandeld op een SEH afdeling en waren gerekruteerd voor een onderzoek. Aan deze respondenten werden eerst twee vragen gesteld, die de korte versie van de vragenlijst vormden. Daarna kregen zij een uitgebreide versie voorgelegd, waarin hen werd gevraagd het aantal

verdiepingen in hun huis te identificeren en vervolgens voor elke verdieping aan te geven of er een rookalarm aanwezig was, of deze werkte en hoe men wist dat deze werkte. De antwoorden werden samengevat om twee variabelen te creëren die vergelijkbaar zijn met de items op het korte formulier: een werkend rookalarm en een werkend rookalarm op elke verdieping. Antwoorden van de korte en uitgebreide formulieren werden vergeleken met behulp van een Kuder-Richardson-test, een maat voor de interne consistentie van binomiale gegevens. Uit een vergelijking van de antwoorden tussen de twee versies bleek dat respondenten meer werkende rookmelders (96% versus 85%) en meer werkende rookmelders op alle verdiepingen (92% versus 73%) rapporteerden in de korte versie ten opzichte van de uitgebreide vragenlijst. Onze resultaten laten zien dat de formulering van en het aantal vragen over rookmelders invloed had op de antwoorden van respondenten; waarschijnlijk heeft de uitgebreide vragenlijst geleid tot een nauwkeuriger rapportage van de aanwezigheid en functionaliteit van rookmelders.

Hoofdstuk 5 rapporteert over een observationeel onderzoek dat is uitgevoerd om het verband te onderzoeken tussen het wonen in suboptimale huizen en het risico op huisbranden en brandwonden bij gezinnen die wonen in buurten met een laag inkomen. Uit dit onderzoek bleek dat vrijwel alle woningen (99%) niet voldeden aan de geldende eisen voor een goede woningkwaliteit en dat er een verband bestond tussen de kwaliteit van woningen en het risico op brandwonden.

Hoofdstuk 6 breidt ons begrip uit van risico's en beschermende factoren voor hete vloeistof verbrandingen door kraanwater door middel van observaties tijdens huisbezoeken. Deze studie werd uitgevoerd in 976 huizen in stedelijke gebieden met een laag inkomen. De resultaten lieten zien dat de temperatuur van warm water onveilig was in 41% van de huizen. Huiseigenaren hadden meer kans op een veiligere warmwatertemperatuur (<49 °C / 120 ° F) dan huurders (63% versus 54%, p <0,01). Deze resultaten suggereren dat warmwater temperaturen gevaarlijk hoog blijven in een aanzienlijk deel van de huizen in stedelijke gebieden met een laag inkomen, ondanks de introductie van vrijwillige normeren en instellen van de watertemperatuur door de fabrikanten. Hoofdstuk 7 rapporteert over een kwalitatief onderzoek, uitgevoerd bij ouders van kinderen met een ongevalsletsel. Hierin werden kenmerken van de opgelopen verwondingen in kaart gebracht en werden de opvattingen van ouders geïnventariseerd over beschermende maatregelen die mogelijk letsel hadden kunnen voorkomen, en over maatregelen om toekomstige letsels te voorkomen door verbetering van de veiligheid in huis. Het meest voorkomende letselmechanisme was een val (46%) en het meest voorkomende betrokken lichaamsdeel was het hoofd/ nek / aangezicht (62%). In bijna alle gevallen konden ouders een factor noemen die volgens hen had bijgedragen aan het ontstaan van het letsel: bij 35% een kenmerk van het huis; 33% woninginrichting, 11% voedsel / drank en 8% speelgoed. Ouders noemden

diverse preventiestrategieën. Van de 110 voorgestelde preventiestrategieën, gaf 40% een aanbeveling aan om de veiligheid van de omgeving te verbeteren (bijv. gevaarlijke producten goed opbergen, 31% een gedragsverandering van het kind (bijv. door nieuwe regels) en 29% voor meer toezicht. Negenenvijftig ouders (57%) meldden dat ze iets hadden veranderd na het ongevalsletsel van hun kind: 51% veranderde de omgeving, 27% verwijderde of verving een bepaald product en 10% verhoogde het toezicht. Veiligheidsveranderingen die door ouders worden gemeld om herhaling van ongevalsletsels in huis te voorkomen, kunnen toekomstige preventiemaatregelen - aangeven met een grotere kans om in de toekomst door andere ouders te worden toegepast.

Deel drie van dit proefschrift maakt gebruik van de derde stap van de volksgezondheidsbenadering: het ontwikkelen en evalueren van preventiestrategieën. Hiermee werd onderzoeksvraag 3 beantwoord: Hoe effectief was het “Johns Hopkins Home Safety Project” in het verbeteren van de veiligheid in huis? Dit deel van het proefschrift presenteert de resultaten van het Johns Hopkins Home Safety Project, een gemeenschapsinterventiestudie gericht op het verminderen van het risico van brand en brandwonden in de huizen van stedelijke families in Baltimore. Hoofdstuk 8 rapporteert over de effectiviteit van dit project in het verhogen van de acceptatie van installatiebezoeken door brandweerkorpsen. De brandweer werd hierbij in de interventiegroep versterkt met gezondheidswerkers Bij aanvang van de studie had 60% van de huizen geen werkende rookmelders op elke verdieping van hun woning; 44% had onveilige watertemperaturen; en 72% had geen koolmonoxidemelders. Bewoners in de gemeenschap met versterking van de brandweer met gezondheidswerkers, lieten de brandweermannen significant vaker in hun huizen binnen (75% versus 62%) dan bewoners in de gemeenschap zonder deze versterking. In de huizen waar een installatiebezoek kon worden uitgevoerd, was hierna in de versterkte gemeenschap significant vaker een werkende rookmelder op elke verdieping van het huis aanwezig (84% versus 78%). Hoofdstuk 9 rapporteert over het effect van het toevoegen van voorlichting over brandwondenpreventie aan het huisbezoek van de brandweer. We evalueerden of huishoudens die deze voorlichting hadden gekregen veiliger gedrag lieten zien ten aanzien van warm water in vergelijking met huishoudens die deze voorlichting niet hadden gekregen. De warmwatertemperatuur en het zelfgerapporteerde preventiegedrag werden geregistreerd tijdens een baselinebezoek en 6-9 maanden later opnieuw tijdens een vervolgbezoek. Er was geen significant verschil tussen de twee onderzoeksgroepen in het percentage huishoudens die hun warmwatertemperatuur hadden aangepast tot veilige niveaus tussen de twee bezoeken ($t = 1,24$; $P = 0,22$). Bewoners die de voorlichting hadden ontvangen, controleerden vaker hun watertemperatuur (27% versus 11%; $P < .01$) en draaiden hun warmwatertemperatuur vaker onder 49 ° C / 120 ° F (43% versus 32%; $P = 0,08$). Onder degenen die onveilige temperatuurniveaus hadden en de watertemperatuur niet verlaagden, was de meest voorkomende reden (26%) dat

ze het "heet water fijn vonden". Deze resultaten laten zien dat watertemperaturen in veel stedelijke huizen onveilig zijn.

Deel vier van dit proefschrift richt zich op de laatste stap van volksgezondheidsbenadering, namelijk het delen van de kennis die vanuit stap 1 t/m 3 tot stand is gekomen met en breed publiek om de bevindingen te implementeren buiten de directe gemeenschap die werd gebruikt om de interventies te ontwikkelen en te evalueren. Deel vier van dit proefschrift beantwoord onderzoeksvraag 4: Welke strategieën kunnen worden gebruikt om de implementatie van maatregelen voor veiligheid in huis te verbeteren? In de hoofdstukken 10 en 11 wordt de kennis die we hebben opgedaan met het gebruik van de volksgezondheidsbenadering voor een breed publiek gepresenteerd.

Hoofdstuk 10 beschrijft de epidemiologie van letsels door ongevallen in huis. Ook vat hoofdstuk 10 het bewijsmateriaal samen over preventiestrategieën die betrekking hebben op de groepen die het grootste risico lopen voor vier van de belangrijkste oorzaken van letsels door ongevallen in huis: ongevallen bij het slapen, huisbranden en brandwonden, vergiftigingen en valongevallen. Er werden effectieve preventiestrategieën geïdentificeerd om het aantal letsels of het risicogedrag te verminderen te verminderen. Het bewijsmateriaal is voor elk van deze oorzaken samengevat in een selectie van preventiestrategieën . Deze preventiestrategieën zijn ingedeeld op basis van de vraag of de geëvalueerde uitkomsten letsels of risicogedrag zijn, en op basis van de sterkte van het bewijs (sterk bewijs, veelbelovend bewijs, aanbevolen praktijk). Hoofdstuk 10 is bedoeld om letselpreventie te bevorderen en professionals in de gezondheidszorg te helpen bij het plannen van programma's.

Hoofdstuk 11 rapporteert over de ontwikkeling en het gebruik van het CHASE-huisbeoordelingsinstrument in een steekproef van 142 huizen van kinderen in Baltimore in een retrospectieve case control-studie. De ontwikkeling van de CHASE-tool resulteerde in vijfentwintig letselitems die zijn geordend in twaalf subdomeinen. Bij gebruik in de steekproef van 142 woningen varieerden de percentages deelnemers die veilig gebruik lieten zien sterk tussen de CHASE-items: 0% had medicatie achter slot en grendel, 11% had raambescherming, 90% had de juiste uitgangen en bij 80% waren de uitgangen vrij van meubels. Het totaalpercentages veilig gebruik voorspelde de case-status de CHASE-subdomeinen, in de zin dat de cases met letsels in vergelijking met de niet-gewonde controles significant minder vaak veilig gebruik lieten zien ($b = -3.315$, $p = .025$). Deze bevinding toonde aan dat het CHASE huisbeoordelingsinstrument onderscheid kon maken tussen gewonde en niet-gewonde kinderen. Het CHASE-instrument biedt diverse mogelijkheden om de risico-inventarisatie van huizen te ondersteunen.

Hoofdstuk 12 bevat een algemene discussie, inclusief een beschrijving en interpretatie van de belangrijkste bevindingen, methodologische overwegingen, implicaties voor beleid en praktijk en aanbevelingen voor toekomstig onderzoek.

Alle onderzoeken gepresenteerd in dit proefschrift en het National Electronic Injury Surveillance System zijn gebaseerd op populaties in de Verenigde Staten die de generaliseerbaarheid beperken. De literatuur die in dit proefschrift wordt aangehaald, is gebaseerd op onderzoek in de Europese Unie, het Verenigd Koninkrijk, Canada en Australië om een meer internationale bewijsbasis voor de preventie van letsels door ongevallen in huis te weerspiegelen.

We concluderen dat letsels door ongevallen in huis een aanzienlijke impact op de volksgezondheid in de Verenigde Staten hebben. De volksgezondheidsbenadering is een waardevolle bandering om de ziektelast van deze letsels mee te begrijpen en aan te pakken. Het gebruik van de volksgezondheidsbenadering heeft waardevolle inzichten opgeleverd over de ziektelast en risicofactoren die samenhangen met letsels door ongevallen in huis. Veel van de onderzochte verwondingen zijn te voorkomen. Een gezamenlijke inspanning en coördinatie tussen meerdere sectoren, waaronder clinici, afleggers van huisbezoeken, brandweer- en veiligheidsprofessionals en het huisvestingsdomein is nodig voor een complete aanpak van de ziektelast van letsels door ongevallen in huis.

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About the author

Wendy Conlan Shields was born on March 9, 1969 in Philadelphia Pennsylvania, USA. In 1987 she completed Haverford Senior High School in Havertown Pennsylvania, USA. In the same year she began her bachelor's studies at Saint Joseph's University in Philadelphia Pennsylvania, USA. In 1991 she received her bachelor's degree with a dual major in Political Science and Secondary Education. Between 1992-1994 she served as a community health volunteer working on malaria prevention for the United States Peace Corps in Buhalu Village, Papua New Guinea. In 1995 she began her Master of Public at the Johns Hopkins Bloomberg School of Public Health in Baltimore Maryland. She obtained her master's degree from Johns Hopkins in 1996. From 1996-2002 she was a Project Director at the Kennedy Krieger Institute. She directed a projected, which aimed to relocate lead poisoned children to lead safe housing. She began working at the Johns Hopkins Center for Injury Research and Policy in 2002 performing tasks of research coordination, data management, and analysis for multiple intervention trials aimed at reducing unintentional home injuries. She was promoted to faculty member at Johns Hopkins Bloomberg School of Public Health in 2006; she was promoted to Assistant Scientist in 2011 and Associate Scientist in 2017. She has been an external PhD student from 2017 through 2019 focusing on the prevention of unintentional injuries in the home with the guidance of Prof.dr. Hein Raat, Dr. Ed Van Beeck, and Dr. Amy van Grieken in the Department of Public Health at Erasmus University Medical Center. Her primary responsibility in her role as faculty member is serving as the research manager for multiple intervention trials. Responsibilities on the intervention trials include oversight of data collection, development and oversight research protocols, and oversight of data analysis for manuscript preparation and presentation. She has also served as the Assistant Director of the Johns Hopkins Center for Injury Research since 2014. Her primary responsibilities as assistant director on the Injury Center include overseeing administrative duties of the Injury Center including long term strategy, coordination between center cores divisions, and reporting on center accomplishments to the Center for Disease Control and Prevention. Ms. Shields' research focuses on the prevention of unintentional injuries. She has experience working on a variety of injury topics including fire prevention, home injuries, motor vehicle, and pedestrian safety. She is affiliated with the Johns Hopkins Center for American Indian Health and works with the Navajo and White Mountain Apache Tribes. Ms. Shields has expertise in the intersection of housing quality and injuries risk, the prevention of scald burns, and the development of injury prevention material of individuals with low literacy skills.

Selected publications

2019

Shields WC Gielen AC, McDonald EM, Frattaroli S, van Beeck EF, Bishai D, Munshi, R
Child Housing Assessment for a Safe Environment (CHASE): a new tool for injury prevention inside the home, 2019 June 03. Injury Prevention.

2018

Doucette M. **Shields WC**, Haring S, Frattaroli S. Storing and Disposing Opioid Pain Relievers: What does our medicine tell us? Ann Intern Med. 2018 Apr 17. doi: 10.7326/M17-3381.

Jones V, **Shields WC**, Ayyagari R, Frattaroli S, McDonald E, Gielen AC. Association Between Unintentional Child Injury in the Home and Parental Implementation of Modifications for Safety JAMA Pediatrics 2018 Oct 8 DOI:10.1001/ jamapediatrics.2018.2781

2017

Omaki E; **Shields WC**, McDonald EM, Aitken M, Bishai D, Case J, Gielen AC. Evaluating a smartphone application to improve child passenger safety and fire safety knowledge and behavior. Inj Prev. 2017 Feb;23(1):58. doi: 10.1136/injuryprev-2016-042161

Omaki E; **Shields WC**, Gielen AC. Six-month Follow-up of Lithium Battery Smoke Alarms and Self-Reported Reasons for Disabling. Inj Prev. 2017 Feb;23(1):67-69. doi: 10.1136/injuryprev-2015-041870

Frattaroli S, **Shields WC**, Malloy M, Omaki E, Gielen AG. How are Prescription Medications Stored in Urban Homes where Children Live? Opportunities for Poisoning Prevention. Clin Pediatr (Phila). 2017 Jun;56(7):678-681. doi: 10.1177/0009922816668631

2016

Shields WC, McDonald EM, McKenzie LB, X Ma, Gielen AC. Does Health Literacy Level Influence the Effectiveness of an Injury Prevention Communication Program Delivered via Computer Kiosk? Clin Pediatr (Phila). 2016 Jan;55(1):48-55. doi: 10.1177/0009922815602889

Shields WC, Omaki EP, Zhu J, McDonald EM, Gielen AC. Some like it hot: Results of a community intervention trial aimed at improving safety behaviors to prevent hot water scald burns. Journal of Epidemiological Research, March 2016 DOI: https://doi.org/10.5430/jer.v2n2p74

Shields WC, McDonald EM, Frattaroli S, Bishai D, AC Gielen. Structural housing elements associated with home injuries in children . Inj Prev. 2016 Apr;22(2):105-9. doi: 10.1136/injuryprev-2015-041621.

McDonald EM, Mack K, **Shields WC**, Lee R, Gielen AC. Primary Care Opportunities to Prevent Unintentional Home Injuries: A focus on children and older Adults. American Journal of Lifestyle Medicine Am J Lifestyle Med. 2016 Feb 12;2016 https://doi.org/10.1177/1559827616629924

2015

Gielen AC, McDonald EM, **Shields WC**. Unintentional Home Injuries Across the Life Span: Problems and Solutions. Annu Rev Public Health. 2015 Mar 18;36:231-53. doi: 10.1146/annurev-publhealth-031914-122722

Shields WC, McDonald EM, Pfisterer K, AC Gielen. Scald burns in children under 3 years: An analysis of NEISS narratives to inform a scald burn prevention program. Inj Prev. 2015 Oct;21(5):296-300. doi: 10.1136/injuryprev-2015-041559

Perry E, **Shields WC**, OBrocki R, Bishai D, Frattaroli S, Jones V, Gielen AC. Examining Fire Department Injury Data as a Tool for Epidemiological Investigation. J Burn Care Res. 2015 Mar-Apr;36(2):310-4. doi: 10.1097/BCR.000000000 0000075

2013

Gielen AC, **Shields W**, Frattaroli S, McDonald E, Jones V, Bishai D, O'Brocki R, Perry EC, Bates-Hopkins B, Tracey P, Parsons S, Enhancing Fire Department Home Visiting Programs: Results of a Community Intervention Trial. J Burn Care Res. 2013 Jul-Aug;34(4):e250-6. doi: 10.1097/BCR.0b013e3182685b3a

Shields WC, Perry E, Szanton S, McDonald, Stepnitz R Andrews MR, Gielen AC. Knowledge and Injury Prevention Practices in Home of Older Adults. Geriatr Nurs. 2013 Jan-Feb;34(1):19-24. doi: 10.1016/j.gerinurse.2012.06.010

Shields WC, McDonald EM, Frattaroli S, Perry E, Zhu J. Gielen AC. Still Too hot: Examination of Water Temperature and Water Heater Characteristics 24 Years After Manufacturers Adopt Voluntary Temperature Setting. J Burn Care Res. 2013 Mar-Apr;34(2):281-7. doi: 10.1097/BCR.0b013e31827e645f.

Submitted for publication

Shields WC, Omaki E; McDonald EM, van Beeck EF, Gielen AG Improving Smoke Alarm self-report via a prompted questionnaire (In review Injury Epidemiology)

PHD portfolio

Summary of Phd training and teaching activities

Name PhD student: Wendy Conlan Shields
Erasmus MC Department: Public Health
Research School: Johns Hopkins Bloomberg School of Public Health
PhD period: October 2012 – December 2018
Promotors: Prof.dr. H. Raat
Co-promotor: dr. E.F. van Beeck
Co-promotor: dr. A van Grieken

1.Phd training	Year	Workload (hours/ECTS)
General Courses		
Junior Faculty Manuscript Writing Workshop	2014	2 ECTS
Conflict of Interest and Commitment	2016	1 ECTS
CPO HIPAA compliance course for understanding the use and disclosure of Health Information in Resource	2017	1 ECTS
BROK Good Clinical Practice for Social and Behavioral Research Human Subjects Research	2017 & 2018	2 ECTS
Road Safety 101 –University of North Carolina Highway Safety Research Center	2017	3 ECTS
Scientific Integrity: Responsible Conduct of Research Johns Hopkins School of Medicine; Office of Policy Coordination; Division of Research Integrity	2018	1 ECTS
Presentation & Posters		
American Burn Association Conference April 2012, Seattle WA	2012	1 ECTS
Society for Advancement of Violence and Injury Research, June 2013, Baltimore, MD	2013	1 ECTS
Society for Advancement of Violence and Injury Research, March 2015, New Orleans, LA	2015	1 ECTS
Healthy Homes Research Agenda Workshop. United States Department for Housing and Urban Development. November 2015, Washington, DC	2015	1 ECTS

World Injury Conference, Sept 2016 Tampere Finland	2016	1 ECTS
American Public Health Association, October 2016, Denver Colorado	2016	1 ECTS
Society for Advancement of Violence and Injury Research, September 2017, Ann Arbor, MI	2017	1 ECTS
Colorado Risk Reduction Network Conference of the Rockies; April 2018, Black Hawk, CO	2018	1 ECTS
Seminar/Symposium		
Symposium; The Smoke Alarm Summit: Evidence Informing Action; March 2015; Baltimore MD	2015	1 ECTS
Symposium; The Prescription Opioid Epidemic: An Evidence-Based Approach; Nov 2015; Baltimore MD	2015	1 ECTS
Conference; US Consumer Product Safety Association; National Smoke Alarm Survey Workshop; March 2017; Bethesda MD	2017	1 ECTS
Conference; Action Through Collaboration: Injury and Violence Prevention Translation Symposium; May 2017; Baltimore MD	2017	1 ECTS

2.Teaching Activities		
Lecturing Law and the Public Health; April 2017	2017	.5 ECTS
Lecturing Lecturer Principles and Practice of Injury Prevention; June 2017	2017	.5 ECTS
Instructor; Principles and Practice of Injury Prevention in America Indian Communities January 2018	2018	4 ECTS
Instructor; Injury Seminar; Unintentional Injuries in the Home March-April 2018	2018	2 ECTS
Clinical Teaching Fellowship Advisor	2015	1ECTS
Undergraduate Internship Supervisor	2016-2017	2 ECTS
MPH Advisor	2015-2019	1 ECTS
MPH Capstone Advisor	2019	.5 ECTS

3. Other Activities	
Reviewer several international scientific journals (e.g. Pediatrics, American Journal of Public Health, Injury Prevention, Journal of Burn Care Research, Geriatric Nursing)	2012-2019