ENCYCLOPEDIA
on Early Childhood
Development

Injury prevention

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Synthesis

How important is it?

Injuries are the most important cause of morbidity and mortality for children in high income countries and are increasingly so for children in low-and middle-income countries. All injuries should be viewed as preventable.

Falls

Falls are the most common injury event and occur when a person comes to rest inadvertently on the ground, the floor or from one level to another. Although falls result in minor bruises and bumps most of the time, injury rates from falls can also become fatal. In 2007, falls ranked first as the leading cause of non-fatal injury events among children under 14 years old in the United States. Worldwide, death and injury rates vary by country and child gender.

Road Traffic Injury

Road traffic injury (RTI) is defined as any collision or incident involving at least one vehicle in motion that leads to a fatal injury. It is estimated that more than one million people die each year from RTI. In fact, road-traffic crashes are projected to be the 5th leading cause of death by 2030. Pedestrians, cyclists, and young children are the most at risk of being involved in those incidents.

Drowning

Drowning refers to a fatal incident caused by respiratory impairment after being submersed in a liquid medium. In most countries, drowning reaches its peak among children between 1 to 4 years of age. The number of drowning incidents is estimated to be around 30,000 deaths each year (especially high in low-and middle-income countries, and rural areas). In some parts of the world, such as Bangladesh, drowning is the most common cause of death for young children.

Burns

According to the World Health Organization, burns are “injuries to the skin or other organic tissue caused by thermal trauma”.[1] It can occur when the skin is damaged by hot liquids (scalds), hot

solids (contact burns) or flames (flame burns). It is estimated that more than 95,000 children under 20 years old died each year from burn related injuries. The population most at risk are children under five years living in low-and-middle income countries.

Poisoning

Poisoning is defined as exposure to a potentially harmful substance such as dangerous chemicals or medications. In the United States, more than 1,500,000 poisoning cases were reported in children (0-19 years-old) in 2009. Children under 5 have the highest rate of poisoning. The number of poisoning events tends to be higher in socioeconomically disadvantaged populations.

What do we know?

Falls

Risks factors related to fall injuries include children's age and development as well as the environmental conditions in which they are living. While toddlers are more likely to fall from steps, stairs, and furniture, older children fall most often from playground equipment and heights (e.g., balconies, trees, roofs, and fire escapes). Other risk factors include the lack of parental supervision and the absence of home safety devices.

Road Traffic Injury (RTI)

One factor explaining children's heighten risk of being involved in RTI is their cognitive immaturity. Children need to first develop complex cognitive skills in order to reduce their tendency to act impulsively and to being able to gauge the appropriate amount of time for crossing a street. The recommended age at which children can safely cross the street by themselves is 10 years old. Another reason for the elevated number of RTI in childhood is the lack of use or misuse of child's safety seats and seat belts. Correct use of seat restraints can reduce the RTI mortality rate by around 70%.

Drowning

While infants are most likely to drown in body of water at or near home (e.g., bathtub, bucket), older children drown most often in pools or natural bodies of water close to their homes. Children's risk of drowning is reduced when pools are isolated by 4-sided fences and when they have been enrolled in formal swimming lessons. The chance of survival increases when they are

resuscitated immediately after the incident by parents or bystanders.

Burns

Risk factors for burn-related injuries depend on children's age, gender, and the level of parental supervision. Infants are more likely to be burned from hot liquids and house fires whereas older children, and especially boys, are more likely to burn themselves when playing with fire or smoker materials (e.g., lighters). Poverty, substandard housing, and open cooking fires are important risk factors for burns.

Poisoning

Children are more or less likely to experience a poisoning event depending on: 1) their age and sex; 2) their behavioural characteristics; 3) the use of child safety measures such as child resistant packaging for poisons in the home; and the availability of old medications and poisons in the home environment.

What can be done?

Falls

The most common countermeasure to reduce fall injuries is the use of window locks or barriers for homes with floors above the ground level. Other effective strategies include the provision of stair gates, handrails, and the use of energy absorbing material under playground equipment. In terms of supervision-related strategies, parents should never leave a baby on a changing table without supervision and they are also encouraged to monitor children's climbing behaviours.

Road Traffic Injury

For motor vehicle occupant injuries, the most important countermeasure is the use of seat restraints. From birth until they weigh about 10 kilograms, children should be restrained in rear-facing child seats. Children should be in forward-facing seats from then until about 4 years of age. Then, booster seats must be used until the adult seat belt fits children properly (around 145 cm of height). Seats should be adjusted correctly and seat belt properly worn on each riding occasion. Finally, parents are encouraged to provide supervision until children are cognitively able to safely cross the street (around 10 years of age).

Drowning

Passive strategies recommended to prevent drowning include: 1) installing a 4-sided fence surrounding the swimming pool; 2) placing a cover on a well; and 3) emptying water from large containers when not used. Although less effective than passive strategies, behavioural interventions should also be considered such as: 1) teaching a child how to swim (it reduces the risk of drowning by 40 to 88% for children between 1 and 4); 2) training lifeguards on beaches and at public swimming pools in CPR (cardiopulmonary resuscitation; and 3) wearing life vests when boating or in open water.

Burns

Prevention strategies to reduce burns include home safety education as well as the regular maintenance of smoke alarm installation. Parents should also ensure that matches, lighters, and hot liquids are kept out of young children's reach. Furthermore, it is recommended that the temperature of hot tap water be reduced to prevent tap water scalds.

Poisoning

The most effective strategy to reduce poisoning is to prevent the child from getting to poisons and toxins in the home. Parents should throw out unused prescription medications and always use child resistant caps on medication bottles. Poisons such as kerosene and pesticides should not be kept in the home, always kept in their original containers equipped with child resistant caps. Finally, parental supervision should always be favoured to sibling supervision considering the latter tends to increase the risk of injury in young children.

Note:

[1] Sethi D, Towner E, Vincenten J, Segui-Gomez M. European report on child Injury prevention. Geneva, Switzerland: World Health Organization; 2008.

Injury Prevention: Burns

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Introduction

Many children die each year as a result of a burn; many more suffer burn-related disabilities and disfigurements leading to considerable personal and economic effects for both individuals and their families. A range of factors put children at particular risk of burns including age, gender, and environmental issues such as supervision and housing. However, by applying successful primary preventive public health interventions that encompass educational, environmental, and legislative approaches and appropriate medical care, it is possible to reduce the mortality and morbidity from burns.

Subject

The World Health Organization (WHO) defines a burn as “an injury to the skin or other organic tissue caused by thermal trauma” which occurs when “the skin or other tissues are destroyed by hot liquids (scalds), hot solids (contact burns) or flames (flame burns).”[1] Similar injuries due to radiation, radioactivity, electricity, friction or contact with chemicals are also considered as burns.

Globally, burns are a major cause of death with more than 95,000 children aged under 20 years dying annually from burn related injuries.[2] Generally, children under 5 are at greatest risk of burns related mortality with global rates of 10.1 and 6.8 deaths per 100,000 population for children under 1 year old and aged 1 to 4 years old, respectively.[2]

Problems

Inequalities exist in childhood death and injury rates from burns. Worldwide death rates from burns in low- and middle-income countries are eleven times higher than that in higher income countries.[2] Moreover, such inequalities persist within countries. In the UK children of families in the lowest socioeconomic group are 37.7 times more likely to die from exposure to smoke, fire and flames than children from families in the highest socioeconomic group.[3] In the UK and Australia,

children from more deprived areas are more likely to suffer a burn-related injury and be admitted to hospital for a burn or scald than children from less deprived areas.[4-6]

The risk factors for burns and consequent prevention practices differ with age and development of a child, thus requiring a continual process of risk assessment. While infants are at greater risk of scalds from hot liquids and burns from house fires, older children, especially boys, are at greater risk due to playing with fire and access to smokers materials. Girls' greater participation in cooking, possibly on open fires increases their risk of burns injury.[2]

The consequences of a nonfatal burn can be significant and long term. The injured child may have to cope with physical and psychological effects of a burn such as pain and lack of self-esteem due to scarring.[7,8] Burns on the hands can result in severe functional impairment. Severe burns may require long term or repeated hospitalizations which cause psychological and economic stress on the family. In terms of health care, burns can be very costly.[9-11]

Research Context

In relation to other public health problems, burns provide a large and diverse research environment. In terms of prevention, research is needed for primary, secondary and tertiary prevention and there are a considerable number of mechanisms to be researched, as evidenced by the range of risk factors. The picture is further complicated by the need for priorities at different ages. The existence of inequalities both between and within countries necessitates the investigation of potential risk factors and culturally-appropriate prevention approaches for diverse population groups.

Key Research Questions

How do we address the inequalities in burns related morbidity and mortality?

How can we demonstrate links from an intervention to injury outcomes rather than intermediate outcomes?

How do we enable policy makers and practitioners to implement what is known to be effective?

Recent Research Results

Three general approaches are advocated for reducing burn injuries in children; education, environmental (including engineering) and legislation.[1]

A recent systematic review found that home safety education with the provision of safety equipment, is effective in increasing burn prevention practices.[12] Risk Watch, a school-based educational program improved fire and burn safety knowledge and skills in children[13] and an information folder to the relatives of young children increased their knowledge on risks of burns.[14] However, the effect of these educational interventions on burn injury rates is unknown.

An audit of first aid treatment received by children attending a hospital in Australia for a burn injury found that while 80.2% received cold water as a first treatment, only 12.1% had cold water applied for the recommended 20 minutes.[15]

While 95% of US households reported having at least one installed smoke alarm and 52% a fire escape plan, only 15% tested their alarm once a month and 16% practiced their escape plan once every 6 months.[16] Authors of a large scale smoke alarm giveaway program conclude that such programs are of little benefit unless alarm installation and maintenance is assured.[17] A recent systematic review found that families receiving home safety education were more likely to possess a functioning smoke alarm than control group families who did not receive education, with a larger effect size for studies that also provided smoke alarms.[12]

Smoke alarms are a relatively cheap and easy-to-install burns prevention tool. However, they rely on regular testing to ensure they are fully functioning and careful positioning to reduce the likelihood of false alarms,[18] hence the importance of home safety education as an essential element of any smoke alarm intervention.[12]

Legislation has successfully regulated the installation of smoke detectors, reduced the temperature of hot tap water and promoted child-resistant lighters.[2,10,19,20] In New South Wales, following the introduction of regulations requiring that all new water installations should have hot water tap temperatures not exceeding 50ºC, hospital admission rates for scalds from hot tap water has reduced by 6% a year.[21]

The incidence of burn injuries from hair straighteners is increasing. Straighteners have been found to stay dangerously hot for up to 44 minutes after being turned off.[22] This raises burn prevention issues for both parents and manufacturers to address.[23]

An examination of cooking-related burn injuries found that the most common mechanism for injury resulted from a child pulling down a hot liquid from a higher level.[24] A study in America found that of 104 non tap water scalds in children, 8.7% were caused by children aged between 18 months and 4 years who removed hot liquid from a microwave.[25] Microwave doors should be adjusted so they cannot be opened by young children.[25]

Thermostatic mixing valves fitted in the homes of families in disadvantaged communities have recently been found to be effective at reducing bath hot tap water temperatures.[26]

Research Gaps

There should be further research into the role of alcohol in incidents leading to burn injuries and parents' ability to supervise children.[27]

Studies are needed to investigate the barriers and facilitators to implementing known effective burns prevention interventions.

In relation to home safety education, especially with the provision of safety equipment, large well-conducted observational studies are needed.[12]

Studies are also needed to investigate the effectiveness of community-based injury prevention programs to prevent burns and scalds in children.[28]

Conclusions

Epidemiological evidence indicates that burns are a leading cause of death, disability and suffering in children. In addition, it is clear that some children are at much greater risk of burn injury than others and that the risk factors associated with a burn depend both on the child's culture and developmental age. The consequences of a severe burn are significant and long term. In parts of certain high-income countries much has been done to lower the burden of burn injury. Effective strategies exist for primary prevention and advances in medical care ensure survival rates after burns have improved significantly for children in high-income countries.[29]

Current research findings indicate that broad approaches such as environmental modification (including engineering), legislation and education can be effective in reducing burn injuries. However, a combination of these approaches may be most effective.[30] It is vital that burn prevention is given higher priority by policy makers and the general public.

Implications for Parents, Services and Policy

A coordinated and multifaceted public health approach is needed linking primary, secondary and tertiary prevention. The health and economic benefits for children, families and society are significant. Effective burn prevention and care is multidisciplinary and multi-sectoral and includes fire fighters, health providers, the housing sector, local and national government, and burn survivor groups. Partnerships are essential to fully address burn prevention.

Legislation and policies on burn prevention are needed particularly in relation to smoke detectors, hot water heaters, cigarette lighters, reduced ignition propensity cigarettes and flame-resistant children's sleepwear.

Parents should ensure that they have a working smoke alarm on every level of their home, that bath water temperature is correctly controlled, that matches and cigarette lighters are kept out of young children's reach, and that hot drinks are kept away from young children. Local public health programs will need to support families in their burn-prevention activities by providing education and possibly safety equipment.

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Injury Prevention: Drowning

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Introduction

Worldwide, over 175,000 children under 20 years of age died from drowning in 2004.[1] For each fatal event it is estimated that there are 1-4 non fatal submersions.[2-5] Those who survive events serious enough to warrant medical attention are often left with permanent neurologic impairment.[6] Importantly there are prevention strategies that are effective; however, consistent implementation of these strategies remains a challenge.

Subject

Drowning is defined as a “process resulting in primary respiratory impairment from submersion/immersion in a liquid medium.[7] This definition includes fatal and nonfatal events. In most countries drowning rates peak in 1-4 year olds, with estimates of more than 30,000 deaths per year.[1] Deaths due to floods and water transport accidents are generally excluded from counts; thus, the true number of deaths is likely much higher, especially in low- and middle-income countries. Statistics on nonfatal events are not systematically collected making it difficult to estimate the full extent of the problem. Prevention strategies are dependent on the specific circumstances surrounding each event, as well as the developmental stage of the child.

Problems

While drowning is a leading cause of injury-related death in all countries, it takes its greatest toll in low- and middle-income countries. Rates in 1-4 year olds range from 2.8/100,000 in high-income countries to 12.7/100,000 in low- and middle-income countries.[1] Rates also vary within countries. For example, in China, rates of drowning in the 1-4 year age group range from 7.7/100,000 in urban areas to 20.1/100,000 in rural areas.[8] In the United States, rates in the same age group for the five-year period of 2002-2006 ranged from <1/100,000 in Connecticut to 8.0/100,000 in Florida.[9] These variations are directly related to varying exposure patterns to water.

The most frequent location of drowning varies with age and developmental stage of the child.[10-12] Infants are most likely to drown in a bathtub, bucket or other relatively small body of water in the home. The circumstances most often involve a lapse in adult supervision, usually when the caregiver leaves the child unattended or in the care of another child for just a few moments, only to return and find the infant submerged under water. As children become more mobile, drownings are most likely to occur outside the home but in a body of water close to the home. The circumstances generally involve a toddler gaining access to a body of water without knowledge of the supervising adult. In developed countries, the body of water is most often a residential pool, whereas in developing countries, the body of water might be a canal, ditch, well, pond or other body of water near the home.[10-12] In both scenarios the child usually has direct access to the body of water from the home.

Research Context

Numerous studies have examined the epidemiology of drowning in high-income countries (e.g., Australia, Canada and the United States).[10,11,13,14] There are fewer studies in low- and middle-income countries; however, the general patterns that are seen are comparable, with young children being at greatest risk.[12,15] Prevention strategies can be classified on a continuum from passive strategies, requiring no action or only a one-time action at the individual level, to active strategies, requiring repeated action at the individual level. In general, passive strategies are thought to be more effective in preventing injuries than are active strategies. One such passive strategy for prevention of drowning is installation of a fence that completely surrounds the body of water. However, it is clear that no one strategy will prevent all drowning but rather that the approach to prevention should be multifaceted.

Key Research Questions

- What is the true magnitude of the problem?
- What are the long-term sequelae of nonfatal events?
- What strategies are available and effective for prevention of drowning in bathtubs and other small bodies of water in the home?
- Which passive strategies are effective in preventing drowning among young mobile children?

- How effective are active strategies, such as interventions that aim to improve adult supervision?
- How effective are swimming lessons in preventing drowning among 1-4 year olds?

Recent Research Results

Although great strides have been made in data collection efforts around the world, the availability and quality of drowning data varies greatly among countries, depending on the surveillance systems in place and the availability and quality of other statistical resources. Despite limitations in data, a few patterns have been found. For example, across the globe, rates of fatal drowning are higher in males than females.[1] This is true in all age groups with the exception of infants less than one. Second, a seizure disorder or epilepsy is known to increase the risk of drowning death in all bodies of water, including bathtubs, swimming pools, ponds and other natural bodies of water.[16,17] Thirdly, there is some evidence to suggest that child drowning is associated with socio-demographic characteristics such as the level of education of the family head or caregivers.

With regards to interventions, there is good evidence that passive strategies that either remove the risk or create a barrier impeding access to water are effective in reducing drowning rates. Examples include a four-sided fence surrounding a swimming pool, completely isolating the pool from the home or placing a cover on a well or emptying water from large containers when not in use.[18,19] A Cochrane systematic review of the research evidence and meta-analysis of pooled data from three case control studies showed that there was a significantly reduced risk of drowning in a fenced pool compared to an unfenced pool.[18] This review found that isolation fencing (4-sided fence) was shown to be far more protective than perimeter fencing (3-sided fence where the house or other structure forms part of the barrier) with an odds ratio of 0.17 or a 83% reduction in risk. We are unaware of studies examining use of isolation fencing for other bodies of water (e.g., ponds).

Examples of behavioural interventions include teaching a child how to swim or an intervention designed to increase adult supervisory behaviour. Recent studies in the U.S. and China have suggested that formal swimming lessons reduced the risk of drowning in the 1-4 year age group by 40%-88%.[20,21] The need for constant adult supervision when young children are in or around water goes without saying. However, studies of interventions to increase supervision are lacking. While there are no studies in the published literature that formally evaluate the effectiveness of lifeguarding as a primary prevention measure, trained lifeguards on beaches and at public

swimming pools can model safe behaviours, control the risk-taking behaviours of pool swimmers and beachgoers, and can provide timely rescue and resuscitation so that the drowning events do not result in death or brain damage.[22] A number of studies of adults have suggested that life vests offer some protection against drowning, particularly when worn while boating.[23,24,25] While the effectiveness of life vests for prevention of drowning among children has not been evaluated, it is likely that under similar circumstances life vests would also be protective for children. Studies have shown that once a drowning occurs, survival rates and outcomes are better if the child is resuscitated immediately rather than waiting for emergency personnel to arrive.[5] Thus, knowledge of CPR by lifeguards and/or other bystanders is an important secondary prevention strategy.

Research Gaps

Studies are needed to define the epidemiology of drowning in low- and middle-income countries. In particular the circumstances surrounding the events need to be delineated to identify potential prevention strategies. Once circumstances are defined there is a need for identification of novel passive strategies for prevention of drowning in bodies of water that are not easily fenced (e.g., canals and ditches). Intervention studies are needed to assess the effectiveness of swimming lessons at the population level. Studies are needed to assess the effectiveness of interventions aimed at increasing adult supervision of both infants and 1-4 year olds when in or around water.

Conclusions

Drowning is a leading cause of injury-related death throughout the world. Toddlers are particularly vulnerable as they are at a developmental stage of curiosity and exploration and they have motor skills that allow them to gain access to an open surface water. Yet, they are not yet cognitively able to understand the risk of submersion. Examination of the circumstances surrounding drowning is important for development of targeted strategies for prevention. For young children the most common scenario is submersion in a body of water in or around the home. Interventions include removal of the risk or creation of a barrier. Importantly barriers will not address all scenarios. Other interventions include efforts to improve adult supervision and strategies to improve survival or outcome once a submersion occurs. Examples of the latter include teaching young children how to swim and teaching adult supervisors how to perform cardiopulmonary resuscitation. It is clear that prevention campaigns must utilize a multifaceted approach to deal with the many circumstances leading to this tragic outcome.

Implications

Parents and other caregivers must be counseled to never leave a young child unattended when in or around a body of water, whether it be a pond, a bathtub or a pool. Further, there should be layers of prevention in place. Residential pools must be completely surrounded by a barrier that prevents access by a toddler to the water. Barriers, such as covers on wells, should be used for other bodies of water, when feasible. Whenever possible the hazard should be removed. For example, water should be emptied from large buckets after use. Those caring for children should be trained in CPR as early resuscitation is associated with a more favorable outcome. Young children should be taught how to swim but caregivers must be cautioned that swimming lessons alone will not prevent drowning. Finally, legislation mandating pool fencing should be enacted as studies have shown that such legislation increases implementation of this proven strategy.

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Parent Supervision to Prevent Injuries to Young Children

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Introduction

Caregivers must assume responsibility for the safety of infants, toddlers and preschoolers because children at these developmental stages have a limited capacity to appraise risk and differentiate unsafe from safe situations. Historically, research on child safety has focused on determining what safety practices caregivers adopt, why they do so, and how to motivate them to enact better safety practices.[1-6] More recently research has shifted to examine caregiver supervision practices, how these influence young children's risk of injury, and what messaging approaches are best to motivate caregivers to improve their supervision practices. These issues are addressed in this article.

Subject

For young children (< 6 years) researchers have defined supervision in terms of specific behaviours that indicate attending to the child (watching, listening).[7] Proximity is particularly important for the safety of younger children under 6 years of age because they often do unpredictable things, and quickly, which increases exposure to and interactions with injury hazards.[8]

Problems

Epidemiology studies reveal that young children are frequently injured when in their homes,[9,10] which is surprising given an adult caregiver should be present and responsible for children at these young ages. Two essential questions are: how are caregivers typically supervising and what constitutes 'adequate supervision' for ensuring a child's safety? Examining how patterns of supervision differentially influence children's risk of injury is an essential first step for determining what constitutes adequate supervision.

Research context

Historically, progress in exploring links between supervision and injury risk had been hampered by the difficulty of measuring supervision in scientifically rigorous ways. Asking parents to report on how they might supervise in different circumstances may or may not accurately reflect how they will do so in real life circumstances.[11,12] Studies that have used direct observations (e.g., parents with children in public places like parks) and self-monitoring techniques (i.e., parents record their own supervisory practices at home throughout the day) have substantially advanced our understanding of factors that influence supervisory practices and how these practices impact children's risk of injury.[13-15] Another popular testing approach to study supervision involves the use of 'contrived hazards' – hazards that appear real but that have been modified to pose no real risk of injury in laboratory settings.[16,17] With this approach one creates a 'simulated' risk situation, and supervisors' reactions can be unobtrusively videotaped, providing a more accurate index of 'typical' supervision practices. These observation-based methods are time- and labour- intensive but have yielded substantial insights regarding links between supervision and child injury risk.

Key Research Questions

1. How often are children routinely 'out of view' of supervisors when at home? Are there parent and/or child attributes that influence children's supervision needs?
2. What patterns of supervision do caregivers show when at home with young children? Are some patterns more effective than others to prevent children from being injured?
3. Are siblings effective supervisors? What factors influence their effectiveness?

Research Findings

In research on how caregivers routinely supervise it was found that when young children (< 6 years) are at home with mothers they are supervised (in view, attended to) more than unsupervised (i.e., parent does not know where child is or what the child is doing – for at least 5 minutes). Nonetheless, young children are completely out of view of supervisors about 20% of their awake time, and the extent of supervision is poorer when they are out of view (e.g., intermittently listening in but not watching).[18,19] Thus, in the course of their daily lives, parents routinely supervise in ways that can elevate children's risk of injury by allowing them to be out of view. Time children spend out of view of supervisors generally increases with children's age because parents assume older children know and will follow safety rules better than younger

children.[20] When sex differences emerge, girls are more closely supervised than boys during the preschool years, which may partly explain why boys routinely experience more injuries than girls.[21,22]

Mothers who score higher in conscientiousness and those with children having behavioural attributes that are likely to increase risk behaviours (i.e., impulsivity, sensation seeking), keep their children in view more of the time.[14] Thus, parents adjust their level of supervision based on both parent and child attributes. Importantly, research has shown that children who scored high in behavioural intensity (i.e., show high activity and intense reactions to new situations and events) had a history of more medically-attended injuries when parents reported reduced supervision but not when parents reported high levels of supervision (see Figure 1).[23] Thus, close supervision can counteract the elevated risk of injury typically found for temperamentally-difficult children.[24,25] On the other hand, the child attribute of inhibitory control (e.g., child can exercise self-control and resist doing things prohibited by a caregiver) serves a protective function and scoring high in this trait predicts a history of fewer medically-attended injuries even under conditions of reduced supervision, whereas for children low in inhibitory control higher levels of supervision are needed to prevent injuries (see Figure 1).[23] Hence, whether lower levels of supervision lead to increased risk of injury depends, in part, on the child's behavioural attributes. Risk of injury to children, therefore, reflects an interaction of many factors, including child characteristics x supervision practices x level of environmental risk.[26]

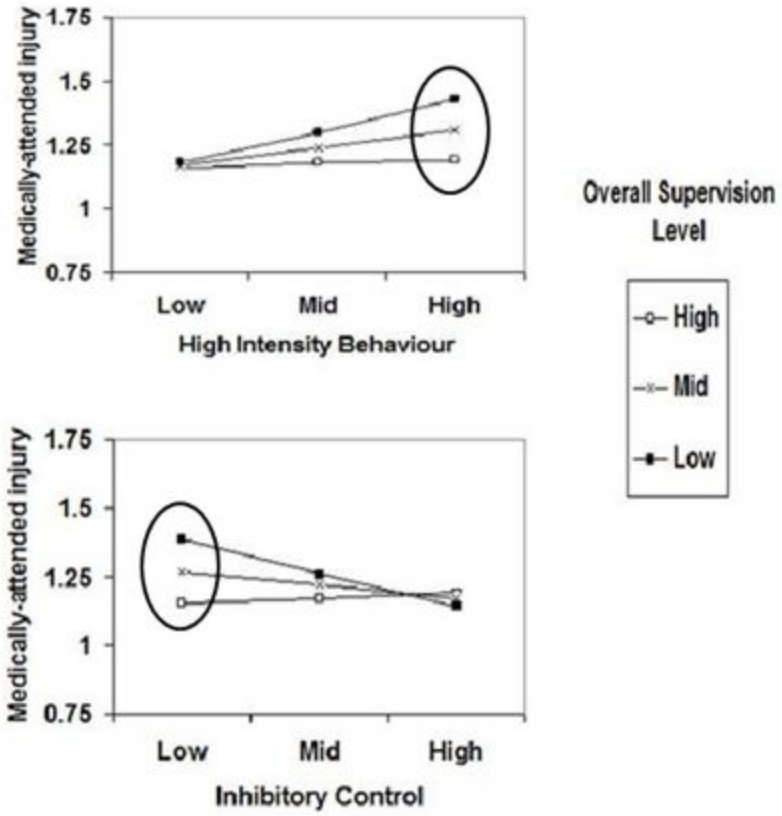

Figure 1. Supervision moderates the relation between child behaviour characteristics and injury. For High Intensity Behaviour, high scores predicted injury when parents showed low and moderate levels of supervision ($p < .05$) but not when they showed high levels of supervision. A similar pattern of significant differences was found for low scores in Inhibitory Control.

At time points when children acquire new developmental milestones (e.g., start to walk), which often occurs unexpectedly for parents, injury rates show temporary peaks.[27] Thus, when children behave unpredictably and parents have not had sufficient time to adjust the level of supervision those children need in order to ensure their safety, then children more frequently get injured, especially at younger ages and in high-hazard contexts like farms.[28]

Studies of young children have documented that lax supervision is associated with greater risk taking, more medically-attended injuries, and more severe injuries.[29] Moreover, particular patterns of supervision differentially relate to frequency of injury, highlighting the importance of closely supervising children, particularly boys.[14] As shown in Figure 2, injury rates for boys and girls differed significantly when mothers used the strategy of intermittently going to check on the child, with boys experiencing more injuries than girls. In fact, injury rates for boys when mothers

intermittently listened in were as high as when mothers left their sons unsupervised, and rates for girls were as low as when mothers provided direct and close supervision; just the threat that a parent might appear to check on what the child was doing was sufficient to deter girls from taking risks, but not boys. Hence, anything less than constant watchful supervision was associated with high injury rates among boys. Generally, the research has shown that boys engage in more risk taking than girls and they are less compliant with parent requests to avoid hazards. Hence, boys require more frequent and effortful supervision practices than girls to ensure their safety.[14,16]

Proportions of injuries occuring to boys and girls as a function of level of supervision

Figure 2. Proportion of injuries for boys (n = 428 total) and girls (n = 137 total) as a function of supervision pattern.

Sibling supervision in which an older child in the family (e.g., 5-12 years) looks after a younger one (e.g., < 5 years) occurs often when children are at home together.30 This supervision arrangement elevates risk of injury for young children compared to parent supervision.[31,32] Research examining the supervisory practices of older siblings compared with mothers revealed that supervisees were allowed to engage in more risk behaviours when supervised by older siblings than by mothers.[33] Moreover, the behaviours of both the sibling supervisors (i.e., less effective supervision) and young supervisees (i.e., non-compliant) contribute to increase risk of injury to the young child.[34,35] Importantly, a rigorous evaluation of an online training program (Safe Sibs) reveals that siblings can learn to be more effective supervisors when given the proper

resources and practice experiences.[36]

Research Gaps

Most research examining supervision and its impact on injury risk has focused on mothers, but fathers also often supervise young children at home. A few studies have compared mothers' with fathers' beliefs about the need for supervision of their young children[37] and reactions to their toddler's risk taking behaviours[38] and found no differences, however, more extensive research is needed. It might be, for example, that differences in supervision between mothers and fathers vary depending on a child's developmental level or behavioural attributes.

Surprisingly, despite how often supervision is mentioned as a risk factor for injury in the pediatric literature, there is only one proven effective intervention program that addresses parent supervision. The Supervising for Home Safety program incorporates a number of messaging approaches that were shown to be effective to change parental beliefs about injuries and supervision.[39] The program has proven effective when delivered in a 1:1 format (e.g., home visiting programs) or a parenting group context.[40,41] Extending this program to meet the needs of high-risk parent populations is an important next step because in the child maltreatment area inadequate supervision is a cornerstone in defining neglectful parenting.[42,43] Hence, interventions that can improve supervision behaviours for parents showing supervisory neglect are sorely needed.

Conclusions

Developments in defining and measuring supervision have paved the way for research on caregiver supervision, including studying how this factor influences young children's risk of injury. Research has confirmed past speculation that poor supervision can elevate risk of injury to children, but the findings also highlight variation in this process depending on parent and child characteristics, as well as level of environmental risk. The evidence indicates that mothers and fathers are more similar than different in supervising young children and that sibling supervision is more lax than parent practices which contributes to elevated injury risk for young supervisees when supervised by older siblings.

Implications

An important aspect of raising young children is preventing unintentional injuries. Supervision is a strategy that has been shown to achieve this goal. The supervision needs of children, however, are influenced by a multitude of factors, including child characteristics (age, sex, behavioural attributes), parent characteristics (conscientiousness, beliefs about injuries) and level of environmental risk. Such complexity suggests that it may not be realistic to aim to develop specific 'supervision guidelines' that can apply broadly. Developing interventions that target caregiver supervision beliefs and behaviours and can be broadly applied, therefore, is essential. The Supervising for Home Safety program meets this need and the focus now has to be on program dissemination to counteract parents' commonly held belief that childhood injuries are 'accidents' and to enhance their motivation for and self-efficacy beliefs that they can more closely supervise their children.[44] In addition, the Safe Sibs program can address the need to train children to be more effective supervisors of younger children. This is essential given that supervision by siblings is a common occurrence and without training these older siblings increase risk of injury to younger children.

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Road Traffic Injury

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Introduction

Road traffic injury (RTI) remains the leading cause of preventable death and injury after infancy in high income countries. The worldwide growth of vehicle fleets and road development has the unintended consequence of propelling an epidemic increase in road injuries, projected to be the fifth leading cause of years of life lost around the world by 2030.[1] Half of those who die in road traffic crashes are pedestrians, cyclists or other vulnerable road users struck by vehicle traffic. Children are overrepresented in this population, particularly in developing countries. Children are also injured as passengers and drivers, particularly in higher-income countries. There is an urgency to apply lessons and strategies learned over the past decades in order to ward off the anticipated growth of road injury as countries build needed transportation infrastructure.

Subject

RTI is defined as a collision or incident involving at least one road [motorized or unmotorized] vehicle in motion, on a road to which the public has right of access, and fatal injury including any person dying within 30 days as a result of an RTI. Encouragingly, there are well-studied and cost-effective prevention strategies which, if implemented, could save millions of lives. Data systems for measuring the burden of RTI are highly developed in some countries, while in others there is large-scale undercounting and underreporting of road traffic injury.

Problems

Rates of RTI in childhood follow an inverted U-shaped curve. They are lower in poor countries with underdeveloped road infrastructure, rise sharply with the proliferation of motorized vehicles and roadways, and eventually begin to fall with the more widespread adoption of injury prevention strategies.[2] To reduce the number of children injured on roadways, research needs to address strategies to reduce the exposure to fast-moving vehicles, reduce risk factors for crashes, and continue to seek cost-effective ways to protect child occupants in a crash.

Research Context

Numerous studies have examined the epidemiology of RTI in high-income countries and increasingly in low- and middle-income countries. However, it is clear that no one strategy will prevent all RTI. Reviews of global RTI can guide deeper inquiry.[1,3] This review will touch on selected areas of progress and future research.

Key Research Questions

- What is the true magnitude of RTI, especially in low- and middle-income countries?
- Which new technologies improve vehicle occupant safety (child restraint devices, vehicle technology)?
- Which strategies can reduce high crash rates for young drivers and facilitate the development of driving skill?
- What are the long-term sequelae of nonfatal RTI?
- Which policies and strategies reduce the rate of unrestrained vehicle occupants, and which of these are effective in low-resource environments?
- What forms of public transportation can replace the riskier single-occupancy vehicle in order to reduce exposure to road traffic injury?
- Which public policy and legislative approaches can reduce the burden of RTI?

Recent Research Results

Among younger children, developmental immaturity puts them at high risk of pedestrian injury.[4] Reducing pedestrian injury for younger children requires parental supervision and better design for separating traffic from walkers. The recommended age at which children can safely cross the street by themselves is 10– much later than most parents realize. This is because of the complex cognitive skills required to cross safely: being able to refrain from an impulse to chase a ball, understanding the directions from which vehicles can approach, and gauging the amount of time for crossing, based on vehicle closing speed and distance.[5,6] Younger children may be able to recite instructions for crossing the street, but will not consistently cross safely under varied traffic conditions.

Walking is a great form of transportation and healthy exercise for children and adults alike. Finding safe ways to encourage walking is an important public health priority. There is an increasing realization that vehicles and people should be separated,[7] and car speeds must be slowed when coming into contact with pedestrians to reduce injury risk. Strategies being investigated include banning vehicle traffic from city centers, slowing vehicle speeds through traffic calming,[8] adding crossing islands and putting crosswalks only at locations where traffic is already forced to stop.[7,9]

One of the surest ways to reducing the risk of child RTI is to depend more heavily on public transportation. Most forms of public transportation are a precursor of a lower injury risk as well as less energy expenditure and significant environmental and urban planning benefits.[3] Achieving global targets for RTI will require a commitment to improve road traffic safety and provide alternatives to single vehicle commuting.

One of the most significant public health advances of the 20th century was the invention of safety belts and child restraint devices such as car seats and booster seats. Improvements in child restraint use have contributed to significant declines in child occupant mortality rates, with protection rates from 71% for rear-facing infant seats, and between 54% and 59% for child seats and booster seats.[10-12] Despite the proven effectiveness of child restraints, it has taken 30 years to raise U.S. seat belt use rates from approximately 10% to 85%.[13] More research is needed on how to close the remaining gap in restraint use, especially for groups at highest risk of injury.

Though impressive gains have been achieved with infant car seats, considerable efforts are needed to raise the use of child car seats and booster seats to similar levels. Recommendations for car seat use continue to evolve with the introduction of new technology and better studies (see, for example, American Academy of Pediatrics recommendations).[14] Studies from Sweden[15,16] and the U.S.[17] suggest that children are five times safer when in rear-facing positions up through two years of age. Children who have outgrown rear-facing restraints graduate to forward-facing harness seats as long as the seat will accommodate the child. The next step is to use a booster seat, which improves fit of the adult-size seat belt and improves seated height in order to take advantage of vehicle safety features. Current recommendations suggest that children should remain in a booster seat until the adult seat belt fits correctly, typically around 4'9" (145 cm) in height. Persuading parents to use child restraints is only a first step; seats must also be properly installed and used on every trip. Misuse rates remain high,[6] and critical areas of misuse, such as loose harness straps and lax attachment of the car seat to the vehicle, place children at increased

risk of injury.[12,18]

Once children have graduated from booster seats, seat belts should be worn on every trip. Seat belt laws are cost-saving even in low resource settings,[19] leading many forward-looking developing countries to adopt legislation requiring seat belt use for all vehicle occupants. Challenges remain for adequate adoption and enforcement to support this critical safety measure.[20]

Drivers face a growing potential for in-vehicle distractions, and ironically these distractions are growing rapidly in high- and low-income countries alike.[21] The presence of friends, mobile phones, other electronic devices, grooming, and eating in the car, have been shown to increase driving risk for adults, and likely have a larger impact on adolescents who have not automated the complex physical and psychological tasks of driving.[22-25] Cohort studies suggest that the use of voice/text devices is associated with crash risks ranging from 4 to 24 times over baseline levels.[26]

Research Gaps

Studies are needed to estimate the magnitude and disability burden of RTI injury, especially in low- and middle-income countries. As the number of vehicles continues to grow, new strategies for reducing pedestrian injury, encouraging alternate forms of transportation, and advances in occupant safety are needed. Hand-in-hand with these advances is the need for translational research to understand how to implement known effective solutions which already can save lives. It is no longer farfetched to envision the elimination of road traffic deaths, and progress towards this goal is being made by countries at all levels of resource development.

Conclusions

Parents should provide supervision until children are cognitively able to judge the safety of road crossing, typically around 10 years of age. Child restraint systems are highly effective at reducing injury in the vehicle, and a major source of preventable injury arises from inconsistent use of car seats, particularly on short trips and for older children. New research suggests that children are safest when riding rear-facing until two years of age, and then using harness-type forward-facing seats as long as the seat will allow. After children outgrow the harness, they should use booster seats until the adult seat belt fits properly. Families and society in general, should seek opportunities to reduce individual driving, the benefits of which extend beyond safety to a healthy lifestyle. Legislation, regulation and policies that support child safety include primary enforcement restraint laws, pedestrian-friendly planning, graduated driving legislation and laws to reduce

drunk driving and distracted driving.

Implications

More than 1.3 million people die from road-traffic crashes each year and this number is expected to double by 2020.[1] Although more difficult to measure, 20 to 50 serious RTIs are estimated to occur for every road death. Globally, the health burden of road traffic injuries is similar to that of malaria and tuberculosis.[1] Children are particularly vulnerable as pedestrians, occupants and the newest generation of drivers. Proven programs exist to reduce the greatest risks of road traffic. If decisive action is taken, we have the means and opportunity to prevent tens of thousands, if not millions, of deaths and injuries in our own neighborhoods and around the globe.

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Injury Prevention: Falls

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Introduction

As children learn to explore and master their environment, stumbles, tumbles, trips and falls are typical and often “expected” consequences of learning to walk, run, jump and climb. Luckily, most falls result in only bumps and bruises. A considerable number of falls, however, result either in death or in short- or long-term disability. Because falls are the most common injury event, and because they frequently result in severe consequences, falls are an important part of the injury burden that should be explored.

Subject

As defined by the World Health Organization, a fall is “an event which results in a person coming to rest inadvertently on the ground, the floor or a lower level.”[1] Falls can occur on the same level as when a child trips or loses his balance, or from one level to another as when a child falls from a window, down the stairs, or off furniture. When these events result in medical care or are fatal, they are coded as fall injuries.

Several factors contribute to the extent of the injury from a fall. Higher distances are more likely to generate injury. The greater the energy-absorbing surface upon which the victim lands, the less severe the injury is likely to be. Factors, such as gender, ethnicity and physical development, are important factors linked to injury.[1] Individual differences in anatomy, such as bone structure and fat composition, also affect injury severity and depend in part on the individual’s age.[2,3]

Problems

The World Health Organization identifies falls as one of the leading causes of injury burden in the world for children ages 0-4 and acknowledges the inequalities that exist in childhood death and injury rates from falls.[4] Worldwide fall death rates vary by country income level and by child gender. For instance, girls living in the high-income countries within the Americas have the lowest

fatal fall injury rate (0.1/100,000) while boys in the low- and middle-income countries of the Eastern Mediterranean have the highest (3.0/100,000).[5]

In the United States, since 2010, falls have remained out of the 'top ten' causes of injury death for children 0-4 years old, save 2015 when falls were the tenth leading cause of injury death for children 1-4 years.[6] In fact, fatal falls among children 0-4 years old dropped from 60 per 100,000 in 2007 to 25 per 100,000 in 2017.[7] It is not known if improvement in the fall fatality rate is due to injury prevention programs and policies or to advances in emergency medical services and medical treatment. Despite this good news, falls continue to be the most common source of nonfatal injuries treated in hospital emergency departments among children in age groups <1, 1-4 years and 5-9 years.[8] The pattern of pediatric injuries tends to track to children's changing developmental abilities and mobility, with younger children's fall injuries happening mostly in the home and older children's fall injuries happening as a result of recreation and sports activities. A recent review of consumer products contributing to children's fall injuries between 2010-2013 found that home furnishings (e.g., beds, sofas, tables and chairs) were associated with fall injuries in children 4 and younger while recreational equipment found outside the home (e.g., monkey bars, swings, trampolines) were commonly associated with fall injuries in children 5 and older.[9]

Internationally, the European Union has had some success in reducing overall injury mortality, but persistent inequalities are reported between low- and middle-income (LMIC) countries compared to high-income countries (HIC).[5,10] Falls, however, are one area where this is not the case.[10,11] Relative to HIC, LMIC falls mortality rates remain higher in both 2007 (0.27 to 1.44) and in 2011 (0.21 to 1.11). The rate ratio for falls deaths remained roughly the same during this time period (5.32 to 5.31, $p = 1$).[11]

Research Context

Most epidemiologic and intervention research has been conducted in HIC countries, although the burden is great in LMIC where the need for reliable and valid data is critical.[5] The research context is complex because there are so many varied circumstances under which children of different ages fall and sustain injury – from rolling off a changing table to falling from residential windows and playground equipment to falls from trees. Risk factors, and therefore the appropriate prevention options, vary greatly. There are few truly passive countermeasures (e.g., energy absorbing surfacing in playgrounds), although there are many effective strategies that require a

limited degree of active engagement by adults – e.g., installing window guards and using stair gates. On the other hand, there are numerous supervision-related strategies for parents, such as never leaving a baby on a changing table and monitoring their natural climbing behaviours.

Many challenges exist to defining adequate supervision and demonstrating its effectiveness across the spectrum of ages and behaviours relevant to children's injuries, and supervision as a prevention strategy has received modest research attention. Morrongiello and colleagues[12] are among the few who study this area and have reported an equivocal relationship between parent supervision and child attributes. Supervision interacted with some child attributes to elevate children's risk of medically attended injury (not just falls) and with other attributes to decrease injury risk.[12]

At a broader level, contemporary public health has experienced an increased focus on social determinants of health. For instance, the US Department of Health and Human Services 2020 health objectives for the nation include safe and healthy housing metrics.[13] This raises the prominence of the role of housing and other aspects of the built environment – including those that contribute to fall risks -- within public health practice.[14] Another shift in contemporary public health practice has occurred in the field of environmental health, specifically the integration of injury prevention in the conceptualization of healthy and safe housing. The 2014 National Healthy Housing Standard[15] addresses many potential falls risk (e.g., condition of stairs, tripping hazards, presence of handrails, etc.) in the home. Together, these two separate but related trends in public health practice create a richer environment within which to study falls from a multidisciplinary perspective and may result in new, more robust interventions.[14] However, we found no such intervention research in the published literature.

Key Research Questions

- How can we most accurately describe the burden of fall-related injuries?
- How can we address the inequalities in fall related morbidity and mortality, both within and among countries and among different socioeconomic groups?
- How can we better understand parents' protective behaviours and the relationship between the use of safety devices and the potential for reduced supervision?
- How can the built environment be (re)designed with the needs and abilities of children in mind to minimize their falls risks?

- How can product regulation be strengthened to reduce child fall risks?
- What environmental and policy changes are necessary to reduce falls in children?
- What types of housing interventions serve to protect children from fall risks?

Recent Research Results

Improvements have been made in data collection efforts globally but the availability of accurate, timely falls data still vary greatly among countries. Surveillance reports have been published from the United States[16] as well as from other countries around the world.[17,18,19] While some cover multiple types of injuries, falls among children are consistently identified as major contributors to the overall burden of injury. Consistently, these findings document the higher rates of fall injuries in males compared to females.

Recent research reports continue to illuminate mechanisms of injury and to elucidate risk and protective factors at the individual level. The home continues to be identified as a significant location for pediatric fall injuries, with works describing falls related to stairs and steps, windows, furniture and beds.[9,14,16-22] Playground and play equipment, balconies and roofs have also been identified as fall risks.[18,19,23,24,25] Strides also have been made in better understanding caregivers' protective behaviours related to falls. For example, parents report being more permissive with risk taking (including during climbing, jumping and running activities) when the child is wearing safety gear or is perceived to be in a safer environment.[20,21,26]

Research that explores falls beyond individual factors is beginning to emerge. For instance, Husain and colleagues geographically mapped pediatric falls in one state to identify high incidence areas.[27] Still another group of researchers used a statewide hospital network to explore neighborhood level risk factors for pediatric falls. Veras and colleagues[28] created a neighborhood risk index from eight socioeconomic census block group measures (education, crowding, vacancy, renter occupancy, poverty, family structure, race/ethnicity, and housing age) and explored the association with pediatric fall rates. Finally, Shields and colleagues[29] created and tested a housing assessment tool with injury-specific assessment items that were identified after a review of leading housing elements linked to pediatric injury. The tool, Child Housing Assessment for a Safe Environment (CHASE), in a retrospective case-control study, successfully revealed statistically significant scores in homes of cases (children coming to emergency department for an injury) relative to homes of controls (children coming to emergency department for an illness).[29]

Prevention recommendations exist but research suggests that they have not been fully adopted or endorsed. For instance, handrails on stairs are known to offer some protection from falls, yet a U.S. survey found that 43% of homes with young children and stairs did not have banisters or handrails.[26] Stair gates are recommended for homes with infants and toddlers, yet there use does not appear to be widespread, with only one-quarter to one-third of families observed to be using them.[30,31] Window locks or safety guards are recommended for homes with floors above ground level, yet a national survey found that 73% of households in which children live or visit did not have such devices installed.[26] Moreover, only two states (New Jersey and Minnesota) have legislation that protects children from falls from windows.[32]

A systematic review was done to identify successful interventions that attempted to modify the home environment specifically for fall risks.[33] The most common countermeasure tested was the provision of stair gates, but other practices included the use or possession of a baby walker, use of window locks or guards, and the use of non-slip mats or decals in the bathtub. The researchers reported that the provision of free or subsidized stair gates was effective in increasing their use, and that there was some evidence that the interventions were effective in reducing baby walker use. However, reductions in fall rates were not observed due to limitations with these studies, including small sample sizes and relatively short follow-up periods.

Another recent systematic review catalogued technology-based interventions, defined as any computer or mobile-based health behavior change program, on unintentional injuries for either children and adults.[34] Fire and burn interventions were the most common injury topic. While no study focused exclusively on pediatric fall prevention, three studies included it as one of their areas of focus.[35,36,37] The reviewed studies provide evidence that technology-based interventions are effective in educating about injury topics and promoting this use of certain safety products (e.g., using stair gates at the top and bottom of stairs) but none of the studies were powered to evaluate their influence on fall rates. Despite this shortcoming, the authors of the review describe such technology approaches as having great promise.[34]

Research Gaps

The prevalence and incidence of fall-related injuries, risk factors, and prevention strategies from low- and middle-income countries is still in a nascent stage. Challenges persist related to accurate and complete reporting and therefore hamper the field’s ability to consider the most effective prevention strategies.

Intervention trials focusing on preventing falls in children have been conducted primarily in HIC. Given the importance of the physical environment as a risk factor for falls, more research is needed to understand the unique risk factors and concomitant prevention strategies for LMIC. Similarly, additional work is needed to evaluate the impact of laws, regulations and policies on child safety, including falls. One U.S. study that focused only on child care settings found that many state regulations for safe playground equipment do not comply with published national health and safety standards.[38] Another study[39] conducted in China examined six common causes of pediatric injury mortality (including falls) and explored the existence of any laws, policies or regulations promoting the use of recommended safety practices. None were found to support any fall prevention recommendations.[39] Studies are needed to better understand how to ensure compliance with national standards and to determine the impact and appropriateness of such standards.

Conclusions

Despite the continuing issues of quality data, falls contribute significantly to the global burden of injury. In order to better direct limited resources, a more accurate and complete reporting of falls is needed. Effective strategies exist for primary prevention of certain types of falls, and these need to be more widely and effectively disseminated to both parents and providers to promote their widespread adoption. However, additional research is needed to identify the best combination of approaches (education, engineering, enforcement) to address the multiple injury risks related to falls across the childhood years. Translation research is needed to better identify and understand the key implementation issues related to success so that lessons learned in one country can strategically guide others. Digital technologies offer new ways to efficiently and effectively reach audiences.

Implications for Parents, Services and Policy

Effective fall prevention requires a coordinated and comprehensive approach that considers the changing developmental capabilities of children within the context of an environment built primarily for adults. Parents and caregivers of infants need to be educated about the fall risks of infants and young children and how to prevent them. Delivering such education, along with free or low-cost products through the health care system would ensure reaching a large proportion of the population, at least in high income countries. Pediatricians can provide effective anticipatory guidance as well as lend support to additional efforts both in the health care setting and in the

community. Day care providers, school administrators, housing authority administrators and policy makers should be encouraged to comply with all relevant safety standards for creating safe environments for the children in their care.

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Injury Prevention: Poisoning

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Introduction

Accidental poisoning remains a very common cause of childhood injury and death worldwide.[1-3] The National Poison Surveillance System of the American Association of Poison Control Centers reported 1,607,054 poisonings in children age 0-19 years in 2009.[1] In spite of significant efforts at prevention, this number has remained fairly constant over more than a decade. The Centers for Disease Control and Prevention (CDC) Wonder database reported a total of 916 deaths from unintentional poisoning in the years 1999-2007 in the age range 0-14 years.[4,5] A study of 2004 data from the U.S. Consumer Product Safety Commission's National Electronic Injury Surveillance System (CPSC NEISS) estimated that 86,194 children <5 years of age were seen in emergency departments for poisoning events, with 13.3% admitted.[6] Where the poisoning site was known, 98% occurred in the home. In older children an increasing proportion of unintentional poisonings involve abuse of drugs. Much effort has been devoted to understanding the dynamics of these events and to designing strategies to either prevent their occurrence or minimize the consequences.

Subject

Poisoning is defined as exposure to a potentially harmful substance not intended for use by the person exposed. The definition in the context of this review also includes situations where medication is taken in excess of prescribed or appropriate doses. In older children and teens a substantial portion of poisoning cases are either drug abuse or suicide attempts. This review will not address the issues of drug abuse and suicide prevention. It will also not address programs aimed at specific problems such as pesticide toxicity among agricultural workers and their families, carbon monoxide detectors in the home, and lead poisoning prevention.

Problems

Poisoning appears to have its greatest impact in populations that are socioeconomically disadvantaged.[2,7] These populations have more limited access to preventive information and strategies, as well as more restricted access to medical care. The agents most commonly responsible for childhood poisonings vary widely in different parts of the world. In North America and Europe most childhood poisonings involve medications, either prescription or over-the-counter medications (OTC). In developing countries poisonings are more likely to involve pesticides, hydrocarbons or caustics. Analysis of data from the National Electronic Injury Surveillance System for 2004 and 2005 estimated 103,441 emergency department visits annually for unintentional poisonings in children ≤18 years of age in the U.S.[8] Pharmaceutical products accounted for 69% of these visits. Of these, 82% were unsupervised ingestions and 81% were in children ≤5 years of age. A number of risk factors have been identified which increase the risks for a poisoning event. These include such things as single parent families, disrupted families, parents with psychiatric problems, the age and sex of the child as well as their behaviour characteristics, the use of child safety measures in the home, and the socioeconomic status of the family. Several approaches, both active and passive, have been studied to reduce the morbidity and mortality associated with childhood poisoning. These approaches include: regulatory, educational (both of the parent/caregiver and/or the child) using a wide variety of modalities and venues, technology and aversion. Despite the use of many of these modalities for decades, the rate of poisoning events in children has not been reduced, although the death rate from poisoning in young children in developed countries has been dramatically reduced. Many countries have seen the development of sophisticated poison information systems, aimed at providing parents easy access to both preventive information and emergency treatment information in the event of a poisoning. These centers have significantly contributed to the reduction of morbidity and mortality when childhood poisoning does occur.[9]

Research Context

The epidemiology and magnitude of childhood poisoning have been well studied in the developed countries. Most efforts at poison prevention have focused on improving parental awareness or behaviour through some variety of educational effort.[10] These efforts have involved one-on-one parental education in the home or healthcare delivery site, group or community educational efforts, passive education through mass-distributed educational content (brochures, internet, television, etc.), and education of preschool-age children in a classroom environment. In general, studies on these educational efforts have been able to demonstrate changes in parent/child

knowledge, and to a lesser degree behaviour.[11] Most studies have not looked at decreased poisoning events as an endpoint, and those that have generally haven't found a significant impact. Many groups have been involved in the development of such materials, but there is no accepted content or delivery method.[12,13]

Starting with the Poison Prevention Packaging Act (1970), various regulatory approaches have been instituted to prevent or minimize childhood poisoning. These include child-resistant closures (CRCs) for medications and toxic consumer products, limited quantities in bottles of some OTC medications, and unit-dose packaging for some medications. The little data available on the effectiveness of these approaches, suggests that these approaches are effective where they are used properly.[14] The last three decades have seen the development of many devices for home use designed to prevent children's access to toxic materials. These include drawer and cabinet locking devices and storage containers for medications and toxic home products designed to be child-resistant. There is no data on the effectiveness of these devices. Finally, several aversive techniques have been tried to discourage children's attraction for toxic materials. The first were a collection of sticker logos designed in the 1970's to scare children away from toxic materials. The most famous is "Mr. Yuk," which is still used today.[15] Several studies suggest that stickers are ineffective.[16-18] Bittering agents have been tried, particularly as an additive to *ethylene glycol*.[19,20] Limited data suggests that these agents may be useful in decreasing the severity of ingestions of some products.[20]

Key Research Questions

Do the CRCs that are currently available reduce the incidence or severity of childhood poisonings when used appropriately? Why do consumers circumvent or disable CRCs? Is unit-dose packaging superior to CRCs for the prevention of childhood poisoning from pharmaceuticals?

Is there a practical, cost-effective parental education program that reduces the incidence of childhood poisonings?

Recent Research Results

While the last 40 years have seen a dramatic decline in the number of pediatric deaths from poisoning in the developed world, there has been no discernable decrease in the rate of pediatric unintentional poisoning. Preventive strategies for pediatric poisoning, as for many other injury prevention efforts, have generally evolved around a two-pronged approach: parental education to

increase awareness of the problem and change preventive behaviours in the home, and passive approaches, including the use of CRCs and other in-home devices, to prevent child access to poisons.

Following the introduction of CRCs several studies were done to look at their impact on child morbidity/mortality, particularly for the ingestion of aspirin, the first product affected. This data, together with data on other products commonly dispensed in CRCs was most recently reviewed by Rodgers.[14] The conclusion reached was that CRCs are a significant deterrent to pediatric ingestions. However, much has changed with CRCs in the last few decades, including their design and the regulatory requirements defining their effectiveness. CRCs now require that 80% of children 42-51 months of age cannot open the CRC within 5 minutes.[21] They also require that they be easily accessible by adults ages 55-65. A recent study and review by Sherrard et al. reports that CRCs often fail.[22] These authors found that many of the CRCs involved in poisoning episodes were defective, either through use or manufacture. McFee and Caraccio investigated 200 ingestions of prescription medications by children ≤6 years of age and concluded that CRCs afforded no protection in their population.[23] While it has been long recognized that many pediatric poisonings occur in spite of the presence of a CRC, this research suggests that we need to look more closely at the currently available products and how well they work in practice. Tenenbein in a recent article looked at the preventive effect of unit-dose packaging of iron supplements and found dramatic decreases in the number of poisonings and pediatric deaths from iron.[24]

In the area of parental education there is much past and ongoing research, most directed at childhood injuries in general, including poisoning. Several excellent reviews/meta analyses have appeared in recent years looking at this literature.[10,11,25-29] The general conclusions of these reviews are that parental education, either in the home, community or office, can increase parent's awareness and knowledge of poisoning, and may lead to the increased use of safety practices in the home. There is, however, little evidence that this translates into a true decrease in poisoning events, although very few studies have looked at poisoning rates as an outcome.[11] Another line of research has looked at parental and child predictors of child injury, including poisonings.[30-32] If these factors can be understood and readily assessed, they offer the possibility of directing intensified community efforts to those families most at risk. The WHO/Swedish model of integrated community-based injury prevention is being actively looked at worldwide as a possibly effective way to reduce injuries, including poisoning.[33-35]

Research Gaps

There is no recent research relating to the use and efficacy of currently available CRCs. Understanding the limitations of this technology could assist in strategies to increase their use and perhaps improve their design and performance.

There is also no published research evaluating a wide range of devices sold for home use in preventing childhood poisoning. These include cabinet and drawer locking devices, as well as containers for the storage of medicines and other toxins.

While there are many parent/child poison prevention educational materials available from various sources, there is no comparative research which might define the most effective messages and delivery methods. Particular emphasis should be placed on widely used materials such *TIPP*® and an educational program distributed by the American Medical Association.[12,13]

Conclusions

It is clear that passive measures of poison prevention are more effective in younger children than are current educational programs. There is also good data that passive measures, even when available, often fail. The reasons for this are essentially unknown. Current research also suggests that most educational programs, even when coupled with the provision of safety equipment for home use do not result in a decreased rate of poisonings, although they have reduced mortality. We do not know the optimal method to affect parental behavior in ways that lead to a significant reduction in childhood poisoning. Data from Sweden suggest that comprehensive, community-based programs, coupled with local and national regulatory activity can lead to significant reductions in unintentional poisonings, as well as other unintentional injuries. Further research should be directed at gaining a better understanding of why our current methods of prevention do not lead to reduced rates of unintentional childhood poisoning.

Implications

Even though educational efforts have thus far not lead to major reductions in childhood poisoning, it is still incumbent on the medical profession and others involved with injury prevention to continue to impress on parents their responsibility for close supervision of young children in the home and the need to take appropriate and practical measures to “poison proof” every child’s living environment. The data clearly show that close supervision of young children in the home is a prerequisite for injury prevention. The Swedish model also suggests that it is important for communities to work together locally to identify problems within their community and institute

potential community solutions. Governmental authorities must foster research into better passive preventive measures for childhood poisoning. This includes systematic evaluation of currently available devices and CRCs. Community level interventions are unlikely to effect changes in the rate of poisoning without improved passive methodologies.

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