REVIEW OF FALL SAFETY OF CHILDREN BETWEEN THE AGES OF 18 MONTHS AND 4 YEARS IN RELATION TO GUARDS AND CLIMBING IN THE BUILT ENVIRONMENT

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WITH PEER REVIEW

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FALL SAFETY OF CHILDREN BETWEEN THE AGES 18 MONTHS AND 4 YEARS IN RELATION TO GUARDS AND CLIMBING IN THE BUILT ENVIRONMENT

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Disclaimer

Abstract

This paper provides a summary of the building code requirements, a critical review of relevant peer-reviewed scientific literature on guard research and injury data related to children's climbing, and an analysis of the latest injury statistics. The paper focuses on children between 18 months and 4 years of age as the most vulnerable population because of their strength and climbing abilities. Three areas related to guards in residential settings are examined: building codes, published research studies, and recent unpublished injury fall data. Model building code requirements and terminology are summarized to provide context. There is inconsistent use of terminology for guards, rails, barriers, balusters, etc., in the building codes. Over 40 peer-review studies on children's physical development, children's cognitive and social development relevant to climbing, and children's falls from buildings and structures are critically reviewed. Research shows that climbing plays an important role in the physical, cognitive and social development of the young child, and that this is encouraged in many situations, such as playgrounds and school gymnasia. Research studies of injuries to children are medically oriented and seldom explore any guard design issues. Studies of the climbability of different fencing designs use inconsistent terminology to describe the designs tested, they use adult encouragement of children to climb the fences, and they provide abundant padding to protect against a fall. Such contrived situations do not reflect how behavior might occur in a naturalistic setting. Some of these studies also use extremely small sample sizes which negates any statistical analysis of the data. Recent fall injury data from the U.S. Consumer Product Safety Commission on accidents with guards was analyzed. The results indicate that falls from these assemblies among young children aged 18 months to 4 years account for an estimated 0.032 percent of injuries resulting in emergency room visits in that population.

Executive Summary

- The National Ornamental & Miscellaneous Metals Association (NOMMA) commissioned this paper in response to a need for data to assist the Code Technology Committee (CTC) of the International Code Council (ICC).

- "Guards" is a term-of-art used in ICC codes, standards, and life safety codes to describe a means of fall protection that is required along open-sided walking surfaces; including porches, decks, balconies, mezzanines, stairs, ramps, and landings that are located more than 30 in (76.2 cm) above the floor or grade below.

- This paper provides a summary of the building code requirements for guards, a critical review of relevant peer-reviewed scientific literature on guard research and injury data related to children's climbing, and an analysis of the latest injury statistics.

- The paper focuses on children between 18 months and 4 years of age as the most vulnerable population because of their strength and climbing abilities.

- Model building code requirements and terminology are summarized to provide context. There is inconsistent use of terminology for guards, rails, barriers, balusters, etc., by peer-review literature and in the National Electronic Injury Surveillance System (NEISS) database of injuries. Building codes tend to be more constant but differences were noted between countries.

- Building codes vary in the height above grade at which a guard is required, from 23.6 in (60 cm) to 39.4 in (100 cm).

- Building codes vary in barrier height requirements between 36 in (91.4 cm) and 42 in (107 cm).

- All building codes reviewed in this study agree that any aperture should be not larger than a 4-in (10 cm) sphere, except for the Building Code of Australia which requires maximum 4.9 in (12.5 cm) sphere.

- The IRC implicitly differentiates between guards and barriers—guards defend against accidental falls from elevated walkways, whereas barriers are intended to minimize incidents of drowning by inhibiting motivation by placement of an imposing obstruction between the child and the pool area.

- Over 40 peer-review studies on children's physical development, children's cognitive and social development relevant to climbing, and children's falls from buildings and structures are critical reviewed.

- Research shows that climbing plays an important role in the physical, cognitive, and social development of the young child, and that this is encouraged in many situations, such as playgrounds and school gymnasia.

- Research studies of injuries to children are medically oriented and seldom explore any guard design issues. These studies extrapolate from smaller, longitudinal data sets, usually within a hospital or particular location, to give a national estimate of injuries. Such estimates typically are much larger than the percentage of injuries recorded in the latest injury data set.

- Studies of the climbability of different fencing designs have used inconsistent terminology to describe the designs tested, have used adult encouragement of children to climb the fences, and also have provided abundant safety padding to protect against a fall. Such contrived situations do not reflect how behavior might occur in a naturalistic setting.

- Some of the research studies on climbing fences also have used sample sizes that are much too small for any statistical analysis of the data.

- No research study has yet investigated whether specific design elements can either entice children to climb or discourage them from attempting to do so.

- From the research it is possible to identify some general design features that will make climbing more difficult, and these include: barrier height (1 m [3.28 ft] plus); top rail that is difficult to grasp, and not broad enough for a child to stand on; horizontal rails with very close or very wide spacing; vertical rails; openings that are too small for stable footholds; and steeply angled surfaces.

- Recent fall injury data from the U.S. Consumer Product Safety Commission on accidents with guards is analyzed. The results indicate that climbing and falls from these assemblies among young children aged 18 months to 4 years account for an estimated 0.032 percent of injuries resulting in emergency room visits in that population.

- Results from either the research studies or the injury data are neither specific enough nor consistent enough to constitute a solid basis for building code requirements.

- Children's safety concerning guards cannot be guaranteed solely by guard design, but must also involve a program of education on when it is appropriate and when it is not appropriate to engage in climbing a structure.

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Introduction

The National Ornamental & Miscellaneous Metals Association[1] (NOMMA) commissioned this paper in response to a need for data to assist the Code Technology Committee (CTC) of the International Code Council[2] (ICC). At the request of the ICC Board of Directors in May 2004, the CTC embarked on a data gathering and review process to assess safety of children in relation to guards. "Guards" is a term-of-art used in ICC codes, standards, and life safety codes to describe a means of fall protection that is required along open-sided walking surfaces; including porches, decks, balconies, mezzanines, stairs, ramps, and landings that are located more than 30 in (76.2 cm) above the floor or grade below.

This paper provides a critical review of relevant peer-reviewed scientific literature on guard research and injury data. The paper was assembled to inform and assist the CTC in the debate about safety of guards for children between the ages 18 months and 4 years. The scope of this paper is inclusive of all known research conducted in the United States and internationally on the topics of climbing, safety, and fall prevention relating to children's physical and mental capabilities. Hospital reported injury data for the United States for years 2002 through 2005 was also examined to assess the incidence rates of fall-related injuries of children in residential settings.

The scope and objectives of CTC's study are summarized below to provide context for the range of issues discussed in this paper. The stated scope of the CTC's study of guards is to determine the need for appropriate measures to prevent or inhibit an individual from utilizing the elements of a guard system including rails, balusters, and ornamental patterns to climb the guard, thereby subjecting that person to the falling hazard which the guard system is intended to prevent. The objective of the CTC investigation includes a determination of the parameters necessary in order to achieve code requirements for providing necessary and reasonable protection against the climbing of guards. These parameters include, but are not limited to:

1. Review code development history.
2. Demographics of persons to be protected.

[1] The National Ornamental & Miscellaneous Metals Association located in McDonough, GA was formed in 1958 and now serves over 1,000 members across the United States and in over a dozen foreign countries. NOMMA members produce metalwork ranging from railings to driveway gates, and from sculpture to light structural steel.

[2] The International Code Council, headquarters located in Washington, D.C., is a membership association dedicated to building safety and fire prevention, develops the codes used to construct residential and commercial buildings, including homes and schools. Most U.S. cities, counties and states that adopt codes choose the International Codes developed by the International Code Council.

3. Identify occupancies where protection is required.

4. Acquire and review statistical injury data relating to the scope of the study.

5. Identify patterns or arrangements of guard elements which implement or prohibit climbing by those meeting demographics.

6. Develop code requirements which are responsive to identified public safety needs while providing reasonable latitude for the design and construction of alternative guard systems.

7. Develop an impact statement concerning the probable reduction of deaths and injuries resulting from a code requirement.

Background

This study was undertaken to glean facts and findings from relevant peer-review research to assess the performance of guards in relation to children climbing guards and injury from subsequent falling over guards. Research studies reporting an analysis of injuries typically do not systematically differentiate between those resulting from climbing over guards versus those from falling through guards. Incidents in residential settings such as porches, decks, balconies, clerestory spaces, windows, cribs, swimming pool barriers, and stairs are included in the study. The scope of this study is limited to children between 18 months and 4 years of age. This age bracket is the most vulnerable population of all children because strength and climbing ability of children younger than 18 months is insufficient for guards to pose a climbing hazard; and children above the age of 4 were deemed to have sufficient climbing and cognitive capabilities such that nearly any barrier design can be defeated.

This study examines three areas related to guards in residential settings. Model building code requirements and terminology are summarized to provide context. Terminology used for guards, rails, barriers, balusters, etc., in the building codes and by researchers are not uniformly applied. The reader needs to be aware of the usage differences to avoid misinterpretation of discussions and findings. Recent fall injury data from the U.S. Consumer Product Safety Commission was examined to assess data quality and its applicability to assigning causality to accidents with guards. And, a critical review of over 40 peer-review studies extracted relevant information on children's physical development, children's cognitive and social development relevant to climbing, and children's falls from buildings and structures.

Building Codes

In the United States, the International Code Council (ICC) oversees the development of the I-Codes; which is a multi-volume set of comprehensive documents that are updated annually with interim amendments and new editions published on a three-year cycle. Germane to this study is the International Residential Code (IRC). In order to understand the evolution of the IRC, a review of predecessor regional codes to the IRC was undertaken in regard to the specifications for guards. Excerpts from model codes dating back to 1990 are summarized in Appendix A for historical context. Included in the Appendix are provisions from the Canadian, Australian, and New Zealand building codes.

U.S. Codes

The IRC 2006 Edition requires a (36 in [91.44 cm] minimum height) guard on open sides of porches, balconies, ramps, or raised floor surfaces that are located more than 30 in (76.2 cm) above the floor or grade below. Guards are required to have intermediate rails or ornamental closures that do not allow passage of a sphere 4 in (10 cm) or larger in diameter.

The IRC 2000 Edition, International One- and Two-Family Dwelling Code 1998 Edition, and BOCA National Building Code 1998 Edition had an additional requirement prohibiting the design and construction of guards such that, "horizontal rails or other ornamental pattern results in a ladder effect." The codes did not provide guidance, specification or definition of "ladder effect." Subsequent editions beginning with IRC 2003 Edition does not have the term "ladder effect" as a criterion for barriers.

Canadian Codes

The National Building Code of Canada (NRC-NBC 2005) requires a (42 in [106.68 cm] minimum height) guard on open sides of porches, balconies, ramps, or raised floor surfaces that are located more than 23.6 in (59.94 cm) above the floor or grade below. Guards are required to have intermediate rails or ornamental closures that do not allow passage of a sphere 4 in (10 cm) or larger in diameter.

The Canadian building code first included a provision for limiting climbability in the 1975 model code, that ultimately became the current provision, "Unless it can be shown that the location and size of openings do not present a hazard, a guard shall be designed so that no member, attachment or opening located between 5.5 in (13.97 cm) and 35.4 in (89.92 cm) above the level being protected by the guard will facilitate climbing."

Over the past several code cycles, mainly 1995-2005, provisions have been added to help explain the terminology "facilitate climbing." The following prescriptive provisions are deemed to meet the intent of the code to limit climbability:

- Elements protruding from the vertical and located within the area between 5.5 in (13.97 cm) and 35.4 in (89.92 cm) above the floor or walking surface protected by the guard are located more than 18 in (45.72 cm) horizontally and vertically from each other;

- provide not more than 0.6 in horizontal offset; and

- do not provide a toe-space more than 1.8 in (4.57 cm) horizontally and 0.8 in (2.03 cm) vertically, or present more than a 1-in-2 slope on the offset.

Australian Codes

Balustrades or other barrier construction are required for floors more than 39.4 in (100 cm) above the surface beneath. When the elevation difference is 13.1 ft (400 cm) any horizontal elements within the balustrade or other barrier between 6 in (15.24 cm) and 30 in (76.20 cm) above the floor must not facilitate climbing.

New Zealand Codes

The New Zealand Building Code 2007 Edition requires a (39.37 in [100 cm] minimum height) barrier on open sides of balconies and decks, and edges of internal floors or mezzanine floors that are located more than 39.4 in (100 cm) above the floor or grade below. Barriers are required to have intermediate rails or ornamental closures that do not allow passage of a sphere 3.94 in (100 cm) or larger in diameter.

The New Zealand Building Code is a performance-based code and it provides prescriptive designs in the Acceptable Solutions section of the code document. While climbability is not specifically mentioned, interpretive comments in the Acceptable Solution section on barriers explicitly address the intention to prevent most children up to the age of 3 from climbing barriers. Also noted is the difficulty children have with climbing barriers with full-height vertical members. Horizontal or near horizontal rails can easily be climbed by 2-year-olds if the rails extend the full height of a barrier, even if the barrier includes a 7.87 in (20 cm)-wide top rail or if it slopes inwards at 15°. Illustrations of barrier designs (see sample illustrations in Appendix A) are provided in the Acceptable Solutions section for guidance and they are treaded as deemed to comply.

Table 1
Comparison of Codes Requirements for Balcony Guards

Code	Requirement	Min. Height	Max. Aperture	Climbing
IRC 2006	> 30 in (76.2 cm) of grade	36 in (91.4 cm)	4 in (10 cm) sphere	
NRC-NBC 2005	> 23.6 in (60 cm)	42 in (108.7 cm)	4 in (10 cm) sphere	no member, attachment or opening located between 5.5 in (3.97 cm) and 35.4 in (89.92 cm) above the level being protected by the guard will facilitate climbing
Australian 2007	> 13.1 ft (400 cm)			any horizontal elements within the balustrade or other barrier between 6 in (15.24 cm) and 30 in (76.2 cm) above the floor must not facilitate climbing
	> 39.4 in (100 cm)	39.4 in (100 cm)	4.9 in (12.5 cm) sphere	balustrades and barriers are required
New Zealand 2007	> 39.4 in (100 cm)	39.4 in (100 cm)	4 in (10 cm) sphere	

Terminology

Guards

"Guards" is a term-of-art used in ICC codes, standards, and life safety codes to describe a means of fall protection that is required along open-sided walking surfaces; including porches, decks, balconies, mezzanines, stairs, ramps, and landings that are located more than 30 in (76.2 cm) above the floor or grade below. Guards are defined as "A building component or a system of building components located near the open sides of elevated walking surfaces that minimizes the possibility of a fall from the walking surface to the lower level."

Barrier

The term "barrier" is used in the International Residential Code in Appendix A to define a physical obstruction to provide protection against potential drowning by restricting access by children to swimming pools, spas, and hot tubs. The term "barrier" does not appear in the definitions section of the IRC. Barriers are required to be 48 in (121.9 cm) above the walk surface, whereas guards are required to be 36 in (91.4 cm) above the walk surface. The IRC implicitly differentiates between guards and barriers—guards defend against accidental falls whereas barriers are intended to inhibit motivation by placement of an imposing obstruction between the child and the pool area.

The New Zealand building code does not use the term "guard," but consistently uses the term "barrier" for pool areas and for open sides of elevated walking surfaces to minimize the possibility of a fall from the walking surface to a lower level. Researchers of peer-review literature in this also use the term "fencing" which is synonymous.

Ladder Effect

In EN-1176-1 (1998) a ladder is defined as "the primary means of access incorporating rungs or steps on which a user can ascend or descend." The term "Ladder Effect" has been used in building codes of the past, although it was not defined and it no longer appears in current model building codes from Australia, Canada, New Zealand and the United States.

Facilitate Climbing

"Facilitate Climbing" is a term found in building codes to ascribe an attribute that is vague and undefined. Secretariats of model building codes have struggled with providing guidance to assist with enforcement of provisions that require guards to be of a design that does not facilitate climbing. Prescriptive recommendations in code commentary documents and professional judgment by designers are often relied upon to demonstrate compliance.

U.S. Fall Injury Data

One method of assessing safety performance of guards and children's risky behavior is by assessing actual injuries. Hospital injury records are commonly used as a metric by researchers and child safety advocates to characterize the relative risk to other hazards. High risk populations and deficient designs reveal themselves as relatively high incident rates of injuries. The basis for this analysis is a database collected and managed by the U.S. Federal Government through the Consumer Product Safety Commission (CPSC). The CPSC maintains the National Electronic Injury Surveillance System (NEISS), which is a database system of consumer product-related injuries—including accidents such as falls that occur in dwellings. The NEISS data is available electronically through the Internet and consists of information provided by a sample of hospital emergency departments in the United States and its territories. Injury records are coded such that they may be screened by age, gender, trauma type, disposition, and product type involved in the accident. Two notes fields provide supplemental information about the injury or physical situation; however, the terminology often used in these fields is undefined and is occasionally helpful and sometimes ambiguous. This was the case when screening the records explicitly for injuries related to falls caused by climbing a guard.

The NEISS data analyzed and reported in Appendix B indicated that relatively few injuries—0.032 percent of all incidents resulting in emergency room visits involving children between the ages of 18 months and 4 years occurred from jumps, falls, or slips from a rail or railing in a home, a daycare setting or an unknown setting. Injuries associated with falling through a guard, falling against or use of adjacent objects to climb over were excluded from the injury data set because the focus of this analysis was climbing and falling over the guard. These records extrapolated to a national estimate of 354 incidents annually. The 1,421,137 injuries reported by NEISS between 2002 and 2005, inclusive, correspond to a national estimate of 51,217,603 based on weighting data included with the record data. The average over the four years is 12,804,401. The weighted estimate of 1,117,278 incidents on average annually for children between the ages of 18 months and 4 years represents about 8.7 percent of these incidents. For all the incidents to children between the ages of 18 months and 4 years, 5.6 percent involved stairs, 1.22 percent involved windows, and 0.87 percent involved porches, balconies, open-sided floors, and floor openings.

The notes fields for 2,222 records with product codes for porches, balconies, open-sided floors, and floor openings or handrails, railings, or banisters for patients between the ages of 18 months and 4 years were examined to identify obvious non-climbing and non-residential guard-related accidents. When non-climbing and non-residential accidents were culled, the incidence rate associated with jumps, falls, slips from rail or railing was 61 records. The weighted national estimate of incidents corresponding to these records is 1,415 (or 354 annually or 2.5 per 100,000[3]). This number represents 0.032 percent of all injuries to children between the ages of 18 months and 4 years resulting in emergency room visits.

Caution should be used in applying the NEISS data to assign causation of an event. The designations provided in the NEISS reporting system focus on "product codes" and not on the mechanism or physical environment surrounding the injury. Two notes fields are provided in the survey instrument for hospital administrators' interpretation and annotation of the event. The fields may be left blank and the terminology used in this section is unstructured and left to the administrators' discretion. The ability to isolate specific details is a significant factor in understanding the mechanism of the type of incident being reported and the current instrument is not optimal for the purpose of assessing with precision the incidence of injuries associated with climbing and falling incidents. One possible enhancement to the NEISS system would be the addition of codes that would identify the precipitating action of an injury-producing incident such as "climbing" or "climbed the guard and fell over" or "climbed on adjacent object and fell over" or "did not observe" or "fell through or under the guard." Another potential approach is to petition the CPSC to conduct a follow-up investigation to develop more information relating to causality.

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[3] Based on an average population between 2002 and 2006 of children that are 18 months to 4 years of age inclusive - 14,160,000 children.

Peer-Review Studies

Introduction

Climbing is a natural childhood activity and plays a significant role in the emergence of coordinated and symmetrical motor skills. Climbing is an integral part of young children's play. Many play structures are available in public, educational, and private settings to encourage young children to practice and take pleasure in their climbing skills. Climbing is integral to the physical, mental, and social development of the child. Climbing also contributes to the incidental learning that occurs through play.

Understanding children's motivation to climb, their perception of hazards, as well as other social and physical factors in their environment that can facilitate climbing is essential to designing barriers that discourage climbing and to protect children as far as is practicable. Design and style can improve the aesthetic appearance of the environment but they should never precede safety concerns.

This report reviews published literature on studies of the climbing skills of young children, on injuries that occur when children accidentally fall, and on the design of protective barriers that aim to discourage children's climbing. It focuses on publications in peer-review journals and on those studies of young children mostly through around 4 years of age. The focus of the review is to determine the characteristics of what might constitute a child-proof barrier. The report does not focus on design guidelines, code requirements, magazine and newspaper articles, or other media coverage of relevant issues.

Children's Physical Development

U.S. Children's Anthropometric Dimensions

Information on the physical dimensions of children serves as a fundamental basis for understanding the physical development of children and for obtaining information that can be applied to the design of any protective barrier that will be capable of preventing a young child from accidentally falling over or through the barrier. The composition of the U.S. population is diverse and anthropometric data for the current population of U.S. children is not publicly available; however, there is some data on relevant dimensions from previous studies. The following physical dimensions are relevant to the design of a successful protective barrier for young children.

- Standing Center of Gravity – when the center of gravity of a standing child is higher than the height of a barrier then it is possible for the child to lose his or her balance and topple over the barrier. Consequently the height of the barrier should exceed the height of the center of gravity of the standing child. For a 4.5-year-old child this means that the barrier should be greater than 25.2 in (64 cm) high (see Figure 1).

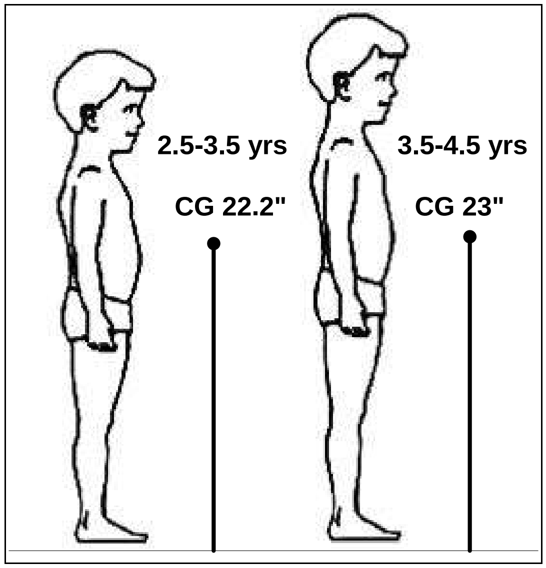
- Head breadth – the breadth of the head (side-to-side) is smaller than the length of the head (front-to-back) and this dimension is used as a guide to prevent entrapment of the head. Here the important dimension is the smallest head size of the youngest child. For a 2-year-old child this means that the size of any aperture in a barrier should be less than 4.7 in (12 cm).

- Foot breadth – the ability to place the whole foot on a support will assist in climbing. The dimensions shown are for a bare foot. Here the important dimension is the smallest foot width of the youngest child. For a 2-year-old child this means that the size of any aperture in a barrier should be less than 2 in (5.3 cm). Climbing may be facilitated if the young child is able to get a toehold rather than a foothold. For a 3-year-old child the toe area of a shoe that is sufficient to aid climbing has a depth of around 1.5 in (3.8 cm) and any protrusion of 3/16 in (~50 mm) may be sufficient to allow a toehold (Stephenson, 1999).

- Step height – the ability of a child to climb a barrier will be affected by the step height distance between footholds. If the maximum step height distance for the oldest child is exceeded then climbing will be more difficult and less comfortable. For a 4.5-year-old child the maximum vertical height between surfaces on which a child could put their foot to use it as a step should exceed 21.9 in (55.5 cm).

Figure 1
Standing Center of Gravity for Boys Aged 2.5-4.5 Years

(based on Snyder, R.G., Schenider, L.W., Owings, C.L., Reynolds, H.M., Golomb, D.H. and M.A. Schork, 1977)



- Stature – the height of the child affects the vertical reach distance for children to be able to grasp the top of a barrier to use their arms to assist in climbing.

- Vertical grip reach – the vertical distance from the floor to a comfortable hand grip affects the child's climbing ability. If the height of the barrier exceeds this distance then the child will not be able to reach to the top of the barrier without some type of aid (jump, object to step on, etc.). Here the important dimension is the greatest vertical reach grip distance of the oldest child. For a 4.5-year-old child this means that the height of a barrier should be more than 53.5 in (136 cm).

Table 2 summarizes the minimum, 5th percentile, mean (50th percentile), 95th percentile, and maximum dimensions of children aged 2 to 4.5 years that are relevant to barrier design.

Table 2
Anthropometric Data (Dimensions Are in Inches: Centimeters) of Children Aged 2 to 4.5

(based on Snyder, R.G., Schenider, L.W., Owings, C.L., Reynolds, H.M., Golomb, D.H. and M.A. Schork, 1977)

Dimension	Percentile	2 – 3.5 yrs				3.5 – 4.5 yrs			
		M		F		M		F	
Standing - Center of Gravity	50th	22.2	(56.3)	21.9	(55.5)	23.0	(58.4)	23.6	(60.0)
	Max	24.0	(61.0)	24.1	(61.2)	24.9	(63.3)	25.2	(64.0)
Head breadth - (smaller than head length)	Min	4.7	(12.0)	4.7	(11.9)	5.0	(12.8)	4.9	(12.4)
	5th	5.0	(12.7)	4.9	(12.5)	5.1	(13.0)	5.0	(12.6)
	50th	5.3	(13.5)	5.2	(13.2)	5.4	(13.7)	5.3	(13.5)
	95th	5.7	(14.7)	5.5	(13.9)	5.7	(14.7)	5.7	(14.4)
	Max	5.9	(15.0)	5.9	(14.9)	7.0	(17.9)	5.9	(15.0)
Foot breadth	Min	2.0	(5.3)	2.2	(5.0)	2.2	(5.5)	2.2	(5.7)
	5th	2.2	(5.5)	2.3	(5.2)	2.3	(5.8)	2.2	(5.7)
	50th	2.4	(6.2)	2.3	(5.9)	2.5	(6.4)	2.5	(6.4)
	95th	2.8	(7.0)	2.8	(6.6)	2.8	(7.2)	2.8	(7.1)
	Max	2.8	(7.2)	3.1	(7.9)	3.1	(7.8)	2.9	(7.4)
Step height	Min	8.7	(22.1)	9.1	(23.2)	10.6	(26.9)	12.0	(30.5)
	5th	8.7	(22.2)	9.3	(23.7)	12.0	(30.4)	12.2	(31.0)
	50th	12.8	(32.4)	12.8	(32.6)	15.7	(39.4)	15.0	(38.0)
	95th	16.6	(42.1)	18.4	(46.7)	19.6	(49.7)	20.8	(52.8)
	Max	17.0	(43.2)	18.5	(47.1)	21.9	(55.5)	21.3	(54.1)
Stature	Min	32.0	(81.3)	33.0	(83.8)	35.8	(90.9)	35.9	(91.1)
	5th	34.3	(87.0)	33.5	(85.1)	36.9	(93.8)	37.0	(93.9)
	50th	37.1	(94.3)	36.2	(92.0)	39.7	(100.8)	40.0	(101.7)
	95th	40.2	(102.2)	39.1	(99.4)	42.9	(109.0)	42.8	(108.7)
	Max	42.7	(108.5)	41.7	(105.9)	44.6	(113.3)	44.9	(114.1)
Vertical grip reach	Min	38.1	(96.8)	38.4	(97.5)	41.1	(104.4)	42.8	(108.6)
	5th	38.2	(97.1)	38.7	(98.2)	41.5	(105.5)	42.9	(108.9)
	50th	41.7	(105.8)	41.6	(105.6)	45.1	(114.5)	46.5	(118.1)
	95th	48.1	(122.2)	45.6	(115.9)	50.3	(127.8)	50.2	(127.6)
	Max	48.9	(124.3)	49.1	(124.6)	53.5	(136.0)	51.0	(129.5)

NOTE: the data are those currently publicly available for U.S. children and they are published in the Final report Anthropometry of Infants, Children and Youths to Age 18 years for Product Safety Design, report UM-HSRI-77-17 prepared for the U.S. Consumer Product Safety Commission by The Highway Safety Research Institute, The University of Michigan, May 31, 1977. Note that since this time the anthropometric dimensions of U.S. children may have increased, which means that any design that satisfies the above will work for current child sizes.

Some updated data on children's anthropometrics was published in the winter of 2002. Table 3 summarizes this anthropometric data for the 10th, 50th and 90th percentiles for the stature of male and female children aged 2, 3, and 4 years.

Table 3
Stature Data of Children Aged 2 to 4 Years

(McDowell, M.A., Fryar, C.D., Hirsch, R. and C. L. Ogden, 2005)

	Percentile	2 yrs		3 yrs		4 yrs	
		M	F	M	F	M	F
Stature (inches)	10th	33.4	33.4	36.4	36.4	39.6	39.5
	50th	35.8	35.3	38.9	38.6	41.9	41.6
	90th	38.4	37.5	40.9	40.2	44.1	44.0
Stature (centimeters)	10th	84.7	84.9	92.5	92.6	100.7	100.3
	50th	91.0	89.7	98.8	98.1	106.5	105.8
	90th	97.6	95.3	103.9	102.2	112.1	111.7

NOTE: the data are those currently publicly available for U.S. children and they are published McDowell, M.A., Fryar, C.D., Hirsch, R. and C. L. Ogden (2005) Anthropometric Reference Data for Children and Adults: U.S. Population, 1999–2002, Advance DATA FROM Vital and Health, Statistics, 361, July 7, U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES Centers for Disease Control and Prevention National Center for Health Statistics. Note that since this time the anthropometric dimensions of U.S. children may have increased, which means that any design that satisfies the above will work for current child sizes.

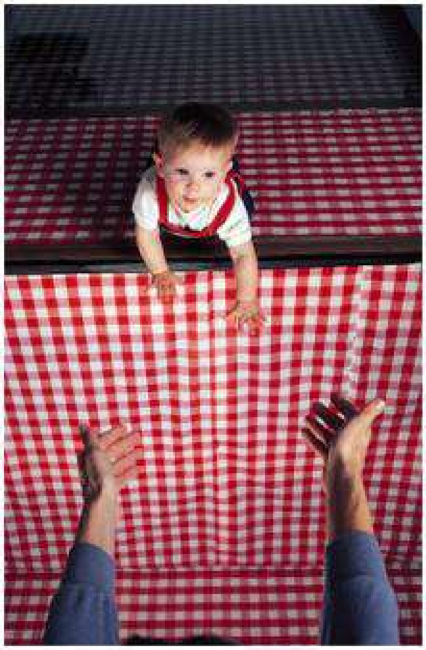
Since the 1977 survey the average height of young children has slightly increased. In 1977 the stature of an average 2-3.5-year-old boy was 37.1 in (94.3 cm) and in 2002 it was 37.4 in (94.8 cm), and the stature of an average 2-3.5-year-old girl was 36.2 in (92 cm) and in 2002 it was 37 in (93.9 cm). In 1977 the stature of an average 3.5-4.5-year-old boy was 39.7 in (100.8 cm) and in 2002 it was 41.9 in (106.5 cm), and the stature of an average 3.5-4.5-year-old girl was 40.0 in (101.7 cm) and in 2002 it was 41.6 in (105.8 cm).

Children's Cognitive and Social Development Relevant to Climbing

Understanding children's cognitive development is important to designing barriers and structures suitable for their safety. Even when children have the physical skills and strength to be good climbers, their desire to climb will be influenced by their personality and attitudes. Children who are somewhat apprehensive and afraid of new situations usually are less likely to climb and spend less time climbing than children who are less fearful. Also, experiencing a fear of heights is a very strong factor inhibiting children from climbing even if they have the physical requirements.

The developing infant displays depth perception skills by the time they are able to crawl and this is critical to their survival ability and may be innate. This ability was first demonstrated in the famous "visual cliff" experiment conducted by Gibson and Walk (1960), who demonstrated that infants old enough to crawl can perceive and avoid a "visual cliff" (see Figure 2) so they can avoid drop-offs such as stairwells and edges of tables.

Figure 2
The Visual Cliff



Even when encouraged, an infant refuses to cross a transparent sheet because, even though he can feel a solid surface visually there appears to be a steep drop. This demonstrates the "visual cliff" phenomenon.

(Image source: http://www.cofc.edu/~psycadvise/images/Visual%20cliff.JPG)

The visual cliff consists of a covered platform and a piece of glass or other clear material placed on this that extends well off of the platform, creating a sort of bridge. An infant is placed on the platform, and the infant's mother stands on the opposite side of the clear bridge and encourages the child to crawl off the platform and onto the clear bridge. Very young infants will do this indicating that they have not yet developed depth perception. Older infants with depth perception will stop when they reach the edge of the platform because as they look down at the "cliff" they aren't yet at the developmental level to know that the clear cover forms a bridge. By the time a child is able to climb stairs and structures s/he will have well developed depth perception. Although babies aged 6-10 months show a fear of changes in floor level, the visual cliff, and although young children may show some reluctance to climb because of their height above the ground, the development of a true fear of heights doesn't appear until around the age of 9 or 10, which is the age when climbing activities begin to decrease in frequency. At some point, however, and often as the result of parental encouragement or peer pressure, or some other "reward or "incentive," even at this young age range most children will be curious enough to overcome their fear and attempt to climb an object that they perceive as potentially hazardous when urged to do so.

Numerous factors affect the cognitive development of the child. One of the earliest investigators of the cognitive development of young children was Jean Piaget, a Swiss psychologist, who provided a very comprehensive theory spanning the period from birth to the end of adolescence. Piaget's theory encompasses the development of cognitive processes, including memory, causality, imitation, and logic and he authored numerous books on the topic. His theory emphasizes the organization of a child's knowledge rather than the processes for the acquisition and application of the information (Small, 1990). Piaget emphasized the biological functions of adaptation and organization as main contributors of the development of cognitive structure. Adaptation has two component functions: accommodation and assimilation. He proposed that all thoughts and actions involve these two processes. Assimilation connects current information and experiences to already existing knowledge or behavior. This results in the establishment of schemes for actions and thoughts. For example, an infant develops an early scheme for clambering onto a sofa and when presented with stairs for the first time will attempt to climb this in a similar manner. After trial and error, infants learn to adjust their climbing technique to different situations. Accommodation refers to this process of refinement and modification of an existing scheme through experiences with different objects or events. In Piaget's theory the constant interaction of accommodation and assimilation together promote the development of cognitive structures and facilitate the emergence of cognitive organization.

Children's ability to perceive hazards and assess risks also is age and intellectual ability dependent. Piaget's theory proposes four periods of cognitive development:

- Sensorimotor period (0-2 years) – in this stage the child learns to differentiate himself from objects, recognizes himself as an agent of action and begins to act intentionally. Cognitively the child attains object permanence, i.e., they realize that things continue to exist even when no longer in view. The child's thinking is egocentric.

- Preoperational period (2-7 years) – The child uses language and to represent objects by words and draws images of objects and words. The child's thinking is still egocentric. The child learns to classify objects by a single feature.

- Concrete operational period (7-11 years) – The child can think logically about objects and events. They achieve conservation of number (age 6), mass (age 7), and weight (age 9). They classify objects according to several features and can order them in series along a single dimension such as size.

- Formal operations (11-15 years) – The child can think logically about abstract propositions, test hypotheses about the world systemically, and become concerned with the hypothetical, the future, and ideological problems.

A framework for understanding cognitive development embraces the tenets of an information-processing approach to cognition, and this focuses on those processes that function to extract information from environmental stimuli (McShane, 1991). According to this framework all humans process environmental information in a series of timely stages, information is transformed during the processing stages, and there is a limited capacity to the amount of processing that occurs at one time. The information-processing model comprises a series of functional components: a sensory register, short-term memory, long-term memory, a central processor, and a response system, and short-term sensory memories, working and long term memories arise from different stages in the flow of information through the sensory system (Small, 1990; Sanders & McCormick, 1993). As information is processed decisions are made and usually these are output by a response system that controls verbal and physical actions. From this framework young children are immature information processors. They often do not have organized perceptual schema to understand situations, they frequently cannot identify patterns (e.g., an inability to read), they have a poor memory system, their reactions times are slow, and they lack the ability to execute coordinated movements in a skilled manner. However, with maturity all these processes ultimately develop to some degree of sophistication.

In addition to the stage of cognitive development, whether or not a child chooses to climb a structure depends on other factors such as their level of motivation. Children often engage in behaviors that are intrinsically motivating (Flavell,1977) and thus they will climb a structure because they find it fun and enjoyable, because they are positioned on the top of a structure that is higher than their peers and because they like to be able to show-off their climbing prowess to others. Childhood games, such as "King of the Castle" further reinforce the social desirability to climb to the top of a structure. Climbing games also provide informal teaching experiences for the young child and they play an important role in their social and motor development (Wood, 1998).

Risk Taking in Children

Children's reactions to hazardous situations arise from a combination of factors that include (a) direct exposure to the hazard combined with the perception of increased physical risk, (b) pre-existing characteristics (e.g., age, gender, ethnicity, emotional maturity), (c) availability of adaptive coping resources, (d) access to social support, (e) the occurrence of major life stressors (e.g., injury or death of family or friends) following the hazard. Unfortunately, there is a dearth of research-based literature on young children's perception of hazards, especially in relation to climbing and falls.

Unintentional injuries can arise as a result of a child misjudging the risks in a situation. Young children show only a rudimentary sense of time and space and they lack a well-developed awareness of cause and effect associations (Ault, 1977) and this contributes to their risk-taking behaviors. Numerous factors exert an influence on children's risk-taking behaviors and these have been systematically reviewed (Morrongiello and Lasenby-Lessard, 2007) and an integrative model of the determinants of children's risk decision has been formulated (Figure 2). This model proposes that children's risk taking is a multi-determined outcome, with child, parent, and social-situational factors all influencing the child's actual behavior.

In this model the individual factors unique to a child play a significant role in their assessment of risk. The limited research on the role of age and hazard identification has focused on children ages 6 years and older, and this work shows that hazard identification generally improves with age. However, there is some evidence that a child's temperament may play a more significant role than their chronological age in making hazard assessments. Gender also plays a role in risk taking and in general boys engage in greater risk taking than do girls. Whether this is an inherent gender difference or whether it relates to other temperamental factors remains unclear. There is no question that a child's temperament has a very significant effect on their hazard assessment and risk-taking behaviors. Children who judge the danger of falling to be low also judge their own personal physical ability for injury to be low and they believe that the potential severity of an unlikely injury will be minor, and consequently they appear more likely to engage in risky behaviors. Children who attribute injuries and accidents to "bad luck" also are more likely to engage in risky behaviors than those who attribute these to their own behavior. There appear to be cognitive differences in the judgments that boys and girls make about the consequence of risk taking and girls generally ask "can I get hurt" whereas boys ask "how hurt might I get." Girls are more likely to attribute injuries to their own behaviors and boys are more likely to attribute these to "bad luck." Related to this, the emotional experience of risk taking also affects the probability that this will occur. Boys generally are more likely to report positive feelings such as fun and excitement as associated with risk taking whereas girls are less likely to experience these emotions. Experience and motivation also exert influences. The more children experience an activity the greater their tolerance for risk-taking behavior. The more success a child has previously experienced in a risky situation, the greater their motivation to engage in a similar behavior in the future. Boys in particular tend to have over-inflated beliefs about their abilities to manage risks whereas girls appear to focus more on the issues of safety in a risky situation. Other temperamental factors that influence risk taking include impulsivity, general activity level, and sensation seeking behaviors. Children who are "thrill seekers" engage in risky behaviors and they also tend to overestimate their own physical abilities.

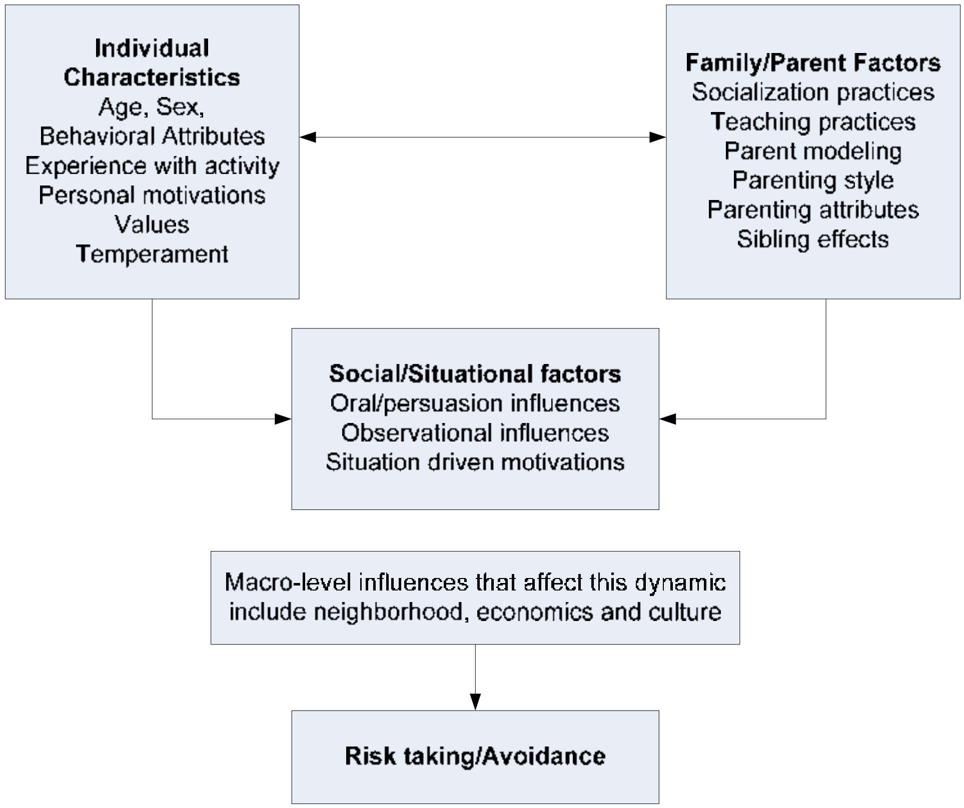
Family and parenting practices have a significant impact on a child's risk-taking behavior. Parents tend to caution their daughters about risk taking and inform them about their vulnerability for injury whereas they explicitly encourage risk taking by their sons. Mothers intervene more frequently and faster than fathers in preventing risky behaviors, especially by their daughters. Daughters are more likely to comply with parental expectations about behavior whereas sons are more likely to exceed parental expectations and engage in greater risk. Girls are more likely to report near injury events or minor injuries than are boys. Raising a child's awareness of parental expectations is likely to be more successful in influencing risk decisions by girls than by boys. That being said, the best predictor of a child's current safety practices is parental teaching about such behaviors. Parents who display risky behaviors while demanding safe practices from their children are less effective at influencing the child's risk decisions than parents whose behavior is consistent with their message. Other family members also influence a child's risk decisions. Older same-sex siblings strongly influence the decisions of younger children. Older girls are more focused on safety-related issues with younger siblings, whereas older boys are more focused on having fun with their younger siblings.

The influence of individual and family factors is mediated by social-situational influences. Group pressure exerts a strong influence on the behavior of young children (6-years-of-age and older have been studied). By the age of 8 a child is more open to oral persuasion by their peers. Young children also are more influenced by their friends than by their acquaintances. They are also influenced by a desire to imitate the actions that they observe in other children. It seems that the mere presence of an unknown peer observing their behavior is sufficient to lead to riskier choices for both boys and girls. The presence of peers also allows children to engage in cooperative activities in which they may aid each other and engage in risky behaviors.

The model that has been developed to synthesize the factors that affect a child's risk decisions is based on research evidence that has mainly been collected for children age 6 to 12 years. Systematic research on the risk decisions of younger children has yet to be conducted. The implications of the model for injury prevention suggests that the strategy of targeting children's attitudes, beliefs, cognitions and emotions may be the most successful in influencing children's safety practices. The authors note that such interventions need to be developed in the context of the family, friends, community and culture of the child if they are to have the greatest chance of success.

Figure 3
Determinants of Children's Risk

(Morrongiello and Lasenby-Lessard, 2007)



Children's Climbing Skills

Climbing exercises children's motor skills and allows them to explore their surroundings from an elevated position. Children will climb or attempt to climb a wide variety of natural and manmade objects. They will climb trees and rocks, they will climb ropes, ladders and play structures, and they will climb walls and barriers. Climbing is a natural and normal contributor to the development of the musculoskeletal system in children.

The act of climbing requires posture-kinetic coordination that develops throughout a child's early years and continues through into adolescence (Testa, Martin and Debû, 2003). Climbing requires the coordination of many muscles, the strength to move parts of the body against gravity, a sense of balance for the maintenance of postural equilibrium and stability in different body postures and orientations, the ability to shift weight from limb to limb, and the sufficient perceptual and cognitive development to allow for the desire and motivation to ascend and even surmount an object. Seven different categories have been distinguished in the development of coordinated climbing skills (van Herrewegen, Molenbroek and Goossens, 2004):

1. Coupling motor skill – the ability to couple movements together into a sequence to create a smooth movement pattern.

2. Movement differentiation or complexity – the ability to differentiate and coordinate complex movements (e.g., simultaneous singing and clapping).

3. Motor adaptation skills – the ability to adapt movement patterns to changing circumstances.

4. Motor reaction skills – the speed and force of movements.

5. Rhythm – the ability to move rhythmically.

6. Movement orientation – the ability to appropriately orient the body in the desired direction of movement.

7. Motor balancing skills – the ability to maintain postural stability and balance.

Skilled climbing requires the successful operation of all seven categories, but as young children learn to climb the categories do not progress evenly and typically some are more developed and some are less developed than others. Also, the rate of acquisition of climbing skills will vary among individuals just as rates of maturation vary. Although there are large individual differences in the acquisition of motor skills by young children, all normal children follow the same general developmental rules:

- Motor skills develop inside to outside – the sequence goes from trunk to shoulders, arms and finally hands.

- Motor skills develop from top to bottom – the arms get stronger before the legs.

- Motor skills develop from gross to fine – large movements by large muscles occur before small movements by fine muscles.

Children begin to practice climbing skills early in life. Many children learn rudimentary climbing before they begin to walk and climbing has been observed as early as 8 months of age (McGraw, 1935, cited in Readdick and Park, 1998). By around one year a child is able to pull himself up onto a ledge or table. By the age of 13 months many children have started walking unaided. By 14 months 25 percent of children are climbing, and this rises to

50 percent by 17 months (Readdick and Park, 1998). At 21 months 75 percent of children are climbing and 90 percent or more are climbing by 22 months of age (ibid.). By 4 years of age boys have started to develop greater upper body strength than girls. By the age of 6 years many children can begin to climb in a manner similar to an adult (van Herrewegen, Molenbroek and Goossens, 2004). As a consequence of these developmental processes, the acquisition of climbing skills mostly occurs between 3 and 6 years of age (van Herrewegen et al., 2004).

Climbing is part of children's everyday play activities. Climbing is part of exploration. Young children are encouraged to climb on play structures, indeed these are often called "climbing frames." From an early age children learn to climb on and off chairs, in and out of cars, and up and down stairs. Children learn to climb up a ladder to descend a slide at the playground. In physical education classes children learn to climb ropes and other structures. Climbing skills are often reinforced by parents and teachers. Children climb for many reasons. Many find it pleasurable. Children climb for enjoyment, mastery, and to practice their motor skills. Some children climb for bravado, some to show off to their friends, some like the sense of achievement and excitement of being atop a high object, some climb for solitude, and often children climb to be on the other side of an object or to retrieve an object that has gone over a barrier, such as a ball over a wall (Readdick and Park, 1998; van Herrewegen et al., 2004).

Chronologically, climbing skills emerge in stages at different ages, as shown in Table 4. Although all children follow the same general sequence of development, at a given age there is considerable variability in climbing skills.

Table 4
Development of Climbing Skills through Age 6

(adapted from van Herrewegen et al., 2004)

Age Range	Climbing Activity
6 – 8 months	Rolling, crawling
9 – 12 months	Holding on to furniture and objects, awareness of "visual cliff," early aided walking
1 – 1.5 years	Starting to walk unaided, negotiating small steps <8 in (20 cm), pulling the body up using vertical using rails, climbing out of crib
1.5 – 2 years	Improved walking and stepping over objects, negotiating stairs improves, climbing on a slide and sliding, maintaining balance, running
2 – 3 years	Better balance, climbing higher obstacles, little or no fear of heights
3 – 4 years	Good balance, jumping over objects, good and bad climbers appear, social and cooperative play, some fear of heights and falling
4 – 6 years	All the seven aspects of climbing skills are being developed. Children negotiate stairs and ladders unaided. Better balance. Children start riding a two-wheel bicycle. Some are able to climb a rope. Still little physical difference between boys and girls.

In young children aged 4 or less there are no consistent gender differences in fence climbing abilities (Nixon, Pearn and Petrie, 1979).

Climbing patterns can be categorized into six stages (Readdick and Park, 1998):

1. Anticipatory behaviors – children approach an object to be climbed with curiosity. The child explores the object visually and through touching it. The child may kneel and rock back and forth in front of the object.

2. Clambering – children use their arms to hold on to the object to be climbed then swing one leg, usually stiff or slightly bent, up and over the object and pull their body up with the strength of their arms (e.g., climbing on to a sofa).

3. Initial climbing – children use both hands to grasp an object at the same level, then they pull up one knee or foot to a foothold, and then they raise the second knee or foot to the same level. This pattern is repeated to climb the object. At this stage climbing is tentative.

4. Transitional climbing – children use both hands to grasp an object at the same level and then they pull up one foot to a foothold and sometimes follow this by raising their other foot to the same level or to a different level so that their feet move in an alternating pattern. Sometimes ipsilateral and sometimes contralateral hand and foot movements are made.

5. Elementary climbing – children use both hands to grasp an object at the same level and then they raise one foot to a foothold, then they reach higher with their opposing hand and once they have a grasp they raise their other foot to a higher level than the first. Climbing continues in an alternating movement pattern. Climbing consists of weight shifting from side to side.

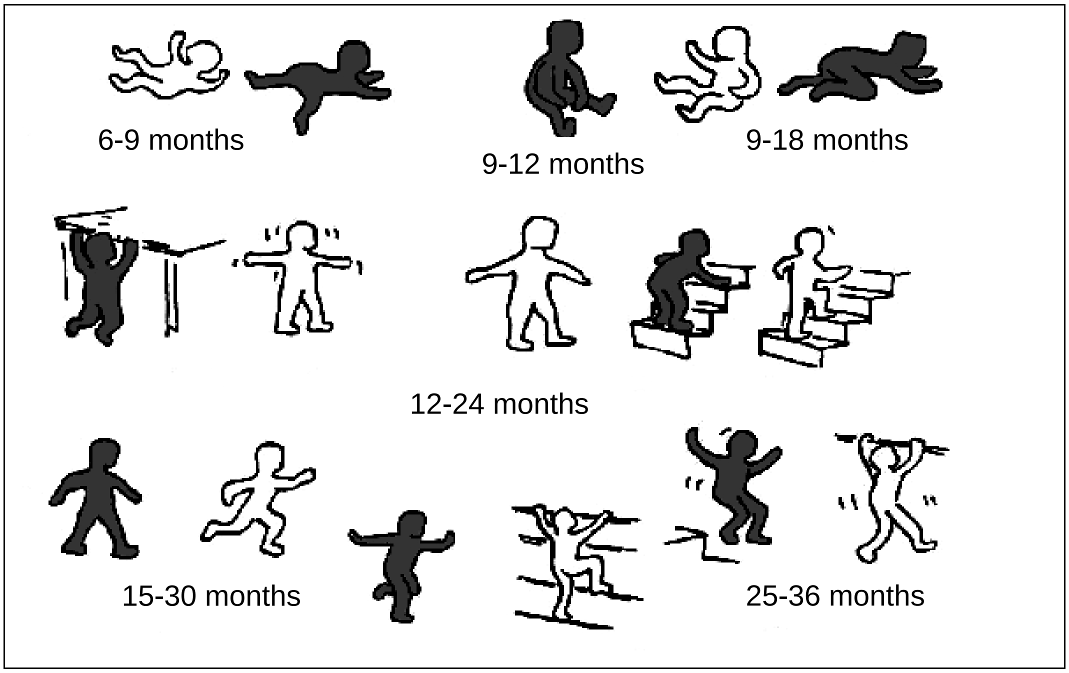
6. Mature climbing – children may start climbing using one hand and then engage the alternating pattern of movements in a fluid climbing style.

Variants on climbing movement patterns depend on the objects being climbed, for example, children may shinny up a pole or a rope.

The progression in motor skill development in young children is summarized in Figure 4.

Figure 4
Gross Motor Development in Young Children

(adapted from van Herrewegen and Molenbroek, 2005)



Several factors play a role in the development of climbing skills and account for individual differences between children, including:

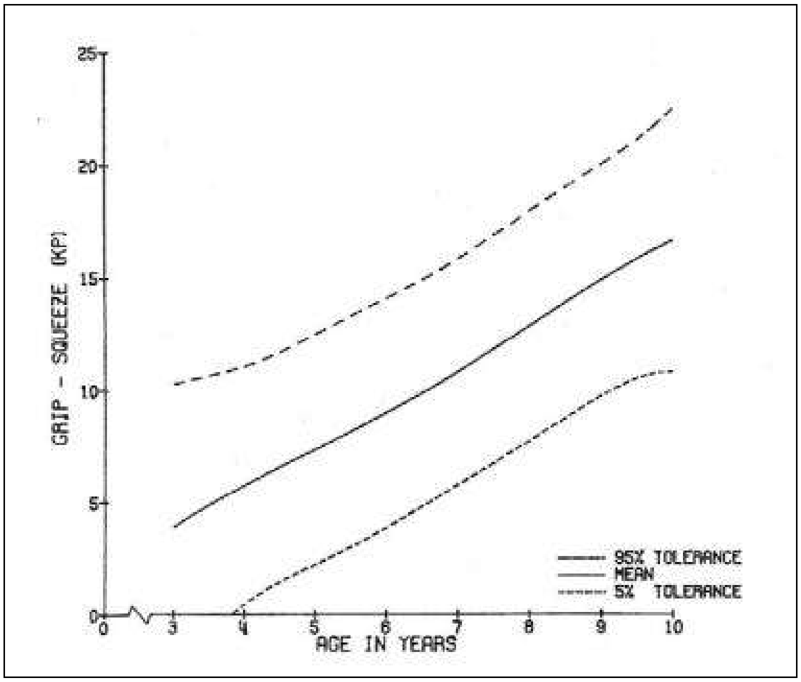
- Personality—Dare-devil disposition, no fear of heights
- Exercise (how physically active is the child—physically active children tend to be better climbers because activity builds strength and coordination)
- Motor development (age—older children are better climbers than younger children)
- Strength—especially in the arms, hands and legs, although for climbing arm and hand strength is more important than leg strength for young children
- Body weight, in combination with strength (lean and strong vs. weak and obese). Lighter children are often are better climbers than heavier children.
- Physique (light or heavy build) and the degree of muscle development
- Physical flexibility

- Living environment (city child or small village child)
- Family members (does the child have older brothers and sisters)
- Footwear (shoes or barefoot)
- Body and limb length

In the above list, anthropometric differences appear to play a more minor role than physio-kinetic development, personality and climbing technique (van Herrewegen et al., 2004). As children grow they develop better muscle coordination and movement control and their muscle strength increases. Hand and arm strength are important for climbing success and by 18 months of age children pull themselves up by their arms when climbing (ibid.). Hand grip strength has been measured for boys and girls aged 3 to 10 years when grasping a handle (Owings, Chaffin, Snyder & Norcutt, 1975). The results for boys and girls combined suggest a linear increase in strength with age in the range that was studied and these results are shown in Figure 5.

Figure 5
Hand Grip Strength Changes with Age

(Owings et al., 1975)



NOTE: 1 kilopond (KP) = 2.20462 pounds force (lbf) = 9.80665 Newtons (N)

This research showed that on average boys had a stronger grip than girls and that this increases by some 20 percent between 3 and 4 years of age. Interestingly, the maximum grip strength of 4-year-old girls exceeded that of boys (see Table 5).

Table 5
Hand Grip Strength Changes with Gender and Age

(Owings et al., 1975)

Age	Gender	Mean		Maximum	
3 years	Male	11.5	(51.2)	17.6	(78.3)
	Female	7.9	(35.1)	9.0	(40.0)
4 years	Male	13.9	(61.8)	19.2	(85.4)
	Female	12.1	(53.8)	25.6	(113.9)

NOTE: Units are pounds force (lbf) and Newtons (N) in parentheses.

Researchers have studied the hand grip preferences of 223 children and 59 adults when asked to climb a 7 ft (~2.1 m) ladder with rungs that were 1 in (~3 cm) diameter and the ladder was angled at 45º, 90º, and 180º (horizontal) to a wall (Gabbard and Patterson, 1980).

Table 6
Age Differences in Ladder Climbing Grips

(Gabbard & Patterson, 1980)

Age	N	Angle	Thumb Over Bar	Thumb Under Bar	Mixed Grip
2	32	45	100.00		
		90	40.91	59.09	
		180	40.00	50.00	
3	32	45	96.88	3.13	
		90	65.63	25.00	9.38
		180	56.25	37.50	6.25
4	32	45	100.00		
		90	56.25	40.63	3.13
		180	78.13	18.75	3.13

Results showed that 97 percent children used a thumb under grip for the 45º ladder climbing task; there was a 50/50 split between a thumb under and a thumb over grip for the 90º ladder climbing task; and a majority used a thumb over grip for the 180º (horizontal bar). Results for children aged 2, 3, and 4 years old are shown in Table 6.

Although the arms are the main limbs used by young children for climbing, a number of additional factors will help to determine whether a child will become a good climber or not.

These include cognitive and attention factors, fluidity of movement, agility, fearlessness and technique (van Herrewegen et al., 2004). These factors are summarized in Table 7.

Table 7
Characteristics of Good and Bad Climbers

(adapted from van Herrewegen et al., 2004)

Good Climbers	Bad Climbers
Aware and attentive – frequently look around, look up to where they are going	Look at their own hands and feet during climbing to control their movements
Multitasks – climbs while talking, looking, eating, playing	Absorbed and focuses all attention on the act of climbing
Often uses two support points (one hand, one foot)	Use three support points (two hands, one foot; two feet, one hand)
Moves with great ease and smoothness	Say close to object being climbed
Does not stop during climbing and climbs fast	Frequently stop to look for support or to look down. Climb slowly.
Use many climbing techniques	Often do not know how to climb an object
Strong enough to carry their own weight	Not strong enough to carry their own weight, often overweight
Dare devils and fearless	Cautious and frightened of heights
Move with rhythm	Lack rhythmic movements
Take alternating steps when climbing	Put feet next to each other before each upward step

As children learn to climb they also make use of any environmental aids to assist them in climbing, such as grabbing hold of adjacent objects, standing on top of objects, pushing against objects, pulling themselves up using any available supports including using their knees to help to pull themselves up, and throwing one leg up to where their hand is and pulling themselves up (ibid.). As children grow so the size and scope of objects that they can climb increases. It has been noted that "anything that can be climbed will be climbed" (Greenman, 1988, cited in Readdick and Park, 1998). In short, children, like many famous mountain climbers, will often climb an object simply "because it is there" (Readdick and Park, 1998). Children who are 5 years or older can quickly scale even very high barriers (Nixon et al., 1979) and they often take pride in their prowess in doing this.

Some examples of the kinds of products that children climb at different ages are shown in Table 8.

Table 8
Examples of Objects that a Child will Climb at Different Ages

(adapted from van Herrewegen et al., 2004)

1-3 Years	Objects that are Climbed
Successive platforms	House stairs, stairs on the slide
Platform	High chair, normal chair, cupboard, table
Wire fence, fence with rails	Baby crib
Irregular shaped objects	Cushions, mattress, pillows, boulders
Angled plane with few support points	Small slide
4-6 Years	
Climbing frame	Climbing frame with irregular steps, hoops
Wire fence	Fence
Angled plane with few support points	Small slide
Angled or horizontal rope network	Climbing rope, mesh, net
Angled climbing wall	Playground climbing wall
Platform	Table, climbing frame

Children's climbing brings physiological, psychological, sociological and biological benefits to the maturing child and consequently climbing is encouraged by the equipment design of modern playgrounds (Frost, Sutterby, Therrell et al., 2002). In addition to aiding in the neuromuscular maturation of the child and the child's social development through collaborative and competitive climbing activities, these authors also note that a well-designed playground teaches children about basic principles of physics, such as gravity, inertia, pendulums and optics. The importance of climbing activities in the physical development of the child is further reinforced by school playground and gymnasium equipment. Against this desire to encourage children to develop their climbing skills are concerns about children's falls and their safety on climbing equipment. As a result of these concerns restricting the height of playground equipment is recommended by every major national playground safety organization (ibid.).

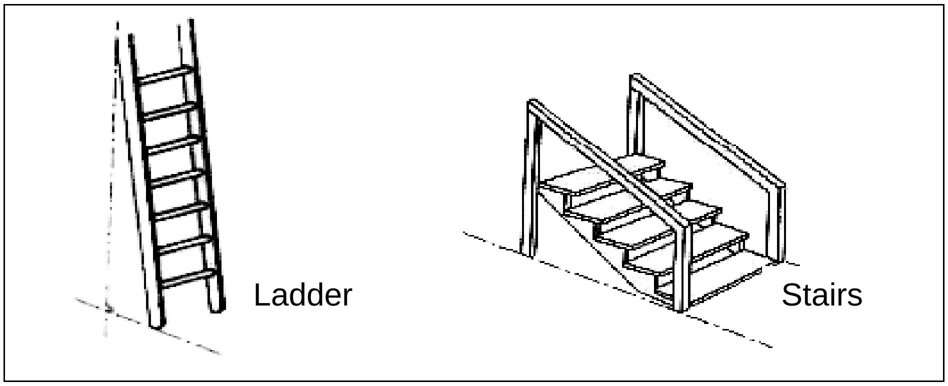
Children's Interaction with the Built Environment

Ladders

A ladder is a vertical or inclined set of rungs or steps fixed inside of two outer frame members and it is different to stairs which also allow for the ascent to or descent from a height (see Figure 6). In EN-1176-1 (1998) a ladder is defined as "the primary means of access incorporating rungs or steps on which a user can ascend or descend." A ladder is normally inclined at an angle between 60° and 90° to the horizontal (section 3.10). A ladder is distinct from stairs which are defined in the standard as the "primary means of access incorporating steps on which a user can ascend or descend. Stairs are normally inclined at an angle between 15° and 60° to the horizontal (section 3.11).

Figure 6
Illustration of Ladder and Stairs

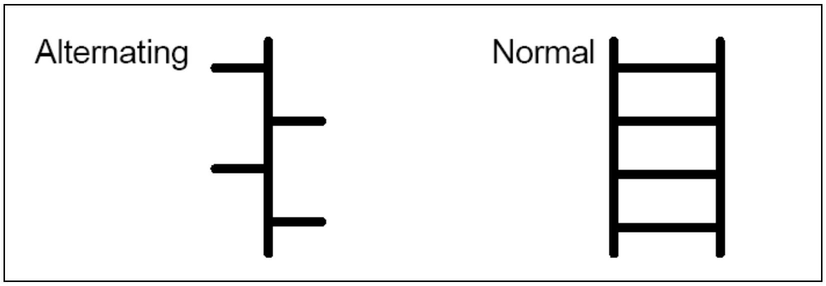
(from van Herrewegen and Molenbroek, 2005)



In children's playgrounds there are many structures that have to be accessed by a ladder. The effects of different ladder designs have been tested with young children (van Herrewegen and Molenbroek, 2005). This work shows that many children younger than 36 months of age and all 3-4-year-old children tested are able to climb a vertical ladder with a first rung height of 15.75 in (40 cm); 18 percent of children under three years can climb a vertical ladder with a first rung height of 23.6 in (60 cm) and 50 percent of children aged 3 to 4 years can climb a ladder with a first rung height of 27.6 in (70 cm). A ladder can be made from various materials, such as wood, metal, plastic or rope and it can be narrow or broad. It can be of varying length. A ladder can have normal, conventional horizontal rungs, or these can be alternating (see Figure 7). The alternating rung pattern is used mainly in industrial ladders (e.g., Lapeyre Stairs – www.lapeyrestair.com). The normal rung pattern can be achieved with rungs that span two vertical uprights, or there can be a single central upright or the rungs can be cut into the upright.

Figure 7
Ladder Rung Patterns

(adapted from van Herrewegen and Molenbroek, 2005)



The term the "ladder effect" temporarily was used in some building codes with reference to the presence of horizontal rails that potentially could create ladder-like rungs that could facilitate climbing by young children (Leto, 2000). However, the term has not been formally defined; precisely what constitutes a "ladder effect" has not been discussed in detail in any peer-review journals, the term has not been systematically researched and is no longer included in any current building codes.

Children's Falls from Buildings and Structures

According to Newton's first law of motion, what goes up must come down. This holds true for children climbing, but unfortunately they do not always make a controlled descent from an object but rather they fall off and suffer a sometimes fatal injury.

Falls are the second leading cause of death in the United States (Marshall, Runyan, Yang et al., 2005) with more than 13,000 deaths in 1998, of which 126 were children aged 14 years or younger (Bull, Agran, Gardner et al., 2001). Across the United States, falls represent up to 4 percent of childhood fatalities, but in urban areas this increases to up to 20 percent of deaths from unintentional injury. Fatalities seldom occur when falls are from the second story or lower (ibid.). Preschool children usually fall from windows and older children from rooftops, fire escapes or balconies, especially during the summer months. The analysis of the NEISS data described in Appendix B indicates that the annual fall rate from guards is considerably less than 1 percent of injuries resulting in emergency visits among children aged 18 – 48 months.

The prevalence of risk and protective factors for falls in homes was estimated from the results of a nationwide telephone survey of 1003 U.S. households. The reported prevalence of falls in the home in the previous 12 months that required medical attention was 7 percent overall, and this was higher if there were young children aged 6 or under (9 percent) or elderly adults (11 percent). Falls were strongly associated with stairs, the absence of railings, and the use of ladders. Households with young children or older adults reported greater use of appropriate anti-fall devices, such as safety gates on stairs (Marshall, Runyan, Yang et al., 2005).

In a retrospective analysis of 729 accidental or unintentional fall patients (393 low-level and 336 high-level) treated from 1992 through 1998, researchers found that over 60 percent of the falls occurred between the ages of 10 months and 4 years (Wang, Kim, Griffith et al., 2001). Of these falls, 21.8 percent were from windows, 15.3 percent were from balconies or fences, and 12.1 percent were from stairs. In this period there were 12 fatalities from falls, and eight of these were high falls (>15 ft [4.6 m]) from windows or balconies. The mortality rate was 2.4 percent for high-level falls (>=15 ft [4.6 m]) compared with 1.0 percent for low-level falls (<15 ft [4.6 m]). Intracranial injury accounted for the majority of deaths from falls. Intracranial and abdominal injury risks were similar for children suffering low-level falls compared with those who fell from greater heights. High-level falls resulted in more orthopedic and thoracic injuries and low-level falls resulted in more abdominal injuries. All four low-level fall deaths had pre-existing abnormal head computed tomography (CT) scans and intracranial hypertension. Intracranial injuries caused 50 percent of high-level falls deaths and 50 percent were caused by severe extracranial injuries. Other research has shown that children have relatively flexible bones and will use their arms to protect their heads (Bull et al., 2001), and children aged 3 years or younger are less likely to suffer serious injury than older children who fall the same distance because they have less muscle mass and more cartilage and fat to dissipate the kinetic energy of the fall (Ivatury, 2005).

In a systematic review of the literature (Khambalia, Joshi, Brussoni et al., 2006) searched electronic databases from 1966 to March 2005 to identify 14 empirical research studies that systematically evaluated unintentional fall injury risk factors for children aged 0–6 years. The major fall injury risk factors included the child's age, sex (boys fell more), height of the fall, type of landing surface, mechanism (child was dropped, fell on stairs or fell using a infant walker), setting (day care versus home care), bunk beds, and low socioeconomic status. The authors concluded that age, sex, and poverty are independent risk factors for injuries due to falls in children.

A retrospective analysis of head injuries/multiple trauma for 241 children aged 16 years or under over a seven-year period in Zurich compared cases to random controls (Mayer, Meuli, Lips and Frey, 2006). Of those children with head injury, 31 (13 percent) had fallen out of a building, and 27 (87 percent) of these children had fallen from the third floor or lower. Two-thirds of falls (68 percent) occurred at home (21 falls) and 15 children (49 percent) had climbed on furniture before falling. The authors note that "dangerous balcony construction "caused five falls (15 percent), but they do not describe how the balconies were judged to be constructed dangerously. Except for three cases (10 percent) with direct parental involvement (one mother jumped out with her child, two mothers threw their child out of the window), parents did not witness the fall which shows that the children were unsupervised. Two children (6 percent) attempted suicide. Children aged 0-5 years were predominantly represented (84 percent), and all six children who died were in this age group. Most falls occurred among younger children of foreign nationals of lower socioeconomic status and in the summer months.

Analysis of the statistics on falls reveals several consistent trends: fall risks are greater in older, multi-story, low-income housing; there is a higher rate of falls among young males than females; and risks are higher for African-American and Latino children (Bull et al., 2001; Mayer et al., 2006).

Environmental considerations and materials also play important roles in the risks of and consequences of falls. For example, surface dryness may be an issue because research has shown that falls on wet linoleum result in greater femur torque than falls on dry linoleum (Deemer, Aguel, Bertocci et al., 2003). Surface type and fall height have been also been shown to influence the biomechanics associated with injury risk in feet-first free falls and forces are less for falls onto playground foam than onto wood, linoleum or padded carpet (Bertocci , Pierce, Deemer et al., 2004). Other considerations include the thermal conductivity of the material, for example, metal will heat up or cool down more rapidly than wood and consequently metal will feel less comfortable to the skin and this may discourage climbing. Materials that are flexible, such as wires, may allow a child to deform them and be able to either climb or squeeze through the barrier.

Windows

Falls from windows are among the most common types of unintentional injuries to children and they are a major public health concern, especially in urban communities in North America (e.g., Benoit, Watts, Dwyer et al., 2000; Istre, McCoy, Stowe, et al., 2003; Stone, Lanpear, Poemrantz & Khoury, 2000; Vish, Powell, Wiltsek and Sheehan, 2005; Meyer, Thelot, Baugnon, and Ricard, 2007). According to the CPSC, in 1993, 90 percent of falls were from windows on the first or second stories of buildings, and these resulted in a variety of injuries. Of those, 45 percent were fractures, internal injuries, concussions, hematomas, and hemorrhages (Bull et al., 2001). The American Academy of Pediatrics reports that some 3 million children per year require treatment for fall-related injuries and that falls result in around 140 deaths annually in children less than 15 years of age (Bull et al., 2001).

An analysis of hospital admissions for 2,322 children, aged 0-14 years, for the period from January 1991 through November 1999, showed that 41 percent of admissions resulted from a fall and 11 percent of these were falls from windows (Benoit et al., 2000). The overall mortality rate was 4 percent and 83 percent of these cases were children aged 0-4 years (ibid.). Between the years 1992-1994, the national cost of fall injuries to children was $958 million went (Bull et al., 2001). In Los Angeles County, for fall-related injuries cost more than $600,000 or about $5,000 per child over a two-year period (1986-1988).

In an analysis of 1,363 fall injuries treated over a seven-year period from January 1, 1991 to December 31, 1997, Stone et al. (2000) found that 6.3 percent (86) of all the incidents involved falls from windows. There were 69 incidents involving falls in children aged 5 years or younger and these young children were over seven times more likely to be involved in a fall than those aged 5 to 14 years (14.6/100,000 versus 2.0/100,000). Fall incidents were twice as common among boys (55 incidents, 8.2/100,000 annual incidence rate) as girls (33 incidents, 4.8/100,000 annual incidence rate) and African-American children were three times more likely to fall (47 incidents, 13.1/100,000 annual incidence rate) than children from other non-black ethnic groups (39 incidents, 4.1/100/000 annual incidence rate). The fall incidence rate was four times greater in urban Cincinnati (64 incidents, 11.6/100/000 annual incidence rate) than in surrounding suburban or rural areas (22 incidents, 2.8/100/000 annual incidence rate). The mortality rate for falls from windows was 4.7 percent which was significantly greater than for other falls (0.07 percent). African-American male children aged less than 5 years and living in an urban setting were the highest risk group for a fall from a window. Unfortunately, the study does not indicate any design variables associated with the falls, such as the window height, whether or not it was open and whether or not there was a guard present.

A retrospective analysis of pediatric trauma patients admitted to a trauma center in Northern Virginia, between January 1991 and November 1999, was undertaken to determine the risk factors for fall incidents (Benoit at Al, 2000). During this period there were 102 falls from windows (11 percent of all falls) and one-third of the children falling from a window were admitted to the hospital between 1997 and 1999. Most of the children who fell from a window were boys (62 percent) and aged less than 4 years (83 percent). Most falls (70 percent) were from a second-story window. Most incidents were not witnessed by an adult. The study did not consider the role of any design variables in either facilitating or preventing the occurrence of a fall.

A Swiss study retrospectively analyzed 241 child head and/or multiple trauma injuries over a seven-year period at a Zurich hospital (Mayer, Meuli and Lips, 2006). Of those injuries, 31 (13 percent) were associated with a fall, and of these 15 cases fell from a window, 13 cases fell from a balcony, one fell through a door, and one fell from a roof. In seven of the window falls the child used a nearby chair, sofa, bed, bedside table, or window ledge to climb to the window. Five of the balcony falls were attributed to dangerous construction, although no design details of why construction was judged dangerous was provided. In eight of the balcony falls the child used a nearby chair or dustbin to climb the balcony.

In Dallas County, Texas there were 98 fall injuries to children under 15 years of age from 1997 to 1999 and 40 percent of these cases required hospital admission (Istre et al., 2003). Most of the falls (77 percent) occurred in apartments and 52 percent were falls from windows compared with 45 percent from balconies. Researchers visited the apartments and took measurements of design variables. Most of the apartments were built before 1984 at a time when building codes allowed for rail spacing of up to 9 in (22.9 cm), and they had not been upgraded to meet current code requirements for rail spacing. Results showed that the window was unguarded and located within 24 in (61 cm) of the floor for more than two-thirds of window-related falls. The balcony rails were an average of 7.5 in (19 cm) apart and the child fell from between the balcony rails for more than two-thirds of balcony related falls. Injury rates were higher for Hispanic and blacks in comparison to whites, because many lower socioeconomic families lived in the higher–risk low-income apartment complexes. Of the 17 falls from balconies in this three-year time period, only four were from private balconies whereas 13 were from common balconies that connected apartments. In 15 of these falls the balconies were made of metal and in 11 instances the children had fallen between the balcony rails which were at least 5 in (13 cm) apart. All of the apartments involved were built prior to 1984 when the building code allowed for a rail spacing of up to 9 in (23 cm).

An analysis of 90 fall cases (55 were male) in Chicago involving young children (median age = 2 years) between 1995 and 2002 showed that 98 percent of falls were from the third floor or lower (Vish et al., 2005). Researchers visited 77 fall sites and found that 96 percent were in four-story buildings or lower. Head trauma and extremity fractures were the most common injuries, though three patients died. Researchers noted that among Chicago preschool children window falls are a frequent cause of injury (15/100,000), and that public health efforts have successfully decreased window fall injuries in Boston and New York (ibid.).

In many instances, children fall through open and unguarded low bedroom and living room windows. These accidents can be prevented by installing steel window screens constructed to withstand a body weight up to 150 lbs (67.5 kg) (Bull et al., 2001). Installation of window guards is a proven preventive strategy. In 1976, the New York City Board of Health implemented a policy to mandate window guards in homes with children ages 10 and younger and this resulted in a 35 percent reduction in deaths attributed to falls from windows, a 50 percent reduction in incidents, and a 96 percent reduction in hospital admissions due to window-fall-related injuries (Bull et al., 2001).

Year 2000 data from the Kids Inpatient Database (KID-HCUP) were used to analyze the demographic risk factors, incidence, and patterns of injury resulting from falls from buildings and calculate a national estimate of hospital admissions due to falls from buildings in the United States (Pressley and Barlow, 2005). In 2000 there were 2,163,402 people aged 18 years of younger who were discharged from U.S. hospitals, and of these, 0.0005 percent (1161) were acute injuries from falls from buildings or structures. Of these falls, 6 percent were intentional falls or jumps (70 persons). Based on these figures the estimated annual cumulative incidence of unintentional falls from buildings or structures requiring emergency or urgent hospital admission for children aged 0-4 years was 4.6 per 100,000 children. This was affected by ethnicity and the estimated cumulative incidence of serious falls for young children of Hispanics was 5.48, for African-Americans it was 4.82, and for whites it was 2.72. Although the reason for the fall was not analyzed, the authors infer that a majority of these are the result of falls from windows rather than from balconies or other building structures. They note that New York City has had a window guard law for many years and that in 2001 there were only 30 fall incidents in New York City, no fatalities and most of the falls involved older adolescents. They state that:

> "Window guards have potential to provide affordable, effective prevention of injuries in developing societies where the population is disproportionately young and living in warm climates, and where high rise and multiple storey buildings are being used increasingly to alleviate overcrowding." (page 272).

They conclude that window guards and fall prevention programs are associated with reduced injury resulting from falls from buildings and should be mandated in multifamily dwellings where small children reside. Indeed, a drastic decline in window-related falls quickly followed the introduction of the New York City window guard legislation in 1976: within three years the number of incidents had decreased from 217 to 80 and in 2002 there were only three incidents (New York City Department of Health and Mental Hygiene, 2007). Thus, as noted by Stone et al. (2000), window falls may be endemic but they are preventable with the use of window guards. In addition, Meyer, Thelot, Baugnon and Ricard (2007) have called for more environmental education on window fall risks with information being provided in multiple languages, and with a focus on high-risk warm periods (spring, summer).

Stairs

The Consumer Product Safety Commission (CPSC) has reported that stair-related falls, mostly in homes, are associated with an estimated 2 million injuries and 1,000 deaths each year in the United States (Sanders, 1993). Several factors impact the risk of a fall on the stairs, including the lack of or improperly placed handrails, the height and depth of treads. Riser heights should be between 4 in (10 cm) and 7 in (18 cm) and tread depths should be at least 11 in (28 cm). The edges on treads should be clearly visible. Research shows that children learn to climb stairs early in life and that they quickly master the skills necessary to climb a stair rail.

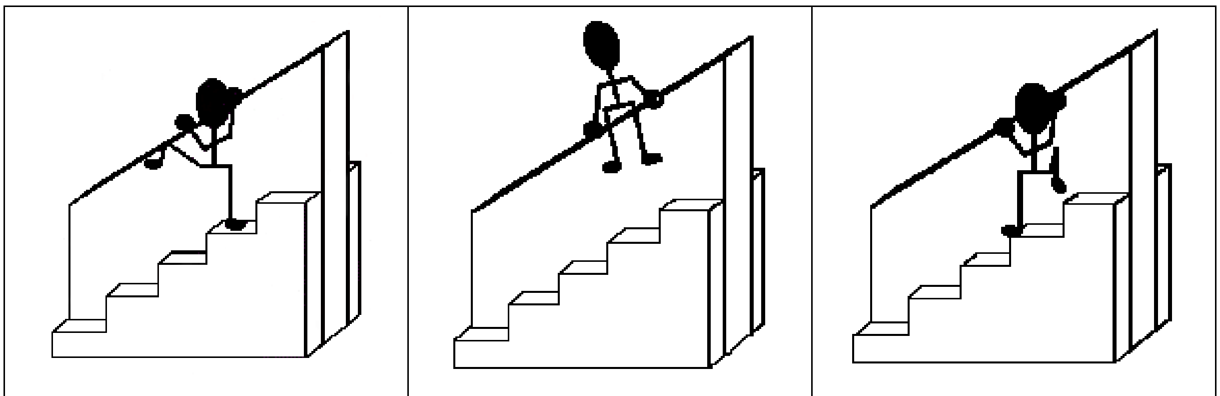
Judgments about stair climbing requirements for normal healthy people seem to be based on a perceptual invariant, namely the angle defined by the ratio between the height of the stair and the distance taken from the feet to the top edge of the stair before the initiation of the movement (Cesari, Formenti and Olivato, 2003). In spite of differences in the kinematics of the motion, anthropometric dimensions, and the skill and ability exhibited, this angle is the same for children, young adults and older adults. Their research shows that although stair climbability judgments often seem to be based on the simple ratio leg length-stair height, and that this is influenced by differences in age, participants of all ages use the above common perceptual variable to coordinate their stair climbing actions.

Berge, Theuring and Adolph (2007) conducted a study of 732 parents who were asked when and how their children learned to climb stairs. Results showed that mastering climbing up stairs typically began around the age of 11 months and that children learned to climb down the stairs at around 12 months of age. Those children living in homes with stairs learned to climb these at an earlier age than those without stairs in the home.

A U.K. study noted that annually there are some 7,500 falls on stairs, in which stair guarding plays a role, that result in an injury requiring hospital attendance and of these falls, 57 percent are the result of children falling off or over stair guarding and 17 percent are the result of children falling through or under stair guarding. The U.K. Building Regulations call for a stair guard that is 90 cm (35.4 in) high so that it is not readily climbable by children. To further investigate the issues associated with stair guard design a two-phase study was undertaken (Riley, Roys and Cayless, 1998). In Phase one, 32 children aged 4 years (13 children), 5 years (12 children), and 6 years of age (7 children) were observed freely playing to see whether they would climb the stair guarding on five step play stairs. Anthropometric measures were taken of those children who chose to climb on or over the guard. In Phase two a different group of children was asked to try to climb the stair guard. This group also comprised 4-year-old (6), 5-year-old (8), and 6-year-old (6) children and their climbing strategies were observed and video recordings were used to assess their climbing time. Physical measurements were taken of those who attempted to climb the stair guard. Results show that a 35.4 in (90 cm) guard rail can be climbed by a majority of 4-, 5-, and 6-year-olds. Younger children attempted to climb after watching older children. For both phases of the study more boys attempted to climb the stair guard than did girls. The physical dimensions of the children were comparable to published anthropometric data for height, leg length, and overhead standing reach distance to grip an object. In the phase two study only one child was unable to climb the guard (a 4-year-old boy). In phase two the mean climbing time was 13.2 seconds but the range was wide varying between 3.2 seconds to 40.9 seconds. There was no evidence that taller children were more skilled or climbed faster than smaller children. Analysis of the video recordings identified three strategies that different children used to climb the guard rail. These strategies are shown in Figure 8. Strategy 1, which is most common and favored most by taller children, involved using both hands to hold the top of the rail, then raising one knee or lower leg onto the rail, and hoisting the torso on the rail. Shorter children favored strategy 2 where both hands grasped the rail and the child used upper body strength to lift the torso onto the rail and then brings one bended knee to the top of the rail. The third strategy, which was used least often, involved grasping the top rail with both hands and then bracing a bended knee against the side of a guard rail to gain the height required to climb the guarding. During free play the observers also noted situations where children helped each other to climb the guard and younger children were influenced and frequently abetted by their elders in climbing. In summary, almost all children were able to climb a 35.4 in (90 cm) stair rail and while the child's height, leg length and reach all impacted climbability, children tended to adopt one of three climbing strategies.

Figure 8
Three Different Strategies for Climbing a Stair Guard

(Riley, Roys and Cayless, 1998)

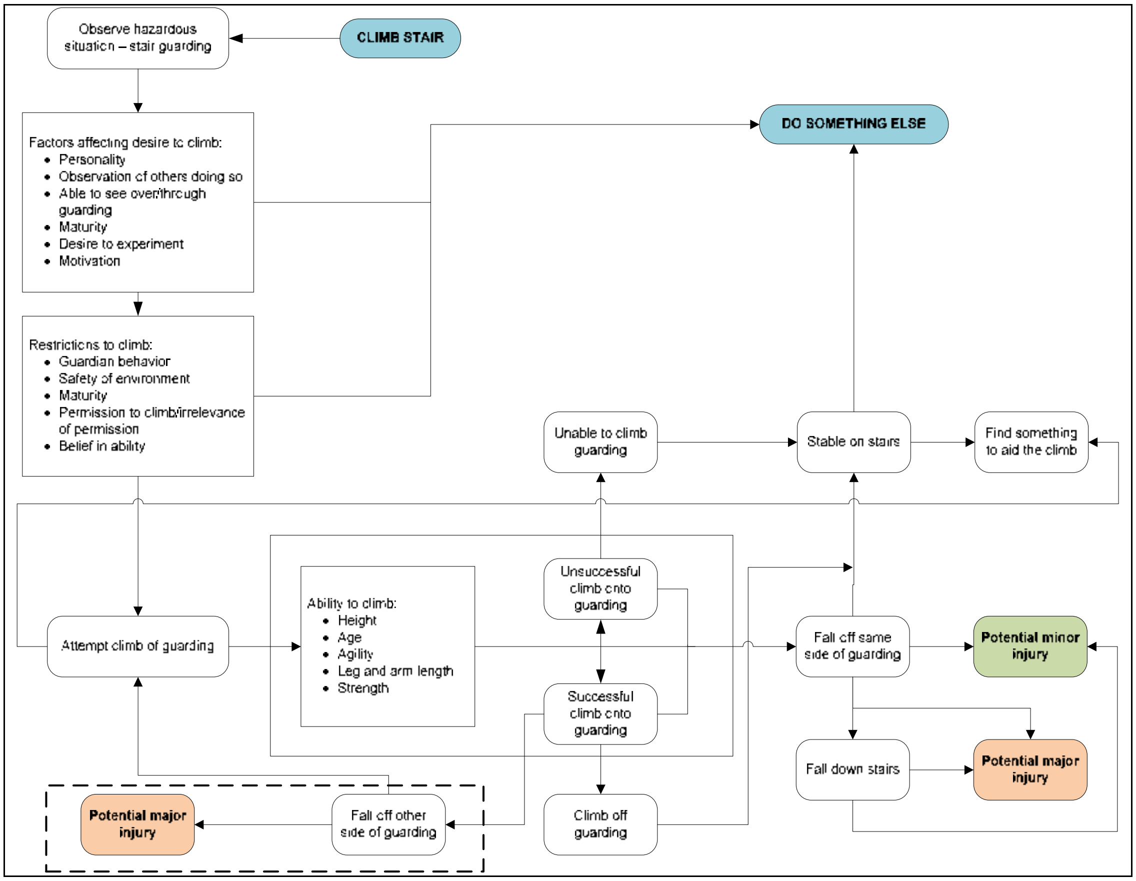


Climbing strategy 1	Climbing strategy 2	Climbing strategy 3

Based upon their observations, the researchers created a flowchart to illustrate the sequence of events and the various factors that influence the likelihood that a child will climb a stair guard (Figure 9). The process begins with the child deciding whether or not to try to climb the stair and various individual factors are thought to influence this process including personality, maturity, and motivation. The presence of a reason, such as permission to climb, also aids in the initial decision. Once the child has decided that there is no restriction then they will attempt to climb. The ability to successfully climb the guard will be influenced by a variety of individual physical factors, such as the height, age, and agility of the child. If the child is unsuccessful in climbing then the child may look for something to assist with climbing. If the child has managed to raise their body off the ground but is unable to complete the climb then there is the potential for a minor injury when they fall off the guard or a more serious injury if they fall down the stairs as a result of this behavior, otherwise the child successfully climbs guard.

Figure 9
Model of the Stair Guard Climbing Decisions Process in Young Children

(redrawn from Riley, Roys and Cayless, 1998)

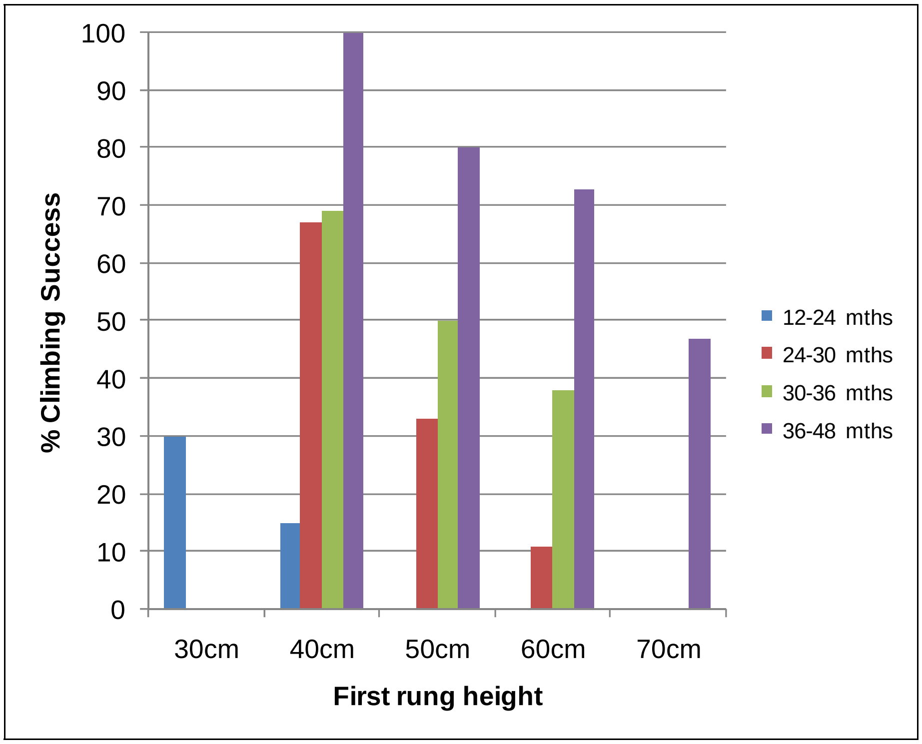


Playgrounds and Ladders

The ability of young children aged 0 to 4 years to climb vertical ladders of different designs has been studied (van Herrewegen and Molenbroek, 2005). In particular, the study sought to determine the height of the first rung of a ladder that these children can climb unaided. Results are shown in Figure 10. Around one-third of children aged 12-24 months were able to climb a ladder with the first rung at 15.75 in (40 cm) above ground level but all children 36 months and older could climb this. By the age of 3 years almost half of the children could climb a vertical ladder with the first run set at 27.5 in (70 cm).

Figure 10
Effects of First Rung Height on Ladder Climbing Success at Different Ages

(plotted from van Herrewegen and Molenbroek, 2005)



Although children's age alone was not a very good predictor of their climbing skills, by age 3 years their motor skills were sufficiently developed to allow climbing a vertical ladder with a variety of rung heights. Interestingly, at all ages tested the children found the slanted ladders to be more frightening to climb than vertical ladders.

A study of the frequency of use of play equipment in public schools and parks in Brisbane, Australia, was undertaken to estimate an annual rate of injury per use of equipment (Nixon, Acton, Wallis et al., 2003). A random sample of 16 parks and 16 schools was selected and children were observed at play on five different pieces of play equipment over a two-year period. The ranked order for equipment use in the 16 schools for average daily use was horizontal ladders (136), slides (61) and climbing equipment (52) and for the 16 parks it was horizontal ladders (156), slides (92), track ride (69) and climbing equipment (20). The results clearly show the popularity of horizontal ladders and other forms of climbing equipment among the school children. Assuming 276 clear days per year, the authors calculated the annual injury rates for the climbing equipment at the 16 schools to be 0.59/100 000 uses of equipment and in the 16 parks to be 0.26/100 000 uses of equipment. The use of climbing equipment aids in the growth and development of children and in this study the children clearly availed themselves of the use of such equipment both at school and in public parks.

The overall rate of injuries/100 000 uses of equipment was higher at school than in the park, possibly reflecting an effect of parental supervision, but in both situations it was low overall. The authors note that the benefit of further injury reduction strategies in this community may be marginal and that these may outweigh the economic costs in addition to reducing challenging play opportunities.

Safety Barriers

A safety barrier is a physical or non-physical means planned to prevent, control, or mitigate undesired events or accidents and they can be passive or active barrier systems, and physical, technical, or human/operational barrier systems (Sklet (2006). As noted by Nixon et al. (1979) to be effective a safety barrier must combine three components:

1. Effective parental training in environmental safety for the child.
2. Present the child with a strong psychological deterrent.
3. Present a physical restraint to the child.

These same authors note that physical barriers can only ever be an adjunct to effective parental training, and the design of the barrier alone can never replace effective environmental safety training.

An effective safety barrier is not synonymous with one that is insurmountable. There may be emergency situations, such as a fire, in which it is desirable that a child be able to scale the safety barrier to escape otherwise they would be trapped and could perish. For a safety barrier to be effective it should be impossible for the child to accidentally fall through or fall over the barrier, but making it unclimbable may be neither feasible nor desirable. The child should know that under normal conditions it is undesirable to attempt to climb over the barrier and the barrier should be designed so that it does not encourage and easily facilitate climbing behavior.

Climbing from Children's Cribs

Ridenour (2002) observed 48 children, 17-32 months with mean age 26 months, climbing from a crib. After children become comfortable walking some begin climbing. She tested a standard wood crib that was 28 in (71 cm) wide x 52 in (132.1 cm) long x 26 in (66 cm) high rail with 6 in (15 cm) thick crib mattress. All of the children were able to walk unaided and all were < 35 in (89 cm) tall (mean = 33.7 in (85.6 cm), min. 31.5 in (80 cm), max. 34.8 in (88.4 cm). Each child was observed climbing out of the crib four times. Results showed that a large majority of children climb out of corner of crib (see Figure 11). Corner climbing was consistently used by 90 percent of children and it was used by 98 percent of children some of the time.

Figure 11
Typical Corner Climbing Pattern

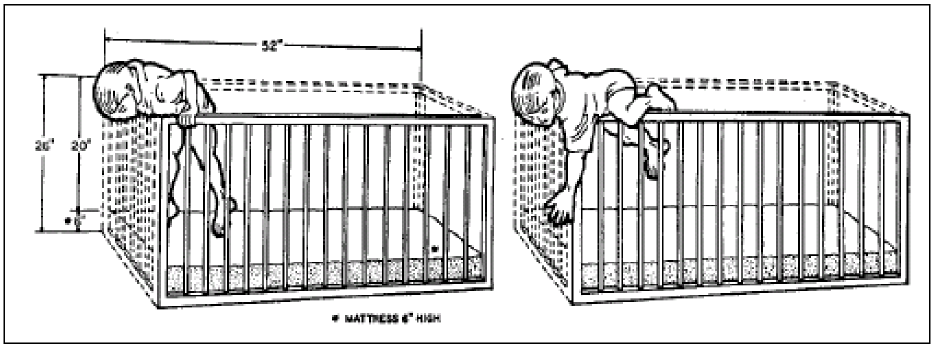
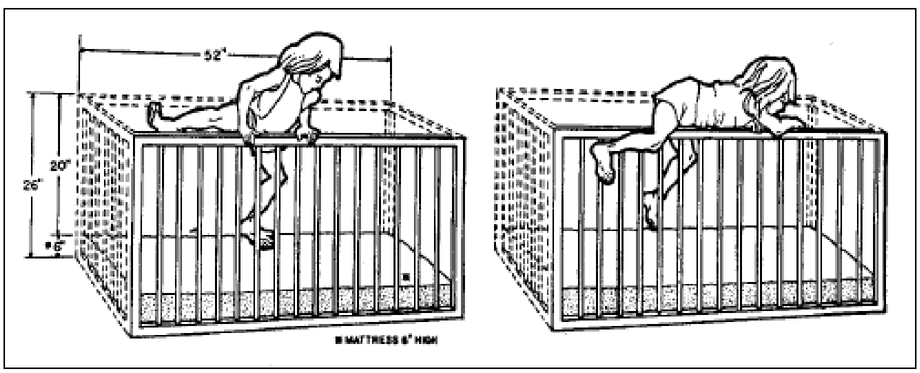


Figure 12
Typical Side Climbing Pattern



The side-climbing pattern was used by the remaining 10 percent of the children in at least one of the four observations (Figure 12). The effective height of the crib side was 20 in (50 cm) and children were able to climb over this barrier. Results show that the corners in cribs usually are used by young children to aid their climbing, and that any potential catch points at the corners should be eliminated because these can be a hanging hazard. One implication of the results not discussed by the authors is that oval, elliptical or circular crib designs should avoid the corner climbing strategy, and if the crib side is high enough at 36 in (91 cm) this should prevent or minimize side climbing.

Child Protective Fencing

It is clear that well designed safety barriers, including balconies, railings, and stair rails sometimes can be the difference between life and death for a child. The primary role of a barrier is to eliminate the risk of accidental falls through or over this. There are many factors that affect the overall design of a safety barrier, including the cognitive development of the child, the physical development of a child's climbing skills, and environmental considerations.

There are approximately 140 deaths from falls and three million children require emergency department care for fall-related injuries each year in children younger than 15 years in the United States (Bull, Agran, Gardner, et al., 2001). The risks of falls can be mitigated by pediatricians and other child health care professionals advocating preventive strategies that include parent counseling, community programs, building code changes, legislation, and environmental modification, such as the installation of window guards and balcony railings.

Removing any hazards or reducing any risks to an acceptable minimum can create a safer environment for children (Page, Powell, Wilson, and Ward, 1995). One effective strategy to reduce hazards is to isolate these by using barriers, especially fence-like barriers used in the home (stair gates and cooker and fire guards and products which have a barrier-function, such as cots and playpens).

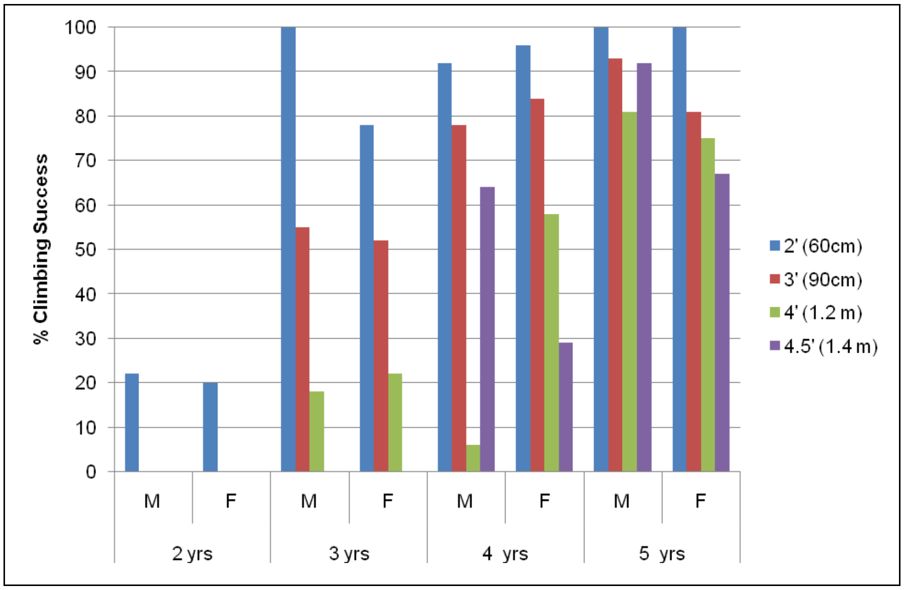
Good barrier design features are discussed in the following sections. However, it is notable that there has been a lack of consistent design terminology in the studies that follow. The reader should note the specific design characteristic of each type of fence tested rather than simply relying on the name given to the fence. For example, in the United States research conducted in the early 1990s a metal fence comprising mainly vertical bars is referred to as an ornamental metal fence, whereas today it most likely would be described as a vertical picket fence. It is stressed that conformance with building standards should be followed by regular assessment of public safety issues and action as appropriate (Culvenor, 2002).

Fence Design: Australian Research

In young children aged 4 or less there are no consistent gender differences in fence climbing abilities and, depending on the design of the fence, by the age of 2 years, 22 percent of children can climb a 24 in (60 cm) fence, by the age of 3 years about 50 percent of children can climb a 36 in (91.4 cm) fence, and 20 percent can climb a 48 in (122 cm) fence (Nixon, Pearn and Petrie, 1979). These results are shown in Figure 13.

Figure 13
Climbing Success at Different Ages for Different Fence Designs

(plotted from Nixon, Pearn and Petrie, 1979)



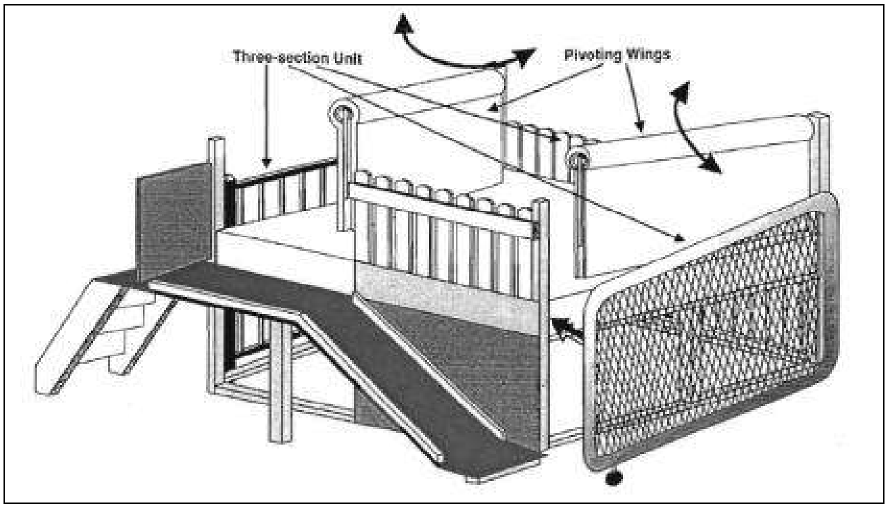
Fence Design: U.S. Research

Three studies were undertaken to evaluate swimming pool perimeter fencing design and the fence-climbing abilities of young children in the high-risk age group for drowning in residential swimming pools (Rabinovich, Lerner and Huey, 1994). In all studies they tested pairs of children to provide social facilitation and encouragement for climbing. They asked children to climb each of several fence designs without giving any instructions on how to climb. All children were encouraged to climb as quickly as possible, preferably surmounting the fence in less than 1 minute, with 3 minutes set as the upper limit for a trial. Age appropriate prizes were offered to motivate children to climb the fences and these were dispensed regardless of climbing success. When not climbing, the children were given time-out to play with toys, and a playful study atmosphere was maintained throughout.

The test apparatus comprised square elevated platform elevated 36 in (91.4 cm) above the ground. The floor of the platform was padded with 6 in (15.2 cm) polyurethane foam blocks, and the outer perimeter floor area was padded with 12 in (30.4 cm) of polyurethane foam blocks. Different fence design sections could be fixed to three sides of the platform, each section being 72 in (182.9 cm) long and these were varied in height, and the platform was exited down a slide (see Figure 14). A hinged joint at each connection point allowed fence sections to swing independently and each section had to allow easy movement of the section to and from the test platform. After the fence sections were placed in position, clamps were used to hold the movable fence sections to the edges of the platform. To motivate younger children some fence sections of 24 in (6 cm) and 36 in (91.4 cm) in height were used to ensure initial success and maintain children's motivation by ensuring periodic successes. However, for the experimental testing all fence sections were at least 48 in (122 cm) high.

Figure 14
Example of Study 1 and Study 3 Apparatus

(Rabinovich et al., 1994)



Climbing Protocol and Success Measure

In the first study, each child was asked to climb each fence design at 24 in (6 cm), 36 in (91.4 cm), and 48 in (122 cm) heights before proceeding to the next fence design, and the different designs were tested in counterbalanced order. Success and time to success were recorded during each session by three experimenters. All experimenters practiced their timing skills by watching video-tapes of pilot sessions and until there was good agreement with the lead experimenter's time. All test sessions were videotaped.

For all sessions one experimenter was responsible for the welfare of each child during their fence climbing attempts, a second experimenter stood at the bottom of the exit slide to ensure the child's safety leaving the platform and a third experimenter stood or kneeled directly behind the child with arms and hands ready to catch the child during climbing attempts but without providing any physical assistance. During climbing, the use of any part of the platform or the fence-mounting structure as an aid in climbing; verbal or physical assistance from the other child; success in climbing the fence with assistance from the other child; and time required to climb the fence with assistance from the other child all were recorded.

If the child was able to climb the fence unassisted by the support structure or another individual this was recorded as a success. Some children accidentally used the support structure to assist them in climbing the fences and this was counted as a success and noted. The success rate was the number of successes divided by the total number of trials.

Study 1 – Effects of Fence Design

The first study tested whether 60 children (22 girls and 38 boys) between the ages of 24 and 54 months could climb each of five fence designs, all set at 48 in (122 cm) height, that, with the exception of a 2.5 in (6.35 cm) chain-link fence, conformed to the CPSC's recommended codes for swimming pool barriers (US CPSC, 1991):

1. Large diagonal chain-link – 2.5 in (6.35 cm)
2. Small diagonal chain-link – 1.25 in (3.18 cm)
3. Picket: Vertical members 4 in (10.16 cm) apart, with a 23 in (58 cm) gap between horizontal members. Boards were 3.25 in (8 cm) wide. No decorative cutouts.
4. Stockade: a wooden fence with vertical members 0.25 in (0.6 cm) apart and a gap between horizontal members off 2.3 in (5.8 cm). Essentially presented a solid wall.
5. Ornamental iron: Vertical members 3.5 in (8.26 cm) apart, with a 45 in (114.3 cm) gap between horizontal members. No decorative cutouts.

An attempt was made to also test a removable nylon fence but because this could not be kept taut it was excluded from the study. The following results were obtained for the percentage climbing success and mean climbing times in seconds from this study:

- 24- to 36-month-old group – there was a statistically significant difference in children's ability to climb the different fence designs (Chi-square (5) = 86.8, $p < 0.01$). For this age group the large chain-link fence was easiest fence to climb (75 percent success, an average of 25.6 seconds), especially compared to climb the small chain-link fence (13 percent success, an average of 18.7 seconds: Chi-square (1) = 19.05, $p < 0.0001$). No child was able to climb the picket, stockade or ornamental iron fence.

- 36- to 42-month-old group – there was a statistically significant difference in children's ability to climb the different fence designs (Chi-square (5) = 28.7, $p < 0.001$). Large chain-link fence (92 percent success, an average of 21.9 seconds) was marginally significantly easier to climb than small chain-link fence (58 percent success, an average of 19 seconds: Chi-square (1) = 3.6, $p < 0.06$). The picket fence was climbed by 50 percent of children in an average of 24.2 seconds. No child was able to climb the stockade and ornamental iron fences.

- 42-to 48-month-old group – there was a statistically significant difference in children's ability to climb the different fence designs (Chi-square (5) = 31.3, $p< 0.001$). All children could quickly climb the large chain-link fence in an average of 11.5 seconds and 92 percent of children could climb the small chain-link fence in an average of 11.6 seconds. Less than half of the children could climb the picket fence (42 percent) but those that succeeded climbed this quickly (an average of 12 seconds). Only 17 percent of children could climb the stockade fence (an average of 14.5 seconds) and 17 percent could climb the ornamental iron fence (an average of 20.5 seconds).

- 48-to 54-month-old group – there was a statistically significant difference in children's ability to climb the different fence designs (Chi-square (5) = 28.5, $p< 0.001$). All children climbed the large chain-link fence very quickly in an average of 7.7 seconds and 83 percent of children could climb the small chain-link fence in an average of 11.4 seconds. Over half of the children (58 percent) climbed the picket fence in an average of 23.3 seconds, and 33 percent climbed the stockade in an average of 11.3 seconds. The ornamental iron fence was the most difficult to climb and only 8 percent of children succeeded with an average climbing time of 11.4 seconds.

These results are summarized for climbing success in Figure 15 and for climbing time in Figure 16. There were no significant differences in climbing success between boys and girls for any of the fence designs. When children were able to use some other part of the platform structure to assist with climbing then success rates for the ornamental iron fence were 13 percent (24-36 months), 8 percent (36-42 months), 25 percent (42-48 months), and 100 percent (48-54 months). However, results consistently showed that the ornamental iron fence was the hardest design to climb unassisted and that when children were successful then usually it took the longest to climb.

Study 2 – Effects of Fence Design Modifications

The second study tested whether 32 children (16 girls and 16 boys) between the ages of 36 and 48 months, could climb each of the five fence designs used in Study 1, but with the presence of either a roller top rail made of a 4 in (10 cm) diameter free-spinning polyvinyl chloride pipe or an angled plate top that was 2 in (5 cm) thick and 12 in (30 cm) deep. Both modifications ran the length of each fence section (see Figure 17).

Figure 15
Age and Design Effects on Climbing Success for a 48 in (122 cm) High Fence

(plotted from Rabinovich et al., 1994)

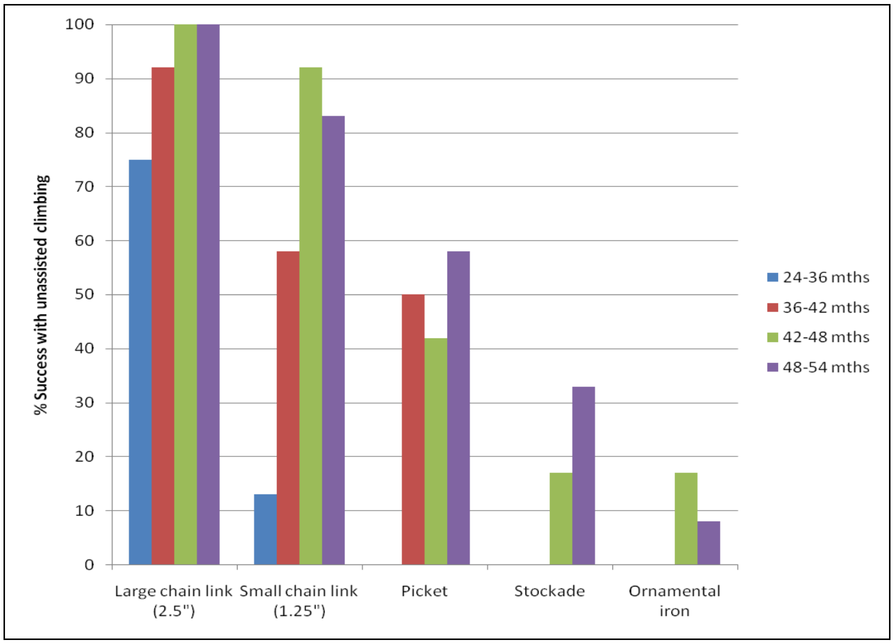


Figure 16
Age and Design Effects on Climbing Speed for a 48 in (122 cm) High Fence

(plotted from Rabinovich et al., 1994)

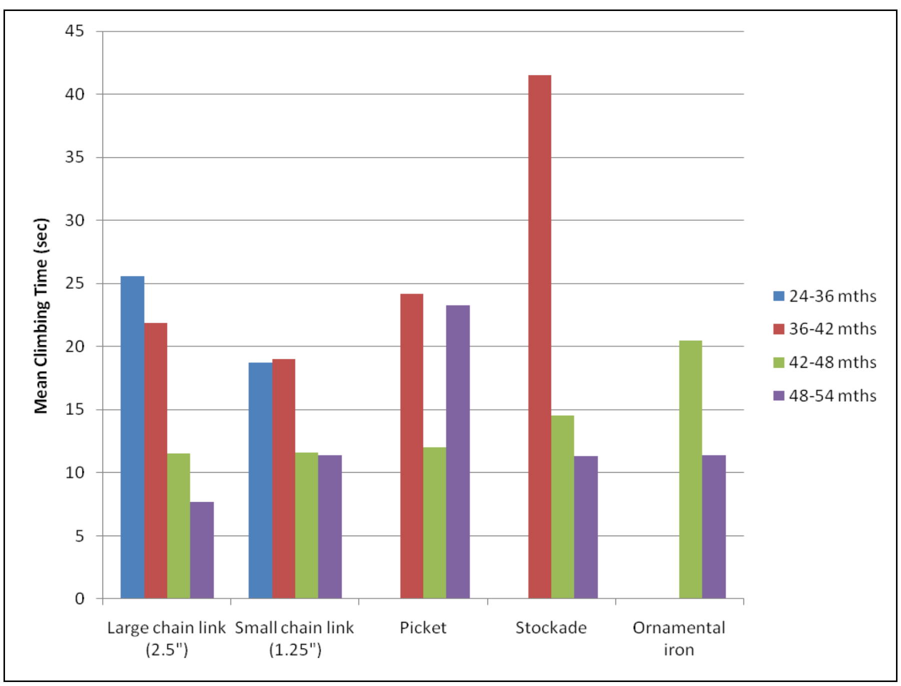
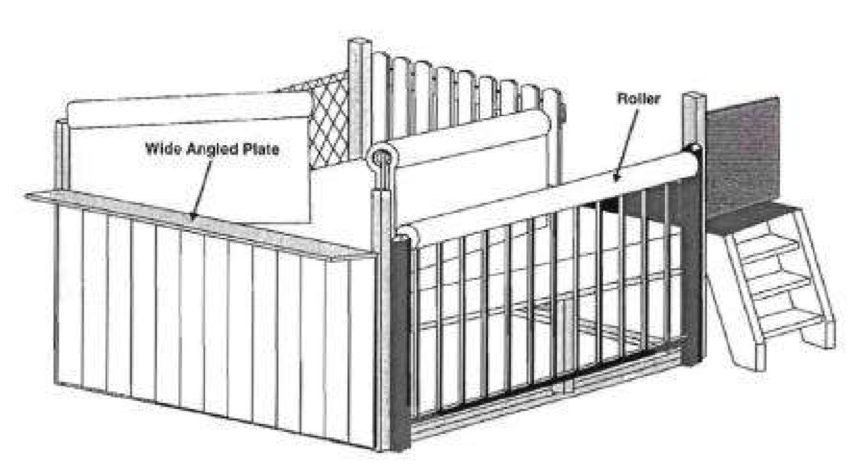


Figure 17
Example of Study 2 Apparatus

(Rabinovich et al., 1994)



The following results were obtained for the percentage climbing success and mean climbing times in seconds from this study:

- 36- to 42-month-old group – there was a statistically significant difference in children's ability to climb the different fence designs (Chi-square (8) = 143.1, $p < 0.001$). Almost all children (95 percent) were able to climb the regular large chain-link fence in an average of 12.8 seconds. Both of the top treatments significantly lowered the percentage of successful climbing attempts for the chain-link fence (Chi-square (8) = 10.8, $p < 0.01$). The presence of the top roller decreased climbing success to 81 percent and slowed climbing time to an average of 19.3 seconds. The presence of the angled top plate decreased climbing success to 54 percent and slowed climbing time to an average of 24.4 seconds. A few children (4 percent) succeeded in climbing the stockade fence in an average of 14.1 seconds, but none climbed the modified stockade. No child was able to climb the ornamental iron fence even when this was unmodified.

- 42-to 48-month-old group – there was a statistically significant difference in children's ability to climb the different fence designs (Chi-square (8) = 48.6, $p < 0.001$). All children could quickly climb the large chain-link fence in an average of 12.1 seconds. The addition of the top roller decreased the percent climbing success to 80 percent and slowed climbing time to an average of 18.6 seconds. The presence of the angled top plate decreased climbing success to 50 percent but this actually reduced climbing time to an average of 12 seconds. The stockade fence was climbed by 30 percent of children in an average of 12 seconds, and 30 percent of children succeeded in climbing the stockade fence with top angle plate in an average of 14.6 seconds. No child climbed the stockade fence with the top roller present. At this age 30 percent of children climbed the ornamental iron fence in an average of 40 seconds. No child climbed the ornamental iron fence with either the top roller or top angle plate present.

These results are summarized for climbing success in Figure 18 and for climbing time in Figure 19. Analysis of the results by gender showed that girls were more successful than boys in climbing the chain-link fence with the roller-top (Chi-square (1) = 3.94, $p < 0.05$) and with the top angle plate (Chi-square (1) = 4.44, $p < 0.05$).

Figure 18
Age and Fence Design Effects on Climbing Success

(plotted from Rabinovich et al., 1994)

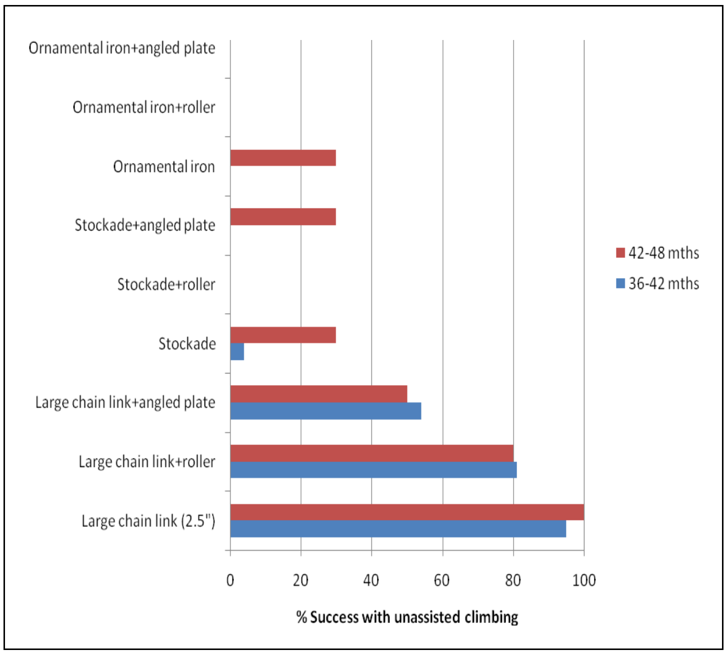
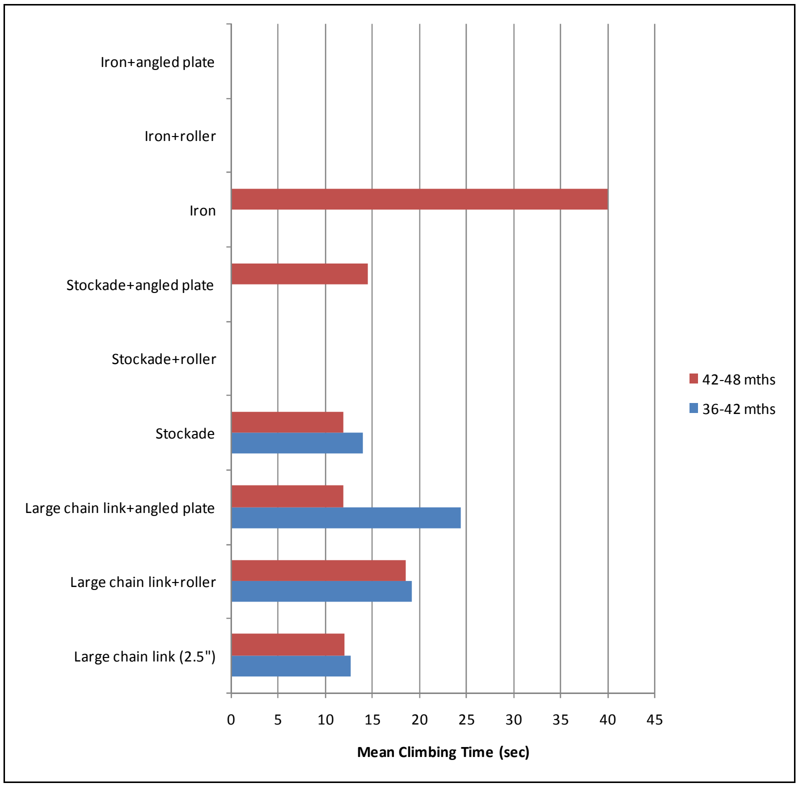


Figure 19
Age and Fence Design Effects on Climbing Speed

(plotted from Rabinovich et al., 1994)



Study 3 – Effects of fence height

The third study tested whether 48 children (22 girls and 26 boys) between the ages of 24 and 48 months, could climb each of the five fence designs used in Study 1, but with a variable fence height of 48 in (122 cm), 54 in (137.2 cm) and 60 in (152.4 cm). The same apparatus as in Study 1 was used (see Figure 10).

The following results were obtained for the percentage climbing success and mean climbing times in seconds from this study:

- 48 in (122 cm) fence height – there was a statistically significant difference in children's ability to climb the 48 in (122 cm) fence designs (Chi-square (4) = 73.7, p< 0.001).
    - o For the 24-36 months age group, the large chain-link fence was the easiest fence to climb (83 percent success, an average of 22.9 seconds) and this was easier to climb than small chain-link fence (17 percent success, an average of

15 seconds). No child in this age range was able to climb the picket, stockade or ornamental iron fence.

  - For the 36-42 months age group, the large chain-link fence was the easiest fence to climb (85 percent success, an average of 11.5 seconds) and this was easier to climb than small chain-link fence (62 percent success, an average of 18.1 seconds). No child in this age range was able to climb the picket, stockade or ornamental iron fence.

  - For the 42-48 months age group, the large chain-link fence was the easiest fence to climb (92 percent success, an average of 8.7 seconds) and this was easier to climb than small chain-link fence (75 percent success, an average of 10.1 seconds). One-quarter of children at this age were able to climb the stockade (25 percent success, an average of 25.3 seconds). A few children in this age range were able to climb the picket (8 percent success, an average of 16 seconds) or ornamental iron fence (8 percent success, an average of 76 seconds). Results confirmed that at 48 in (122 cm) the ornamental iron fence was the hardest to climb.

- 54 in (137.2 cm) fence height – there was a statistically significant difference in children's ability to climb the 54 in (137.2 cm) fence designs (Chi-square (4) = 63.5, $p< 0.001$).

  - For the 24-36 months age group, the large chain-link fence was the easiest fence to climb (65 percent success, an average of 22.7 seconds) and this was easier to climb than small chain-link fence (4 percent success, an average of 51 seconds). No child in this age range was able to climb the picket, stockade or ornamental iron fence.

  - For the 36-42 months age group, the large chain-link fence was the easiest fence to climb (92 percent success, an average of 15.1 seconds) and this was easier to climb than small chain- link fence (15 percent success, an average of 25 seconds). No child in this age range was able to climb the picket, stockade or ornamental iron fence.

  - For the 42-48 months age group, the large chain-link fence was the easiest fence to climb (92 percent success, an average of 11.8 seconds) and this was easier to climb than small chain-link fence (67 percent success, an average of 20 seconds). Less than one quarter of children at this age were able to climb the stockade (17 percent success, an average of 12.5 seconds). A few children in this age range were able to climb the picket (8 percent success, an average of 15 seconds). No children were able to climb the ornamental iron fence. Results confirmed that at 54 in (137.2 cm) the ornamental iron fence could not be climbed by children in the ages tested.

- 60 in (152.4 cm) fence height – there was a statistically significant difference in children's ability to climb the 60 in (152.4 cm) fence designs (Chi-square (4) = 63.5, $p < 0.001$).

  - For the 24-36 months age group, the large chain-link fence was the easiest fence to climb (65 percent success, an average of 23.5 seconds) and this was easier to climb than small chain-link fence (4 percent success, an average of 20 seconds). No child in this age range was able to climb the picket, stockade or ornamental iron fence.

  - For the 36-42 months age group, the large chain-link fence was the easiest fence to climb (92 percent success, an average of 15.2 seconds) and this was easier to climb than small chain-link fence (15 percent success, an average of 17 seconds). No child in this age range was able to climb the picket, stockade or ornamental iron fence.

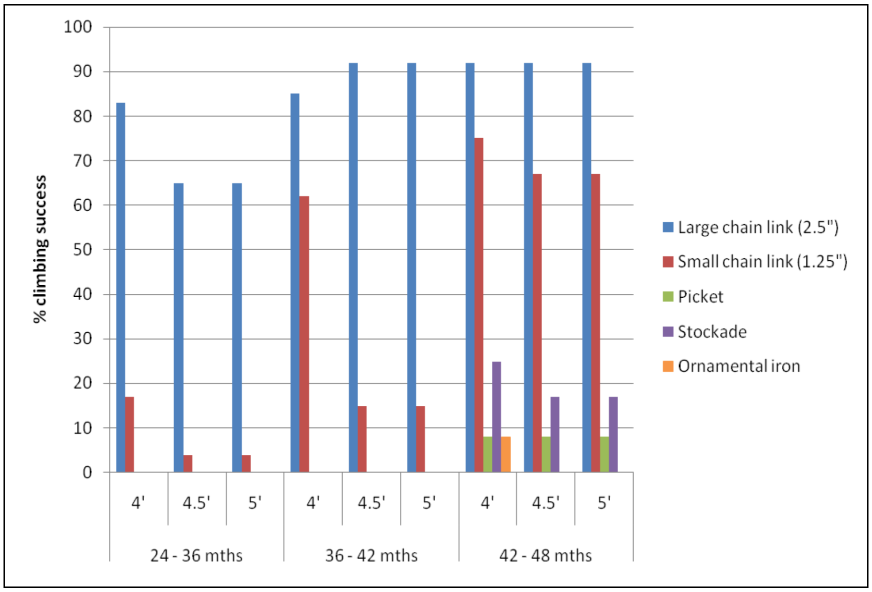
  - For the 42-48 months age group, the large chain-link fence was the easiest fence to climb (92 percent success, an average of 11.6 seconds) and this was easier to climb than small chain-link fence (67 percent success, an average of 20 seconds). Less than one-quarter of children at this age were able to climb the stockade (17 percent success, an average of 17 seconds). A few children in this age range were able to climb the picket (8 percent success, an average of 42 seconds). No children were able to climb the ornamental iron fence. Results confirmed that at 60 in (152.4 cm) no children in the ages tested were able to climb the ornamental iron fence.

These results are summarized for climbing success in Figure 20 and for climbing time in Figure 21. There were no significant differences in climbing success between boys and girls for any of the fence designs. When children were able to use some other part of the platform structure to assist with climbing then success rates for the ornamental iron fence were 13 percent (24-36 months), 8 percent (36-42 months), 25 percent (42-48 months) and 100 percent (48-54 months). However, results consistently showed that the ornamental iron fence was the hardest design to climb unassisted and that when children were successful then usually it took the longest to climb.

Results from these three studies show that fence design and children's age, and sometimes children's gender, all influence climbing success. Although more boys are involved in submersion incidents in swimming pools, the results of this study did not show that boys were better climbers than girls for the ages tested. In general, the study found little evidence of significant gender differences in ability to climb the fences.

Figure 20
Age and Fence Height Effects on Climbing Success

(plotted from Rabinovich et al., 1994)

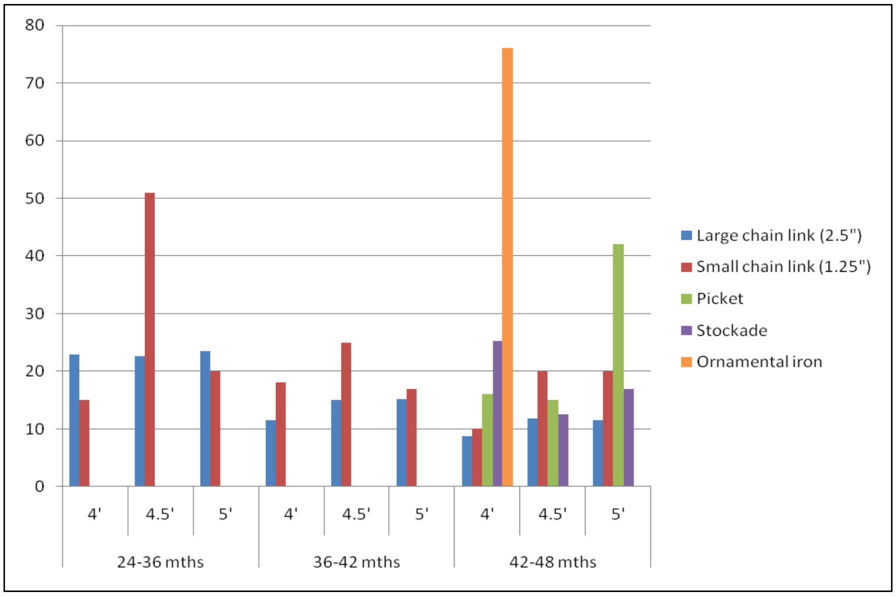


The results clearly showed that chain-link fences can most easily be climbed, especially when this is a large-aperture chain-link (2.5 in, 6.35 cm). Even in the youngest group (24-36 months), 75 percent of children were able to climb a 48 in (122 cm) high large chain-link fence and 13 percent could climb a small chain-link fence. Even with the roller and angled plate top treatments, the 48 in (122 cm) high large chain-link fence was easy for children age 36-48 months to climb.

Apart from the chain-link designs, the young children aged 24-36 months were unable to climb any of the other fence designs in the allotted time. However, for the three older groups (36 to 42 months, 42 to 48 months, and 48 to 54 months), at least some of the children could climb all of the fences at a 48 in (122 cm) height, with the possible exception of the ornamental iron fence where this was only climbed with the use of the platform structure to assist with climbing.

Figure 21
Age and Fence Height Effects on Climbing Speed

(plotted from Rabinovich et al., 1994)



Results for the stockade fence design were mixed. In study 1, children younger than 42 months were unable to climb the stockade fence, but 17 percent of those aged 42-48 months and 33 percent of those aged 48-54 months were able to climb this design. In study 2, 14.1 percent of children 36-42 months and 12 percent of children 42-48 months were able to climb the stockade, and even when the top angle plate was added, 14.6 percent of those aged 42-48 months were able to climb the stockade. None of the children were able to climb the stockade with roller top treatment.

In all studies the ornamental iron fence was the most difficult design to overcome (with the exception of the stockade with the angled plate for the children in the oldest group). The 48 in (122 cm) high ornamental iron fence could not be climbed by children younger than 42 months and either the addition of the roller top or the top angle plate, or raising the fence height to 54 in (137.2 cm) or 60 in (152.4 cm) made this design unclimbable by children aged 42-48 months. Even when it was climbed, the climbing time almost invariably was longest for the ornamental iron fence design. The ornamental iron fence consistently was the most difficult to climb on all measures and the authors note that this may be an especially good choice because, in addition to being difficult to climb, it also affords excellent vision through the fence, which can improve supervision.

Fence Design – Dutch Research

Research in the Netherlands (Jaartsveld, ten Wolde and van Aken, 1995) has tested the effects of three different rail fence heights: 31.5 in (80 cm); 39.4 in (100 cm); and 47.2 in (120 cm) for a 2 in (5 cm) diagonal chain-link fence with rigid posts and a top rail, and at a 39.4 in (100 cm) height, the effects of four other different fence designs:

- Line - Diagonal chain-link - 2 in (5 cm), with rigid posts and a top wire
- Flex - Diagonal chain-link - 2 in (5 cm), with flexible posts and a top wire
- Bar - 1 in (2.6 cm) diameter bars spaced at 5.9 in (15 cm)
- Panel - welded steel wires with a mesh size of 2 in (5 cm) x 7.9 in (20 cm)

A total of 66 children (31 boys and 35 girls) aged between 2.5 and 6 years of age participated in the study. Children were asked to climb over the fence starting with the lowest fence height. An experimenter was positioned either side of the fence to prevent the child from falling. The youngest children, aged 2.5 to 3 years, were asked to retrieve a ball that was positioned behind the fence.

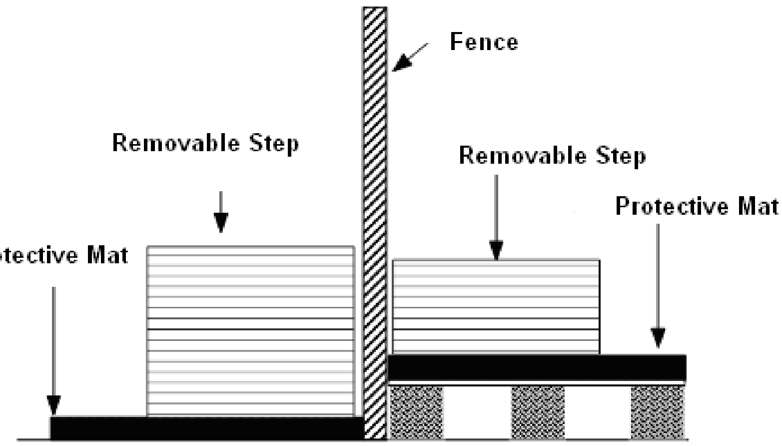
Results from the study showed a statistically significant effect of age: the older the child the greater the chance of climbing success and the faster the climb over the fence ($r = 0.5$, $p<0.001$). There was also a statistically significant effect of height for the panel fence and for the different heights of the rail fence, and taller children surmounted these obstacles more quickly than shorter children ($r = 0.53$, $p<0.01$).

Technique was important for climbing the bar fence, where children who succeeded jumped up to support themselves with their hands. Shoe style was important, and children wearing wider shoes had significantly greater difficulty climbing the chain-link fences ($F=3.05$, $p=0.02$). There was no effect of clothing.

The experimental apparatus is shown in Figure 22.

Figure 22
Experimental Apparatus

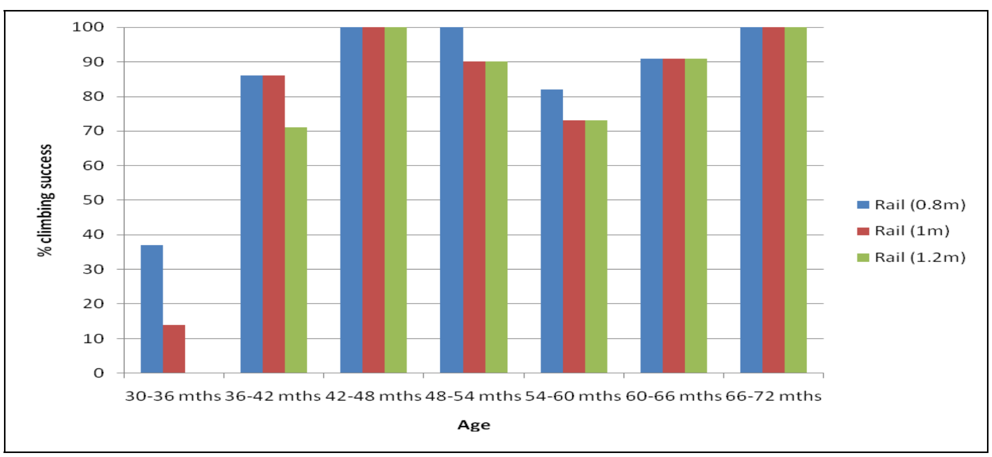
(redrawn from Jaartsveld et al., 1995)



Results for the effects of age on the percent climbing success for the three different rail fence heights are shown in Figure 23, and those for the five different fence designs at a 39.4 in (100 cm) height are shown in Figure 24. The height of the rail chain-link fence had a significant effect on climbing success for those under 36 months of age; otherwise it was not very effective in the range tested as an obstacle to climbing. The chain-link fence was easy to climb because the apertures in the mesh worked well as footholds and handholds. The flex fence was harder to climb, especially for the children younger than 42 months. The bar fence was effective in preventing children under 48 months from successfully climbing the fence. With this design it is important that the horizontal spacing of the bars is less than 4 in (10 cm) to prevent younger children from squeezing between the bars.

Figure 23
Age and Height Effects on Climbing Success for the Rail Fence

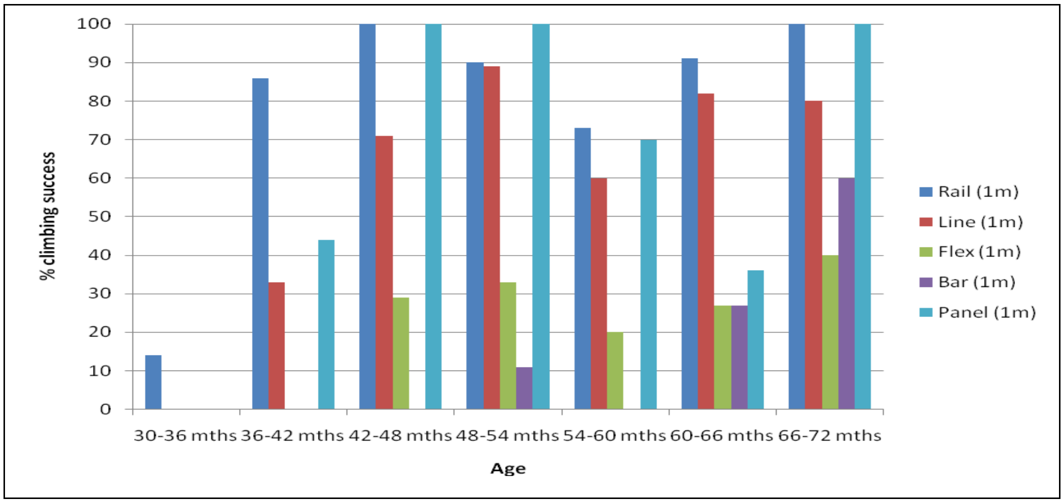
(plotted from Jaartsveld et al., 1995)



The panel fence was effective in stopping younger children from climbing but older children were able to surmount this design. The authors conclude that a vertical bar fence design is the most effective design overall, that this should be at least 39.4 in (100 cm) high, and that any supports, corner posts or horizontal elements or wires should be situated on the far side of the fence so that children cannot use these as a stepping aid to climb over the fence.

Figure 24
Age and Fence Design Effects on Climbing Success at a 39.4 in (100 cm) Height

(plotted from Jaartsveld et al., 1995)

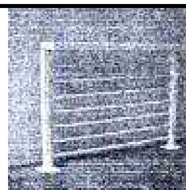
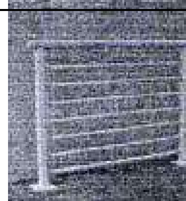
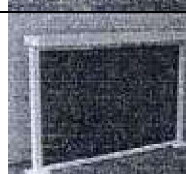
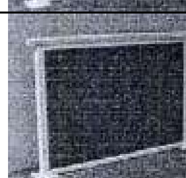
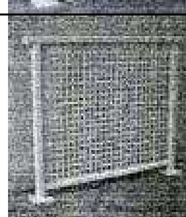
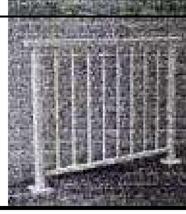


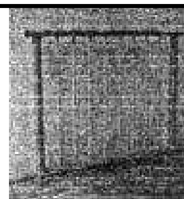
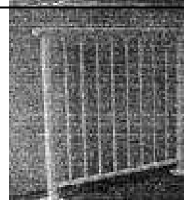
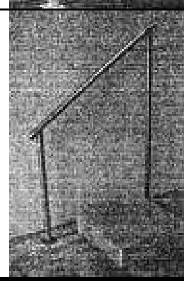
Fence Design – NZ Research

The New Zealand Building Code calls for barriers that guard a change in elevation to be designed to restrict the passage of children less than 6 years of age. The typical barrier on a New Zealand house deck or balcony is 39.4 in (100 cm), and designs do not have toeholds between 5.9 in (15 cm) and 30 in (76 cm) height. To test the effectiveness of different barrier designs, a test was conducted on a small sample of 19 children (11 boys, 8 girls) aged from 15 months to 5 years who were asked to try to climb a series of 10 barriers of different design and construction (Alchemy Engineering & design, 2002). Two boys were aged from 15-21 months, five children were 2 years old (4 boys, 1 girl), four were 3 years old (3 boys, 1 girl), seven were 4 years old (1 boy, 6 girls), and one girl was 5 years old. The gender breakdown was not given for the different age ranges. All barriers were made of metal (nine aluminum, one stainless steel). All test barriers were 47.24 in (120 cm) wide but their height and configurations were varied.

Table 9
Barrier Designs and Test Results

(Alchemy Engineering & Design, 2002)

Test Barriers	Image	% Climbing Success (success/total attempts+no attempts) (# successes/# failures/ # no attempts) 2 yrs	3 yrs	4 yrs	5 yrs
1A – 1m high. Horizontal infill members with spacing <= 10cm. Plated barrier top with inward return (20.5 cm from top, 15cm underneath)		40% (2/2/1)	75% (3/0/1)	100% (7/0/0)	100% (1/0/0)
1B – same as 1A but reversed.		60% (3/1/1)	75% (3/0/1)	100% (7/0/0)	100% (1/0/0)
1C – same as 1A but top rail replaced by centrally located rail 7cm wide.		80% (4/0/1)	75% (3/0/1)	100% (7/0/0)	100% (1/0/0)
2A – 81cm high with solid plywood infill. Centered top rail centrally (20cm wide x 5.5cm thick).		0% (0/2/3)	0% (0/1/3)	100% (7/0/0)	100% (1/0/0)
2B – same as 2A but top rail replaced with centered rail 7cm wide.		0% (0/2/3)	50% (2/0/2)	100% (7/0/0)	100% (1/0/0)
3A – 1m high. Perforated aluminum panel (3cm square, 4cm diagonal)		0% (0/2/3)	25% (1/1/2)	43% (3/2/2)	0% (0/1/0)
4A – 90cm high vertical tube balustrade with 10cm spacing. Horizontal rail 10cm from ground.		0% (0/1/4)	0% (0/2/2)	86% (6/1/0)	100% (1/0/0)

Test Barriers	Image	% Climbing Success (success/total attempts+no attempts) (# successes/# failures/ # no attempts)			
		2 yrs	3 yrs	4 yrs	5 yrs
4B – same as 4A but 1m high.		0% (0/1/4)	0% (0/2/2)	71% (5/2/0)	0% (0/1/0)
4C – same as 4A but 1.1m high.		0% (0/1/4)	0% (0/2/2)	57% (4/3/0)	0% (0/1/0)
5 – Stair balustrade, 1m high, 34° slope. Vertical posts 1.2m apart. Wire infill spaced at 9.5cm, parallel to 5cm top handrail.		0% (0/1/4)	0% (0/2/2)	86% (6/0/1)	100% (1/0/0)

Results of this study showed that children under the age of 2 years or less were not physically mature or strong enough to climb any of the barriers that were tested. Between 40 percent and 80 percent of the children aged 2 years were able to climb the barriers that had the horizontal rails, but were unable to climb any other barrier design. Seventy-five percent of the 3-year-old children were able to climb the barriers with horizontal rails, 50 percent were able to climb the solid barrier with a narrow top rail, and 25 percent were able to climb the perforated aluminum panel, but the children were unable to climb any of the other designs. All of the 4-year-old children were able to climb the barriers with the horizontal rails and those with the solid barrier, and 43 percent were able to climb the perforated aluminum barrier. Eighty-six percent of the 4-year olds were able to climb the barrier with vertical elements when this was 35.4 in (90 cm), 71 percent when it was 39.4 in (100 cm) high, and 53 percent when it was 43.3 in (110 cm) high. The 5-year-old child was able to climb all of the barriers except for the perforated aluminum and the 39.4 in (100 cm) and 43.3 in (110 cm) barriers with vertical elements. The researchers noted that when the barriers had wide tops those children who succeeded in climbing tended to stand on these and then jump off. The 39.4 in (100 cm) and 43.3 in (110 cm) barriers with the vertical elements were judged to be the most effective barrier designs. Although this particular study suffers from a small number of test children, the findings generally agree with the results obtained by Rabinovich et al. (1994) and Jaartsveld et al., 1995).

Swimming Pool Fencing

In the United States, accidental drowning is the third leading cause of death among children aged 1 to 4 years, and in California, Arizona, and Florida it is the leading cause of death (Morgenstern, Bingham, and Reza, 2000). A two-stage study was undertaken in Los Angeles County, California, to evaluate the impact of local pool-fencing ordnance (ibid.) In stage one, estimates for the number of children younger than 10 years who died from drowning in a swimming pool in the period 1990 through 1995 were compiled. In stage two, for each case swimming pools and control swimming pools without a drowning incident were randomly selected from all pools built before 1996 and whether or not the pool was fenced was noted. The results of stage one identified 146 childhood drowning incidents which represent an annual incidence of pool drowning of 1.77/100,000. The drowning rate was almost 10 times higher in toddlers (1-4 years) and almost three times higher in boys than girls. Surprisingly, results from stage two showed that the overall drowning rate was not lower in pools that had fencing, indeed, 81 percent of all drowning occurred in pools that had fencing. Overall, the results suggest that the pool fencing ordinance enacted in Los Angeles County has not been effective in reducing the incidence of childhood drowning in residential swimming pools.

There are several reasons why pool fencing may be ineffective—in order to drown, children have to already be in the pool. If children are left unsupervised, the presence or absence of fencing will not adjust the risk of drowning, or children may be able to climb the pool fencing. Ridenour (2001) investigated children's climbing skills when faced with the side of an above-ground swimming pool wall. The study tested 15 children (42-54 months) who were asked to attempt to climb a 48 in (122 cm) swimming pool wall. The average height of the sampled children was 42 in (106.7 cm) and the range was from a minimum of 39 in (99.1 cm) to a maximum of 43 in (109.2 cm). The children were asked to attempt to climb over the pool wall in three conditions: without any aid, with adjacent pool filter 12 in (30.5 cm) from the wall, and with the safety ladder frame in place. The order of these conditions was randomized during testing. Results showed that six of the 15 children failed to climb the pool wall in any condition; five of 15 children were able to climb the pool wall without any aid; and four children were able to climb the wall with the use of an aid (three used the pool filter and one used the safety ladder frame). The height and age of child did not affect their climbing success; however, their climbing technique was important. Techniques for climbing the swimming pool wall in each of the three conditions are illustrated in Figure 25, Figure 26, and Figure 27. The 48 in (122 cm) wall of the home swimming pool did not consistently function as an effective barrier to climbing, and consequently the author recommends the use of additional pool fencing and constant supervision to prevent children from accidentally entering above-ground home swimming pools.

Figure 25
Typical Movement Pattern of a Child Climbing Over the Pool Wall

(Ridenour, 2001)

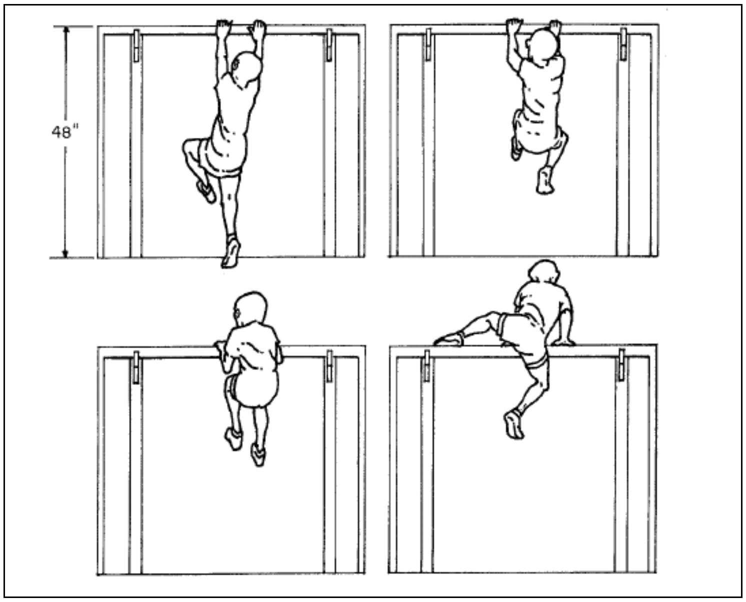


Figure 26
Typical Movement Pattern of a Child Climbing Over the Pool Wall with the Aid of the Pool Filter

(Ridenour, 2001)

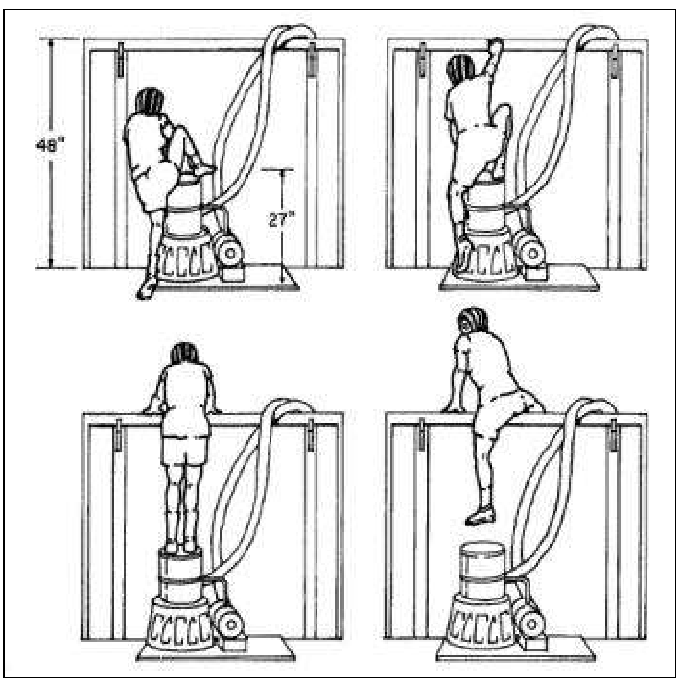
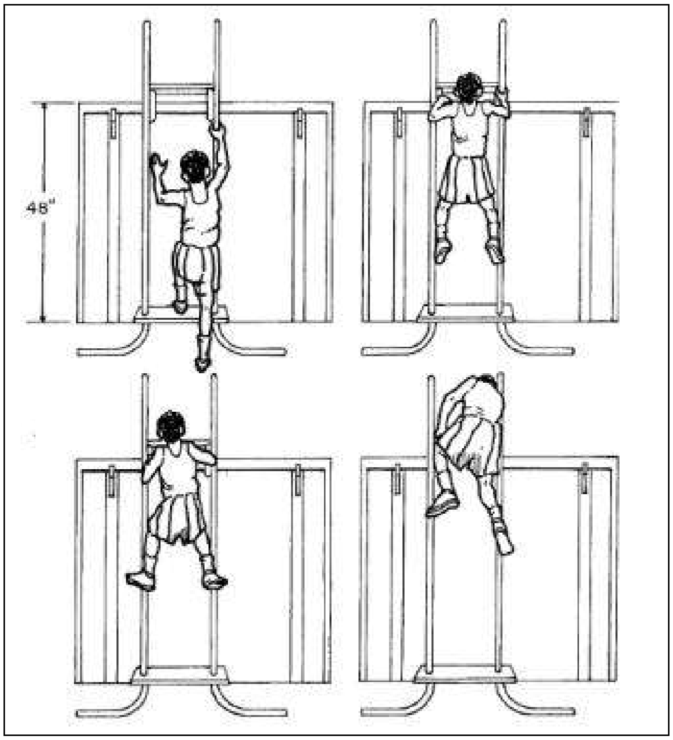


Figure 27
Typical Movement Pattern of a Child Climbing Over the Pool Wall with the Aid of the Safety Ladder Frame

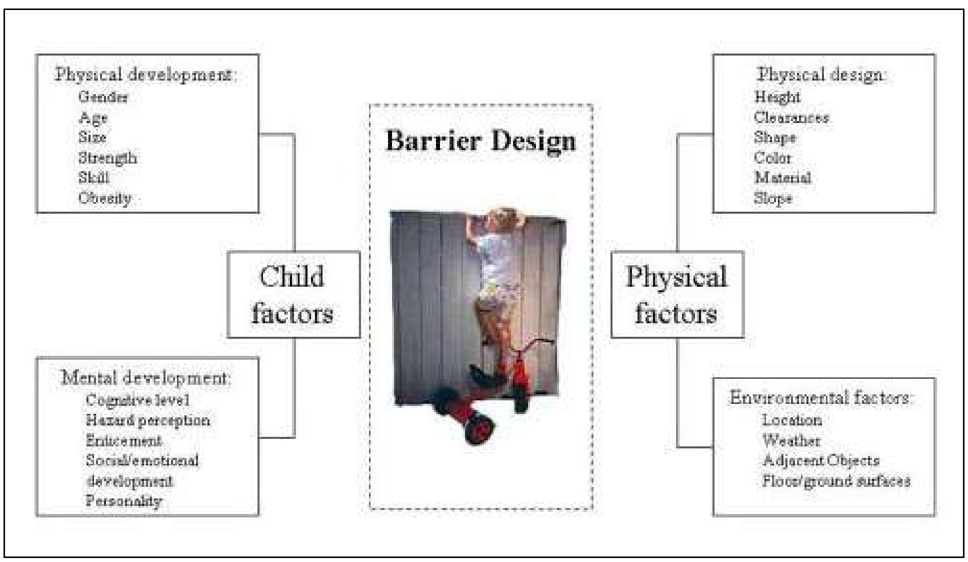
(Ridenour, 2001)



Conclusions

Evidence has been reviewed showing that climbing is an inevitable and integral part of childhood development. Climbing is involved in the child's physical, psychological, and social development. Climbing skills are often taught and encouraged by parents, especially with boys, and climbing is a part of physical education at school. The literature identifies many factors that affect a child's propensity to climb and their climbing prowess. Among young children less than 5 years old there is no evidence of a significant difference between boys and girls in either their climbing skill or their climbing speed. However, early socialization process encourage greater caution in young girls while greater risk taking is tolerated and sometimes celebrated in young boys. By the age of 5 years most children will attempt to climb almost any barrier and many will succeed. The success with which climbing occurs will depend on a variety of factors that relate to the child and also a variety of factors that relate to the design of the area that is being climbed, and these have been discussed in the report (see Figure 28).

Figure 28
Some Factors that Influence a Child's Climbing Ability



Much of the research that has been conducted has focused on window falls in young children, and most of the studies have been conducted using incidents that occurred without window guards. Estimates of the incidence of falls vary widely between studies and this is probably because the national estimates that are computed are based on a limited number of local samples of injuries. Virtually all of these studies have focused on the nature of the injuries and on the general category of the fall (e.g., window, stair) and they have neglected specific design details of where and how the incident occurred. The New York City legislation on window guards has produced a dramatic decrease in childhood falls through open windows.

A few studies have also looked at falls from balconies. In these studies the balconies mostly have been in low-income older housing stock that was built long before the current building code for balconies was enacted. None of the studies contain any details of the design and construction of the balconies or the circumstances whereby a fall occurred (e.g., did the child fall through the rails, did they climb over the balcony, did they use another object to aid climbing). Moreover, the published studies of balcony falls have examined data collected prior to the current 4 in (10 cm) rail spacing requirement and to date not a single research study has evaluated the impact that the current building code has had on reducing the incidence of falls, for example, the potentially protective effect of setting the spacing of vertical elements to exclude a 4 in (10 cm) sphere.

Studies also generally agree that it is probably impossible and most likely undesirable to render any environment completely "safe" from children's climbing. There can be situations in which children do need to climb over a barrier to escape. It is questionable whether the design of a barrier alone can determine children's behavior. As studies of swimming pool fencing show, even when extreme measures have been taken to prevent climbing children will still use other objects or devise unusual ways of climbing a barrier. It may be impractical to create a barrier that children cannot climb; however, it is possible to encourage designs that discourage climbing in locations that are potentially hazardous. The climbability of any structure is affected by the barrier height, the size, and distance between any horizontal and vertical supports, the smoothness and shape of the supports, and that materials used to construct the barrier. Higher barriers with fewer smoother, rounded horizontal supports, preferably metal, and placed at greater vertical distances will be more difficult to climb because of the difficulty of using the supports as a foot or handhold. This is why the choice of materiality is essential when considering objects that come in touch with children.

Climbing simulation studies have been conducted in several countries to determine the design details that either facilitate or impair a young child's ability to climb. In these studies, various fence designs have been tested but the nomenclature used has been inconsistent and it is not always clear precisely what the physical design attributes were. Some of these studies have used exceedingly small numbers of children, making statistical analysis impossible, and while those studies conducted in the United States generally have tested respectable numbers of children, all have focused on testing swimming pool fencing rather than balcony guard rails. Unfortunately, none of the studies has adopted a truly naturalistic approach where children are observed without them being aware of this. In the studies that have been conducted, especially those of fencing designs, none has investigated whether the presence of horizontal bars serves to encourage a child to climb has or not. In all of the research studies, the children have been encouraged by adults to try to climb whatever was being tested and, in some instances, up to three adults have been present to provide such encouragement and to help to catch the child should s/he actually fall. When children have climbed a structure, generally the researchers have gone to considerable lengths to provide substantial padding to cushion any fall. Thus, all studies have essentially removed any "fear factor" from their research, and consequently the results may not translate directly to reality where encouraging adults and cushioned surfaces generally are absent. From the studies reviewed in this report, it is possible to generally identify the design factors that either facilitate or inhibit climbing (Table 10). Some studies have looked at children climbing ladders and the results show that vertical ladders are more discouraging than angled ladders. Other studies of fence designs agree that for a barrier to be unclimbable by a young child under 4 years of age this has to be at least 55.1 in (140 cm) high and made of vertical rounded metal rails, but such a design is impractical in many situations.

Table 10
Some Design Details that Affect the Ease of Climbing a Barrier

Facilitating Design Elements	Inhibiting Design Elements
Low barrier height (less than 39.4 in (100 cm)	Higher barrier height (39.4 in [100 cm] plus)
Easily graspable top rail	Top rail that is difficult to grasp, and not broad enough for a child to stand on
Horizontal rails spaced to serve as rungs	Horizontal rails with very close or very wide spacing
	Vertical rails
Openings to flat surfaces that serve as stable footholds	Openings that are too small for footholds
	Steeply angled surfaces

Most of the simulation studies reviewed note the inherent limitation of only addressing the physical design of a barrier as one component in the etiology of children's falls, and many also suggest that a comprehensive safety education program for young children, especially during the warmer months, is desirable and likely to have the greatest impact on minimizing the incidence of falls. Given the wide variation in the scope, methodology, and quality of the research studies on climbing that have been conducted and that are included in this report and the lack of scientific testing of specific design alternatives, it is premature to use the research studies that have been reviewed as the basis for any code requirements for the design and construction of balcony guard rails.

References

Alchemy Engineering and Design (2002) *Child resistant barrier tests*, Building Industry Authority, New Zealand, April.

Ault, R. (1977). *Children's Cognitive Development*. New York: Oxford University Press.

Benoit, R. Watts, D. D., Dwyer, K., Kaufmann, C., Fakhry & M. Samir. (2000) Windows 99: A Source of Suburban Pediatric Trauma, *Journal of Trauma-Injury Infection & Critical Care*. *49*(3):477-482

Berger, S.E., Theuring, C. & K.E. Adolph. (2007) How and when infants learn to climb stairs. *Infant Behavior & Development*, *30* (1), 36-49.

Bertocci, G.E., Pierce, M.C., Deemer, E., Ague, F., Janosky, J.E. & E. Vogeley. (2004) Influence of fall height and impact surface on biomechanics of feet-first free falls in children. *Injury*, *35* (4), 417-424.

Bull, M.J., Agran, P., Gardner, H.G., Laraque, D., Pollack, S.H., Smith, G.A., Spivak, H.R. & M. Tenebein. (2001) Falls From Heights: Windows, Roofs, and Balconies. *Pediatrics*, *107* (5), 1188-1191.

Cesari, P., Formenti, F. & P. Olivato. (2003) A common perceptual parameter for stair climbing for children, young and old adults. *Human Movement Science*, *22* (1), 111-124.

Consumer Product Safety Commission, NEISS – The National Electronic Injury Surveillance System – A Tool for Researchers, 2002-2005.

Culvenor, J.F. (2002) Design of Childproof Barriers to Prevent Falls from a Height in Public Places. *The Proceeding of the XVI Annual International Occupational Ergonomics and Safety Conference*, 1-7.

Deemer, E., Aguel, F., Bertocci, G., Pierce, M.C., Janosky, J. & E. Vogeley. (2003) Influence of wet surfaces and fall height on pediatric injury risk in feet first free falls as predicted using an ATD. *Proceedings of the Summer Bioengineering Conference*, June 25-29, Sonesta Beach resort, Biscayne, FL. 2 pages.

EN 1176-1 (1998) *Playground equipment – Part 1: General Safety requirements and test methods*.

Flavell J. H. (1977). *Cognitive Development*. New Jersey: Prentice-Hall Inc.
Frost, J., Sutterby, J., Therrell, J., Brown, P. & C. Thornton (2002) Does height matter? - Playgrounds - Cover Story - preventing accidents. *Parks & Recreation*, April, 9 pages.

Gabbard, C.P. & P.E. Patterson. (1980) Grip preferences of children on ladder apparatus. *Perceptual and Motor Skills*, *50*, 1168-1170.

Gibson, E. & Walk, R.D. (1960) The Visual Cliff. *Scientific American*, *202*, 80-92.

Istre. G.R., McCoy, M.A., Stowe, M., Davies, K., Zane, D., Anderson, R.J. & R. Wiebe. (2003) Childhood injuries due to falls from apartment balconies and windows. *Injury Prevention*, *9*, 349-352.

Ivatury, R.R. (2005) Jumpers, fallers, and stumblers: Children should not drop and elders should not trip. *Critical Care Medicine*, *33* (6), 1426-1428.

Jaartsveld, R.F.M., ten Wolde, S.A. and D.A. van Aken. (1995) The protective effect of fences: providing protection to the 0-4 year-old. *International Journal for Consumer Safety*, *2* (1), 21-30.

International Code Council, (2006) *International Residential Code.* International Code Council, Washington, D.C.

Khambalia, A., Joshi, P., Brussoni, M., Raina, P., Morrongiello, B. & C. Macarthur. (2006) Risk factors for unintentional injuries due to falls in children aged 0–6 years: a systematic review. *Injury Prevention*, *12*, 378-381.

McShane, J. (1991). *Cognitive Development: An Information Processing Approach*. Oxford, UK: Basil Blackwell Ltd.

Marshall, S.W., Runyan, C.W., Yang, J.Z., Coyne-Beasley, T., Waller, A.E., Johnson, R.M. & D. Perkis. (2005) Prevalence of selected risk and protective factors for falls in the home. *American Journal of Preventive Medicine*, *28* (1), 95-101.

Mayer L., Meuli M., Lips U. & B. Frey. (2006) The silent epidemic of falls from buildings: Analysis of risk factors. *Pediatric Surgery International*, *22* (9), 743-748.

McDowell, M.A., Fryar, C.D., Hirsch, R. & C. L. Ogden. (2005) Anthropometric Reference Data for Children and Adults: U.S. Population, 1999–2002, *Advance DATA FROM Vital and Health, Statistics*, *361*, July 7, U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES Centers for Disease Control and Prevention National Center for Health Statistics.

Meyer, P.G., Thelot, B., Baugnon, T. & C. Ricard. (2007) The epidemiology of pediatric falls from heights. *Pediatric Surgery International*, *23* (1), 95-96.

Morgenstern, H., Bingham, T. & A. Reza. (2000) Effects of pool-fencing ordinances and other factors on childhood drowning in Los Angeles County, 1990-1995. *American journal of Public Health*, *90* (4), 595-601.

Morrongiello, B.A. and J. Lasenby-Lessard. (2007) Psychological determinants of risk taking by children: an integrative model and implications for interventions. *Injury Prevention*, *13*, 20-25.

Nixon, J., Pearn, J. & G. Petrie. (1979) Childproof safety barriers. *Australian Pediatric Journal*, *15*, 260-262.

Nixon, W., Acton, C.H.C., Wallis, B., Ballesteros, M.F. & D. Battistutta. (2003) Injury and frequency of use of playground equipment in public schools and parks in Brisbane, Australia. *Injury Prevention*, *9*, 210-213.

New York City Department of Health and Mental Hygiene (2007) Window Falls Prevention Program. http://home2.nyc.gov/html/doh/html/win/win.shtml (accessed on 9/17/07).

Owings, C.L., Chaffin, D.B., Snyder, R.G. & R.H. Norcutt. (1975) *Strength Characteristics of U.S. Children for Product Safety Design*. Univ. Michigan, October, Final Report, CPSC Contract FDA-73-32. 356 pages.

Page, M., Powell, L., Wilson, M. & E. Ward (1995) The Development of Safety Criteria for Specifying the Performance of Children's Safety Barriers. *Proceedings of the 3rd International Conference on Product Safety Research, Amsterdam*, 6-7 March 1995, Edited by W. van Weperen. CIP-Gegevens Koninklijke Bibliotheek, The Hague, 1–19.

Pressley, J.C. & B. Barlow. (2005) Child and adolescent injury as a result of falls from buildings and structures. *Injury Prevention*, *11*, 267-273

Rabinovich, B.A., Lerner N.D., and R. W. Huey. (1994) Young Children's Ability to Climb Fences. *Human Factors*, *36* (4), 733-744.

Readdick C.A. & J.J. Park. (1998) Achieving great heights: The climbing child. *Young Children*, *53* (6), 14-19.

Ridenour, M.V. (2001) Climbing performance of children: Is the above-ground pool wall a climbing barrier? *Perceptual and Motor Skills*, *92* (3 Pt. 2), 1255-1262.
Ridenour, M.V. (2002) How do children climb out of cribs? *Perceptual and Motor Skills*, *95* (2), 363-366.

Riley, J.E., Roys M.S. & S.M. Cayless. (1998) Initial assessment of children's ability to climb stair guarding. *The Journal of the Royal Society for the Promotion of Health*. *118*(6) 331-337.

Sanders, M.M. & E.J. McCormick. (1993) *Human Factors in Engineering & Design 7th ed.*, McGraw-Hill, NY.

Sklet, S. (2006) Safety barriers: Definition, classification, and performance. *Journal of Loss Prevention in the Process Industries*, *19*, 494-506.

Small, M.Y. (1990) *Cognitive Development*. San Diego: Harcourt Brace Jovanovich Inc. Publishers.

Snyder, R.G., Spencer, M.L. & C.J. Owings. (1975) *Physical Characteristics of Children as Related to Death and Injury for Consumer Product Design and Use.* Highway Safety Research Institute, University of Michigan, May 31. UM-HSRI-BI- 75-5 Final Report. 240 pages.

Snyder, R.G., Schenider, L.W., Owings, C.L., Reynolds, H.M., Golomb, D.H. & M.A. Schork. (1977) *Anthropometry of Infants, Children and youths to Age 18 for Product Safety Design*. Highway Safety Research Institute, University of Michigan, May 31. UM-HSRI- 77-17 Final Report. 648 pages.

Testa, M. Martin, L. & B. Debû. (2003) 3D analysis of posture-kinetic coordination associated with a climbing task in children and teenagers. *Neuroscience Letters*, *336*, 45-49.

van Herrewegen, J., Molenbroek, J. & H. Goossens. (2004) *Children's Climbing Skills*, ANEC Report, November. 42 pages.

van Herrewegen, J. & J. Molenbroek. (2005) *Practical Test "Children and Ladders"*, ANEC Report. November. 59 pages.

Vish, N.L., Powell, E.C., Wiltsek, D. & K.M. Sheehan. (2005) Pediatric window falls: not just a problem for children in high rises*. Injury Prevention*, *11*, 300-303.

Wang, M.Y., Kim, K.A., Griffith, P.M., Summers, S., McComb, J.G., Levy, M.L. & G.H. Mahour. (2001) Injuries from falls in the pediatric population: An analysis of 729 cases *Journal of Pediatric Surgery*, *36* (10), 1528-1534.

Wood, D. J. (1998). *How Children Think and Learn: The Social Contexts of Cognitive Development*. Blackwell Publishing

Additional Sources of Anthropometric Data for Children

Norris, B.J. & J. R. Wilson. (1995) *Childata: the handbook of child measurements and capabilities: data for design safety*. London: Department of Trade and Industry

Pheasant, S. & C.M. Haslegreave. (2006) *Bodyspace: Anthropometry, ergonomics and the design of work*, 3rd ed. London, Taylor & Francis.

Roebuck Jr., J.A. (1995) *Anthropometric methods: Designing to fit the human body*, Chapanis, A. (Series ed.) Monographs in human factors and Ergonomics, Santa Monica, Ca. Human Factor and Ergonomics Society.

Tilley, A.R. & Henry Dreyfuss Associates (2002) *The measure of Man and Woman: Human Factors in Design*, John Wiley & Sons Inc., New York.

Additional Publications

Leto, T. (2000) The Ladder Effect. Ornamental & Miscellaneous Metal Fabricator, July/August, p.60.

Stephenson, E.O. (1999) Climbable guards: an unnecessary hazard to children. *Southern Building*, May/June, 4, 6.

Stephenson, E.O. (2002) Climbable guards: the special enemy of the world's 2- and 3-year-old children. *The Code Official*, BOCA International Inc., 36-41.

Appendix A

Excerpts of Provisions on Guards
from National Model Building Codes

I. Introduction

This is a summary of building code requirements for Guards and Guardrails for the United States, Canada, and Australia. Excerpted provisions are relevant sections of the referenced codes that relate to specifications for guards. A statement of scope, definition of terms and applicability are provided for context. Provisions that reference "facilitate climbing," "climbability," or "ladder effect" are highlighted in bold, italic font and underlined.

Codes reviewed are as follows:

- International Residential Code (IRC 2000, 2003, and 2006) published by the International Code Council (ICC)

- International Building Code (IBC 2000, 2003, and 2006) published by the International Code Council (ICC)

- International One- and Two-Family Dwelling Code (1998) published by the International Code Council (ICC)

- One and Two Family Dwelling Code (CABO 1992 and 1995) published by the Council of American Building Officials (CABO)

- Uniform Building Code (UBC 1991 - 1997) published by International Conference of Building Officials (ICBO)

- Standard Building Code (SBC 1991 - 1997) published by Southern Building Code Congress International (SBCCI)

- National Building Code (BOCA 1990, 1993, and 1999) published by the Building Officials and Code Administrators International (BOCA)

- Canadian Housing Code (CHC 1990, Rev. Jan 1994) published by National Research Council of Canada (NRC-CNRC)

- National Building Code of Canada (NBC 1990 and 2005) published by National Research Council of Canada (NRC-CNRC)
- Building Code of Australia (BCA 2005) published by Australian Building Codes Board
- Building Code of New Zealand (BNZ 2007) published by Department of Building and Housing, New Zealand

II. BUILDING CODES WITH CLIMBABILITY, CLIMBING, OR LADDER EFFECT

A. INTERNATIONAL RESIDENTIAL CODE

INTERNATIONAL RESIDENTIAL CODE 2000 Edition

SECTION R101 TITLE, SCOPE AND PURPOSE

R101.2 Scope. The provisions of the *International Residential Code for One- and Two-Family Dwellings* shall apply to construction, alteration, movement, enlargement, replacement, repair, equipment, use and occupancy, location, removal and demolition of detached one- and two-family dwellings and multiple single-family dwellings (townhouses) not more than three stories in height with a separate means of egress and their accessory structures.

SEC. R202 DEFINITIONS

Guard. A building component or a system of building components located near the open sides of elevated walking surfaces that minimizes the possibility of a fall from the walking surface to the lower level.

Deck. An exterior floor supported on at least two opposing sides by an adjacent structure, and /or post, piers or other independent supports.

Balcony, Exterior. An exterior floor projecting from and supported by a structure without additional independent supports.

Porch. *No Definition Given in 2000 or 2006 IRC*

SEC. R316 GUARDS

R316.1 Guards required. Porches, balconies, or raised floor surfaces located more than 30 inches (762 mm) above the floor or grade below shall have guards not less than 36 inches (914 mm) in height. Open sides of stairs with a total rise of more than 30 inches (762 mm) above the floor or grade below shall have guards not less than 34 inches (864 mm) in height measured vertically from the nosing of the treads.

R316.2 Guard opening limitations. Required guards on open sides of stairways, raised floor areas, balconies and porches shall have intermediate rails or ornamental closures that do not allow passage of a sphere 4 inches (102 mm) in diameter. ***Required guards shall not be constructed with horizontal rails or other ornamental pattern that results in a ladder effect***.

INTERNATIONAL RESIDENTIAL CODE 2003 Edition

R312.1 Guards required. Porches, balconies, or raised floor surfaces located more than 30 inches (762 mm) above the floor or grade below shall have guards not less than 36 inches (914 mm) in height. Open sides of stairs with a total rise of more than 30 inches (762 mm) above the floor or grade below shall have guards not less than 34 inches (864 mm) in height measured vertically from the nosing of the treads.

Porches and decks which are enclosed with insect screening shall be provided with guards where the walking surface is located more than 30 inches (762mm) above the walking surface.

R316.2 Guard opening limitations. Required guards on open sides of stairways, raised floor areas, balconies and porches shall have intermediate rails or ornamental closures that do not allow passage of a sphere 4 inches (102 mm) or more in diameter.

Exceptions:

1. Triangular Openings formed by the riser, tread and bottom rail of a guard at the open side of a stairway are permitted to be of such a size that sphere 6 inches (152mm) cannot pass through.

2. Openings for required guards on the sides of stair treads shall not allow a sphere 4 3/8 inches (107mm) to pass through.

INTERNATIONAL RESIDENTIAL CODE 2006 Edition

R312.1 Guards required. Porches, balconies, ramps or raised floor surfaces located more than 30 inches (762 mm) above the floor or grade below shall have guards not less than 36 inches (914 mm) in height. Open sides of stairs with a total rise of more than 30 inches (762 mm) above the floor or grade below shall have guards not less than 34 inches (864 mm) in height measured vertically from the nosing of the treads.

Porches and decks which are enclosed with insect screening shall be provided with guards where the walking surface is located more than 30 inches (762mm) above the walking surface.

R316.2 Guard opening limitations. Required guards on open sides of stairways, raised floor areas, balconies and porches shall have intermediate rails or ornamental closures that do not allow passage of a sphere 4 inches (102 mm) or more in diameter.

Exceptions:

1. Triangular Openings formed by the riser, tread and bottom rail of a guard at the open side of a stairway are permitted to be of such a size that sphere 6 inches (152mm) cannot pass through.

2. Openings for required guards on the sides of stair treads shall not allow a sphere 4 3/8 inches (107mm) to pass through.

B. BOCA NATIONAL BUILDING CODE (BOCA 1993 & 1999)

SECTION 406.0 OPEN PARKING STRUCTURES:

406.5 Guards: All open-sided floor areas shall be provided with a guard in accordance with Section 1021.0

SECTION 408.0 PUBLIC GARAGES:

408.3.2 Roof storage of motor vehicles: Where the roof of a building is occupied for the parking or storage of motor vehicles, such roof shall be provided with a parapet wall or a guard constructed in accordance with Section 1021.0

SECTION 1005.0 GENERAL LIMITATIONS

1005.5 Open-Sided Floor Areas: Guards shall be located along open-sided walking surfaces, mezzanines, and landings which are located more than 30 inches (762 mm) above the floor or grade below. The guards shall be constructed in accordance with Section 1021.0

SECTION 1016.0 RAMPS

1016.5 Guards and handrails: Guards shall be provided on both sides of the ramp and shall be constructed in accordance with Section 1021.0.

SECTION 1825.0 RETAINING WALLS

1825.5 Guards: Where retaining walls with differences in grade level on either side of the wall in excess of 4 feet (1219 mm) are located closer than 2 feet (610 mm) to a walk, path, parking lot or driveway on the high side, such retaining walls shall be provided with guards that are constructed in accordance with Section 1021.0 or other approved protective measures.

SECTION 502.0 DEFINITIONS

Mezzanine. An intermediate level or levels between the floor and ceiling of any story with an aggregate floor area of not more than one-third of the area of the room in which the level or levels are located.

Balcony, Deck, Porch. *No Definition Given in 1993 BOCA*

SECTION 1021.0 GUARDS

1021.1 General: Where required by the provisions of Sections 406.5 …... and 1825.5, guards shall be designed and constructed in accordance with the requirements of this section and Section 1615.8. A guardrail system is a system of building components located near the open sides of elevated walking surfaces for the purpose of minimizing the possibility of an accidental fall from the walking surface to the lower level.

1021.3 Opening limitations: In occupancies in Use Group A, B, E, H-4,I-1, I-2, M and R, and in public garages and open parking structures, open guards shall have balusters or be of solid material such that a sphere with a diameter of 4 inches (102 mm) cannot pass through any opening. ***<u>Guards shall not have an ornamental pattern that would provide a ladder effect.</u>***

C. INTERNATIONAL ONE-AND TWO-FAMILY DWELLING CODE (IOTFDC 1998)

SECTION 102 SCOPE

103.1 Application. The provisions of this code apply to the construction, addition, prefabrication, alteration, repair, use, occupancy and maintenance of detached one- and two- family dwellings and one-family townhouses not more than three stories in height, and their accessory structures.

SECTION 202 GENERAL BUILDING DEFINITIONS

Balcony (Exterior). An exterior floor system projecting from a structure and supported by that structure, with no additional independent supports.

Deck. An exterior floor system supported on at least two opposing sides by an adjoining structure and/or posts, piers, or other independent supports.

Guardrail System. A system of building components located near open sides of elevated walking surfaces.

Porches are not defined in the 1998 IOTFDC.

SECTION 315 HANDRAILS AND GUARDRAILS

315.3 Guardrail details. Porches, balconies or raised floor surfaces located more than 30 inches (762 mm) above the floor or grade below shall have guardrails not less than 36 inches (914 mm) in height. Open sides of stairs with a total rise of more than 30 inches (762 mm) above the floor or grade below shall have guardrails not less than 34 inches (864 mm) in height measured vertically from the nosing of the treads.

315.4 Guardrail opening limitations. Required guardrails on open sides of stairways, raised floor areas, balconies and porches shall have intermediate rails or ornamental closures which do not allow passage of an object 4 inches (102 mm) or more in diameter. ***Required guards shall not be constructed with horizontal rails or other ornamental pattern that results in a ladder effect.***

D. CANADIAN HOUSING CODE (CHC 1990, Revised 1994)

Part 1 Scope and Definitions

Section 1.1.2 Scope

1.1.2.2.

(1) This Code applies to the construction of detached, semi-detached and row houses, together with their ancillary private storage garages, provided such houses

(a) have no shared egress facilities,

(b) have no dwelling unit above or below them,

(c) have no shared service spaces, service shafts or service rooms,

(d) are self-contained with respect to heating and ventilation,

(e) have a building area not greater than 600 m^2 (6456 ft^2), and

(f) have a building height of not more than 3 storeys.

(2) Houses other than those described in Sentence (1) shall conform to the National Building Code of Canada 1990.

Section 1.1.3 Definitions of Words and Phrases

Mezzanine means an intermediate floor assembly between the floor and ceiling of any room or storey and includes an interior balcony.

Landing, Porch, and Gallery are not defined in CHC 1990.

Part 9 Housing

Section 9.8 Stairs, Ramps, Handrails and Guards

9.8.8. Guards

9.8.8.1. Required Guards

(1) Every exterior landing, porch and every balcony, mezzanine, gallery, raised walkway and roof to which access is provided for other than maintenance purposes, shall be protected by *guards* on all open sides where the difference in elevation between adjacent levels exceeds 600 mm (23.6 in).

(2) Every exterior stair with more than 6 risers shall be protected with *guards* on all open sides where the difference in elevation between the adjacent ground level and the stair exceeds 600 mm (23.6 in).

(3) When an interior stair has more than 2 risers, the sides of the stair and the landing or floor level around the stair well shall be enclosed by walls or be protected by *guards*, except that a stair to an unfinished basement in a dwelling unit may have one unprotected side.

9.8.8.5 Design to Prevent Climbing. ***Guards around exterior balconies shall be designed so that no member, attachment or opening between 100 mm (3.9 in) and 900 mm (35.4 in) above the balcony floor will facilitate climbing.***

E. NATIONAL BUILDING CODE OF CANADA (NRC-NBC 1990, Revised 1991)

Part 1 Scope and Definitions

Section 1.1.3. Definitions of Words and Phrases

Guard means a protective barrier around openings in floors or at the open sides of stairs, landings, balconies, mezzanines, galleries, raised walkways or other locations to prevent accidental falls from one level to another. Such barrier may or may not have openings through it.

Mezzanine means an intermediate floor assembly between the floor and ceiling of any room or storey and includes an interior balcony.

Landings, Balconies, and Galleries are not defined in NRC-NBC 1990

Part 3 Use and Occupancy

Section 3.3.1. Requirements Applying to All Floor Areas

Section 3.3.1.17. Guards.

(1) A *guard* not less than 1070 mm (42 in) high shall be provided

(a) around each roof to which access is provided for other than maintenance,

(b) at openings into smoke shafts described in Subsection 3.2.6. that are less than 1070 mm (42 in) above the floor, and

(c) at each raised floor, mezzanine, balcony, gallery and at any other locations where the difference in floor elevations is more than 600 mm (23.6 in).

Section 3.3.4 Residential Occupancy

3.3.4.7 Guards for Residential Occupancies. ***Guards around balconies in balconies of residential occupancy shall be designed so that no member, attachment or opening located between 100 mm (4 in) and 900 mm (35.4 in) above the balcony will facilitate climbing.***

Part 9 Housing and Small Buildings

Section 9.8 Stairs, Ramps, Handrails and Guards

9.8.8.5 Design to Prevent Climbing. ***Guards around exterior balconies shall be designed so that no member, attachment or opening between 100 mm (4 in) and 900 mm (35.4 in) above the balcony floor will facilitate climbing.***

F. NATIONAL BUILDING CODE OF CANADA (NRC-NBC 2005)

Part 3 Fire Protection, Occupant Safety and Accessibility

Section 3.3. Safety within Floor Areas

Section 3.3.1. All Floor Areas

3.3.1.18. Guards

1) Except as provided in Sentence (4) and Article 3.3.2.9., a guard not less than 1070 mm (42 in) high shall be provided

a) around any roof to which access is provided for purposes other than maintenance,

b) at openings into smoke shafts referred to in Subsection 3.2.6. that are less than 1070 mm (42 in) above the floor, and

c) at each raised floor, mezzanine, balcony, gallery, interior or exterior vehicular ramp, and at other locations where the difference in level is more than 600 mm (23.6 in).

3) ***Unless it can be shown that the location and size of openings do not present a hazard, a guard shall be designed so that no member, attachment or opening located between 140 mm (5.5 in) and 900 mm (35.4 in) above the level protected by the guard will facilitate climbing.***

Section 3.3.4 Residential Occupancy

3.3.4.7 Stairs, Handrails and Guards for Dwelling Units

1) Stairs, handrails and guards within a dwelling unit shall conform to Section 9.8

Section 3.4 Exits

Section 3.4.6. Types of Exit Facilities

3.4.6.5. Guards

1) Every exit shall have a wall or a well-secured guard on each side.

7) ***Unless it can be shown that the location and size of openings do not present a hazard, a guard shall be designed so that no member, attachment or opening located between 140 mm (5.5 in) and 900 mm (35.4 in) above the level being protected by the guard will facilitate climbing.***

Section 3.4.7. Fire Escapes

3.4.7.6 Guards and Railings

1) The open sides of every platform, balcony and stairway forming part of a fire escape shall be protected by guards not less than 920 mm (36 in) high measured vertically above the nosing of any tread or platform.

5) ***Unless it can be shown that the location and size of an opening do not present a hazard, a guard for a fire escape shall be designed so that no member, attachment or opening located between 140 mm (5.5 in) and 900 mm (35.4 in) above a platform or the nosing of any tread will facilitate climbing.***

Part 9 Housing and Small Buildings

Section 9.8 Stairs, Ramps, Handrails and Guards

Section 9.8.8 Guards

9.8.8.1 Required Guards

1) Except as provided in Sentences (2) and (3), every surface to which access is provided for other than maintenance purposes, including but not limited to flights of steps and ramps, exterior landings, porches, balconies, mezzanines, galleries and raised walkways, shall be protected by a guard on each side that is not protected by a wall for the length where

a) there is a difference in elevation of more than 600 mm (23.6 in) between the walking surface and the adjacent surface, or

b) the adjacent surface within 1.2 m (47.2 in) of the walking surface has a slope of more than 1 in 2.

9.8.8.6 Design to Prevent Climbing.

1) ***Guards required by Article 9.8.8.1., except those in industrial occupancies and where it can be shown that the location and size of openings do not present a hazard , shall be designed so that no member, attachment or opening will facilitate climbing.***

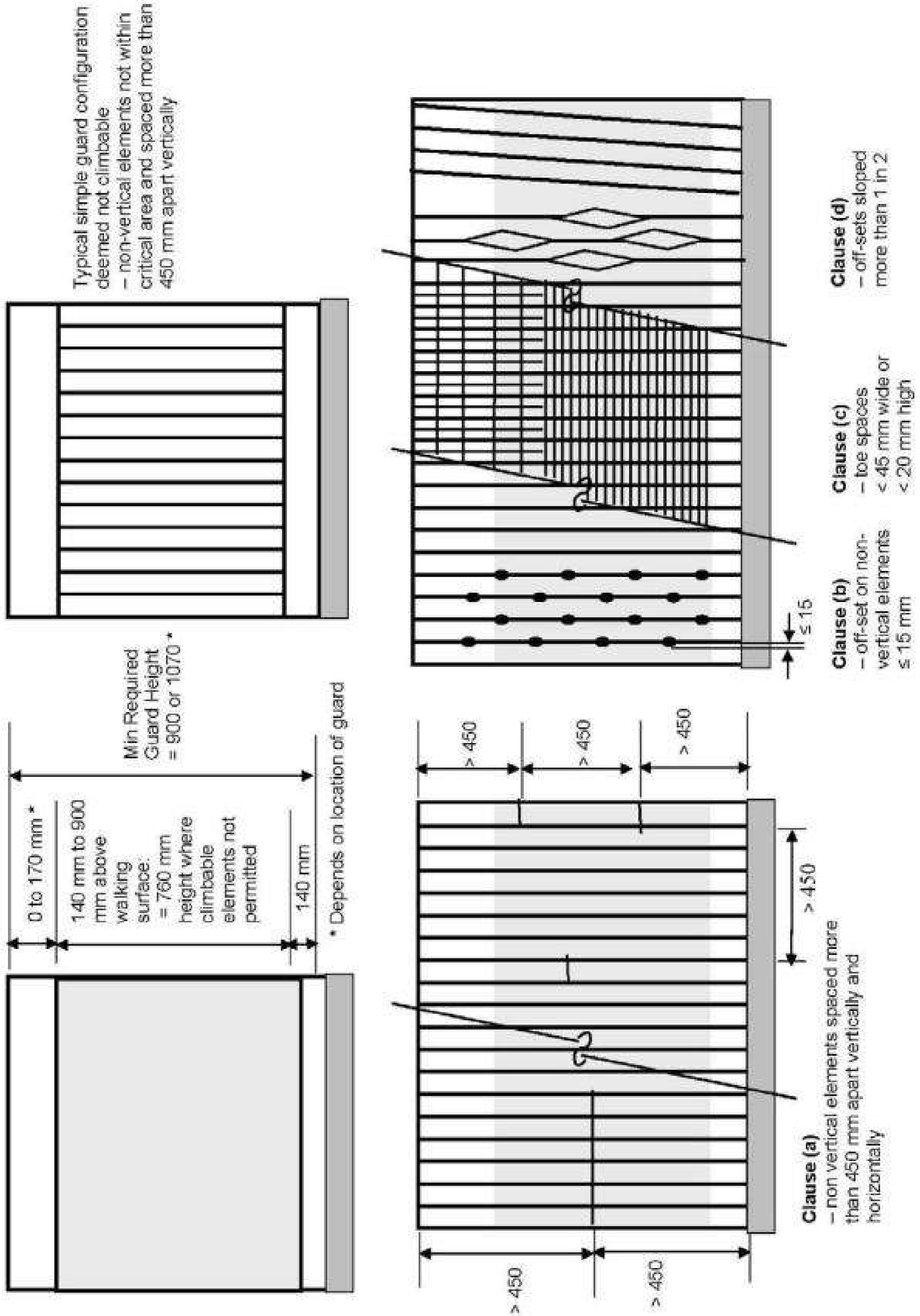
2) ***Guards shall be deemed to comply with Sentence (1) where any elements protruding from the vertical and located within the area between 140 mm (5.5 in) and 900 mm (35.4 in) above the floor or walking surface protected by the guard***

a) ***are located more than 450 mm (18 in) horizontally and vertically from each other,***

b) ***provide not more than 15 mm (0.6 in) horizontal offset,***

c) ***do not provide a toe-space more than 45 mm (1.8 in) horizontally and 20 mm (0.8 in) vertically, or***

d) ***present more than a 1-in-2 slope on the offset.***


0 to 170 mm *
140 mm to 900 mm above walking surface: = 760 mm height where climbable elements not permitted
140 mm
Min Required Guard Height = 900 or 1070 *
* Depends on location of guard
Typical simple guard configuration deemed not climbable
– non-vertical elements not within critical area and spaced more than 450 mm apart vertically
> 450
> 450
> 450
> 450
> 450
> 450
Clause (a)
– non vertical elements spaced more than 450 mm apart vertically and horizontally
≤ 15
Clause (b)
– off-set on non-vertical elements ≤ 15 mm
Clause (c)
– toe spaces < 45 mm wide or < 20 mm high
Clause (d)
– off-sets sloped more than 1 in 2

G. BUILDING CODE OF AUSTRALIA (BCA 2005)

Applicable Buildings

Class 1: One or more buildings which in association constitute -

(a) Class 1a - a single dwelling being -

(i) a detached house; or

(ii) one of a group of two or more attached dwellings, each being a building, separated by a fire-resisting wall, including a row house, terrace house, town house or villa unit; or

(b) Class 1b - a boarding house, guest house, hostel or the like -

(i) with a total area of all floors not exceeding $300m^2$ measured over the enclosing walls of the Class 1b; and

(ii) in which not more than 12 persons would ordinarily be resident, which is not located above or below another dwelling or another Class of building other than a private garage.

Section 3.9.2.3 Balustrades or Other Barrier Construction

(a) Required when a walking surface is 1 m (39.4 in) or greater above an adjacent surface.

(b) For floors more than 4 m(13 ft) above the surface beneath, any horizontal elements within the balustrade or other barrier between 150 mm (6 in) and 760 mm (30 in) above the floor must not facilitate climbing.

H. New Zealand Building Code 2007

Clause F4 Safety from Falling

OBJECTIVE

F4.1 The objective of this provision is to safeguard people from injury caused by falling.

FUNCTIONAL REQUIREMENT

F4.2 Buildings shall be constructed to reduce the likelihood of accidental fall.

PERFORMANCE

F4.3.1 Where people could fall 39.37-inches or more from an opening in the external envelope or floor of a building, or from a sudden change of level within or associated with a building, a barrier shall be provided.

Acceptable Solution F4/AS1

1.0 Barriers in Buildings

1.1 Barrier heights

1.1.1 Minimum barrier heights are 35.4-inches for landings and 39.37-inches for balconies and decks, and edges of internal floors or mezzanine floors.

1.2 Barrier construction

1.2.1 In housing and other areas likely to be frequented by children under 6 years of age:

a) Figures 1-4 (1 and 2 are noted below) show acceptable barrier constructions

b) Openings anywhere over the full height of the barrier shall be such a size that a 3.94-inches diameter sphere cannot pass through them…

Figure 1: Barriers in areas likely to be frequented by children under 6 years of age – mesh and composite
Paragraph 1.2.1 a)

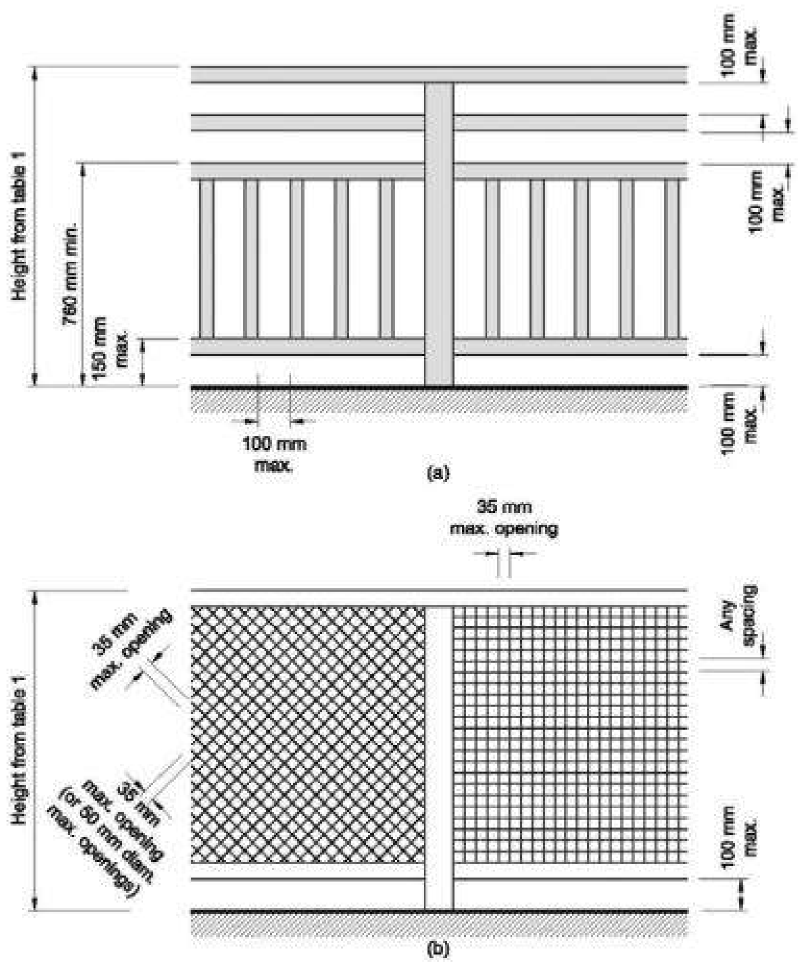


Illustration Courtesy of the Department of Building and Housing

www.dbh.govt.nz

Figure 2: Barriers in areas likely to be frequented by children under 6 years of age – parallel members
Paragraph 1.2.1 a)

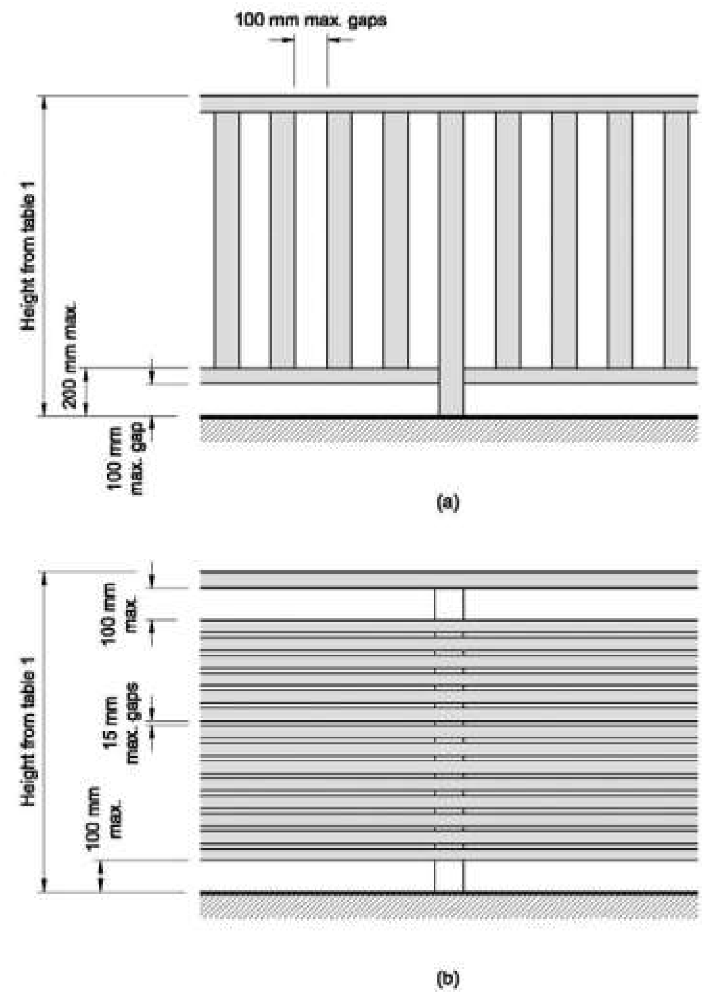


Illustration Courtesy of the Department of Building and Housing

www.dbh.govt.nz

Appendix B

National Electronic Injury Surveillance System (NEISS)
Data Set 2002 through 2005
Consumer Product Safety Commission

Introduction

The purpose of this section is to discuss the nature of information contained in the National Electronic Injury Surveillance System (NEISS) as it relates to injuries to children between the ages of 18 months and 4 years (inclusive) that result from climbing on guards. A guard, as defined on page 14 of the 2006 edition of the International Residential Code, is "a building component or a system of building components located at or near the open sides of elevated walking surfaces that minimizes the possibility of a fall from the walking surfaces to a lower level." An examination of NEISS data from recent years for records in the system that relate to guard-involved injuries was conducted.

The Consumer Product Safety Commission (CPSC) maintains the NEISS which is a database system of consumer product-related injuries. The NEISS data consists of information provided by a sample of hospital emergency departments in the United States and its territories. Collection of the data begins when a patient gives the details of an injury to a nurse, doctor or clerk in the emergency room of one of the NEISS participating hospitals. Hospital personnel enter the information into the patient's medical records. At the conclusion of each day, a designated NEISS coordinator gathers relevant cases from the day's records. The coordinator abstracts information for the required NEISS fields and transcribes all needed information to coding sheets and enters the coded data into a NEISS personal computer installed at the hospital. The data entry software includes error checking routines to ensure the validity of the entries. CPSC collects the information via telephone lines nightly.

The resulting information contained in the data system is, at times, cited in literature concerning injuries related to specific consumer products including such building components as guards. Web access to the system allows information to be downloaded and analyzed by interested parties. This feature made it possible to download NEISS records for the years 2002 through 2005.

Data Examination

NEISS data records include two product code fields that together identify up to two consumer products that were involved in an injury. Each field can contain a numeric code that is associated with a specific consumer product. Supporting documentation published by the CPSC provides a listing of the codes and the meaning of each.

A search of the documentation revealed no product code corresponding to the word “guards” (other than Guardrails which are not reported). In the absence of such a code, product codes for “Handrails, railings or banisters” (1829), and for “Porches, balconies, open side floors and floor openings” (1817) were selected for use as filters in a search of NEISS records for the years 2002 through 2005 for “guard” associated injuries related to children between the ages of 18 months and 4 years.

The table below reflects the resulting year-by-year and total record counts for the data used. As can be seen, the NEISS database contains a total of about 1.4 million injury records for the four-year period. Of these records, 2,222 contained either the code 1817 or 1829 and involved a patient between the ages of 18 months and 4 years. Table B 1 below presents a breakdown of the records by year.

Table B 1
Tabulations on NEISS Records 2002 - 2005

Year	Total number or records In NEISS database	Age 18 months to 4 years	Age 18 months to 4 years and Product Code = 1817 [4] or 1829 [5]
2002	359,980	41,507	553
2003	347,389	39,793	562
2004	353,394	41,460	609
2005	360,374	41,168	498
Total	1,421,137	163,928	2,222

The NEISS records originate in hospitals that are selected to serve as a probability sample of hospitals in the United States. Since the resulting data represents a sample of the emergency room visits, each of the records in the data system contains a weight that allows extension of the reported incidents to estimates of the number of incidents occurring nationally. Summing of the weights for each record in a set satisfying a given criterion produces an estimate of the number of such incidents that result in visits to emergency departments at the national level. Table B 2 below presents the number of

[4] Product Code 1817 (Porches, Balconies, Open-Side Floors Or Floor Openings)
[5] Product Code 1829 (Handrails, Railings Or Banisters)

records over the four-year period for the categories presented above and the corresponding national estimates based on these weights.

Table B 2
Weighted National Estimates Based on Tabulations of NEISS Records 2002 - 2005

	Total records In NEISS database	Age 18 months to 4 years	Age 18 months to 4 years and Product Code = 1817 or 1829
Records in NEISS Database	1,421,137	163,928	2,222
National Estimate	51,217,603	4,469,111	53,818

As a way of comparison, a query of data records from the 2002 - 2005 NEISS data system for injuries to patients between 18 months and 4 years produced the following results for Balconies, Stairs, and Windows.

Table B 3
Number of Records Found in NEISS Data Years 2002 through 2005 for Incidents Involving Patients 18 Months through 4 Years of Age

Product Code Categories	Number of Records	National Weighted Estimate
Porches, Balconies, Open Side Floors and Floor Openings [6]	1,534	38,827
Stairs[7]	10,306	250,274
Windows[8]	2,209	54,682

Examination of NEISS Records for Climbing of Guards

Since the focus of this paper is injuries resulting from climbing guards, a preliminary search of the narrative fields of the 2,222 records for some form of the word "climb" or a synonym was formulated. A search of Merriam-Webster's Online Thesaurus yields the following synonyms for the word "climb"—clamber, scramble. It also identifies shin, shinny, inch, mount, scale, surmount, claw, and struggle as related words and refers the reader to the word "ascend." The synonyms for ascend are listed as arise, climb, lift, mount, rise, soar, up, uprise, upsweep, upturn. Related words are boost, elevate, raise, uplift, upraise, take off, zoom, crest, scale, surmount and top. From this list, the following words were selected to be used for keyword searches of the narrative fields: climb,

[6] Product Code 1817 (Porches, balconies, open-side floors or floor openings)
[7] Product Codes 1840 (Pull-down or folding stairs) and 1842 (Stair or steps (excluding pull-down or folding stairs))
[8]Product Codes 1826 (Storm windows), 1828 (Window screens), 1836 (Jalousie glass windows), 1870 (Windowsills or frames), 1873 (Windows or window glass, not specified), 1875 (Other windows or window glass), 1888 (Window or door security barriers) and 1894 (Windows and window glass, other than storm windows)

ascend, clamber, mount, scale, scramble or shin(ny). The resulting search yielded 27 records.

Examination of the narrative fields of the 27 records revealed that eight of these records were related to climbing on items other than rails, railings or banisters: climbing steps or stairs (3); climbing on chairs (3); and climbing on other objects (playground equipment located on porch and a gate) (2). Another three records indicated patient climbing through the railing or banister, and four other records reflected some degree of ambiguity in the circumstance or some action other than climbing on a rail, railing or banister (climbing on Mom, climbing on rock box or rail, climbing on a terrace and fell 1 foot and climbing over a second floor balcony).

The narrative descriptions of the remaining 12 records indicated or were suggestive of climbing on either a banister, railing, or over a rail. However, one of these records indicated that the patient was climbing on a railing that separates checkout stands. Another record referred to a railing associated with steps outside a department store. Of the remaining ten records, none included the word guard.

Second Examination of NEISS Records

An additional examination identified records that had the same product codes and age constraints that also contain one of the keywords: fall, fell, jump, leap, slip, standing on, stood on, straddle and that refer to terms that could be used to represent a guard.

As indicated earlier, the NEISS Product Category 1829 is titled “Handrails, railings, or banisters.” Since no category corresponding to guards other than guardrails exists, this product code was deemed the category for classifying guard-related injuries. A handrail, as defined by the Merriam-Webster Online Dictionary, is “a narrow rail for grasping with the hand as a support.” This definition would seem to rule out incidents involving hand rails as guard-related. Similarly, the same source defines a banister as “a handrail with its supporting posts.” Since this term, along with handrail, is likely associated with stairs or ramps and not guards, both terms were not used in the search criteria. A railing is defined as “a barrier consisting of a rail and supports.” The definition given for the term rail includes: “a bar extending from one post or support to another and serving as a guard or barrier.” While the definition of the term railing appears to be closest to the term guard, the definition of rail as a member of a railing assembly indicates that records using the term rail should not be ruled out. A balustrade is defined as “a row of balusters topped by a rail.” The definition of a baluster includes—“an upright often vase-shaped support for a rail.” Balustrade and baluster were also retained for use in the query.

Based on the above information, the following terms were added to the search criteria: rail; baluster; balustrade; or guard. The resulting overall criteria for identifying records potentially related to the guard-related injuries was formulated to consider records with a product code of 1817 or 1829 for patients between the ages of 18 months and 4 years where the narrative includes one of the following terms: fell; jump; leap; slip; standing on; stood on; or straddle, and one of the following terms: baluster, balustrade, rail or railing.

The following table presents the results of the search broken down into categories based on the occurrence of either railing or rail and other words or phrases mentioned in the narrative that accompanies each record. This search resulted in the identification of 312 records. Not all of these records reflect falls, jumps or slips from or over guards or standing on or straddling them. Records that satisfied the criteria but were related to other types of incidents were also identified. The search identified 75 records that appear to be related to incidents involving falls, jumps, or slips from or over guards or standing on or straddling them.

Table B 4
Railing or Rail Related Records

Classification	Railing	Rail	Combined
Fell Against or Struck Rail or Railing	86	14	100
Hanging or Swinging On or Swinging Off	8	2	10
Miscellaneous/Other	24	10	34
Sliding On or Down	2	1	3
Steps or Stairs Environs	60	17	77
Uncertain Circumstances or Unclear Descriptions	12	1	13
Jumps, Falls, Slips From Rail or Railing	60	15	75
Total	236	60	312

While every effort was made to develop a meaningful system for categorizing the incidents, the classification of the identified injuries into the above categories was necessarily subjective at times. Alternative classifications of some records were possible. The purpose of this effort was to identify records that seem to represent falls from guards. Given this, record counts for other categories should not be taken as the basis of comprehensive estimates for those categories. It also should be noted that the incidents reflected in the table above included incidents that occurred at home and elsewhere. No attempt was made at that stage to limit the findings to incidents occurring at home.

Records Reflecting Jumps, Falls, or Slips From a Rail or Railing

In summarizing the 75 rail- and railing-related records, it appears that 61 occurred in the home, at daycare, or in an unknown place. The other 14 seemed to have occurred in settings that might not be relevant to the subject of guards.

The locations of these 14 incidents include a zoo, stores, the fairgrounds, a park, places for recreation or sports (ballgame), a restaurant, the motor vehicle department, a school, and possibly other public places. The records indicate the following circumstances: fell backward off railing at zoo; climbing on the railing that separates checkout stands and fell; fell off of a railing; fell from a railing 7 to 8 feet; fell from railing at fairgrounds; fell over railing while feeding the ducks at the park; flipped over railing and fell 2 feet at store; sitting on a railing and fell backwards 3 to 4 feet; standing on railing and fell into seat in front of him; fell from a rail while at a ballgame; sitting on a rail while at restaurant and fell; fell forward off a rail and landed on the linoleum floor at the MVD; and fell off rail at school. Since these incidents may not be the type that would involve a guard intended to stop falls off a balcony or from a similar location, these records were dropped from further discussion.

Of the 61 remaining records of incidents occurring at home, daycare or in an unknown place, the narratives of 19 provide little information other than the occurrence of a fall, slip or jump from a rail or railing. One indicates the patient was walking on a rail. Another indicates climbing on a rail. The product code fields of these 19 records indicate the involvement of the product category "Handrails, railings or banisters" with no entry in the second product code field.

The narrative entries for another 20 of the 61 records indicate a fall off, over, or on a rail or a jump from a rail associated with a deck, a patio, a porch or a balcony.

The narrative information in the other 22 records contains varying amounts of information concerning the circumstance of the incident. Six indicate only that the patient fell from or off a rail or railing and struck either concrete or cement. One indicates the patient was climbing on a rail and fell against a wall. Six indicate falls of 4 – 7 feet, two records indicate a fall from a second story, one indicates a fall over a 3-foot railing, one patient flipped backwards from a 3-foot railing, two others indicate that the patient struck the ground, one indicates a jump from a railing onto the floor, one patient was playing on an iron railing, and one patient fell over a railing at daycare.

Weighting Records to National Estimates

As stated earlier, the NEISS records originate in the emergency department of hospitals that are selected to serve as a probability sample of hospitals in the United States. Each record in the data system contains a weight that allows extension of the reported incidents to estimates of the number of incidents occurring nationally that result in visits to emergency departments. Summing of the weights for each record in a set satisfying a given criterion produces an estimate of the number of such incidents occurring at the national level. A table presenting record counts and the corresponding weighted estimates and their average annual values is presented below. The annual estimates are based on a simple average over the four-year period. This approach was adopted since no consistent trend was noted for the four-year period.

Table B 5
Breakdown of 61 Records, Corresponding Estimates and Annual Averages

Category	Record Count	Weighted Estimate	Weighted Annual Estimate
Little to no detail	19	252	63
Additional level of detail	22	614	154
Involves balcony, deck or porch	20	548	137
Total	61	1,415	354

Based on the weights in the identified records, the estimate of incidents that occurred between 2002 and 2005 nationally that correspond to the category involving balconies, decks, patios, porches or balconies is 548. The number corresponding to the records with narrative entries containing little amplifying data is 252. The weights for records with narratives that contain more information sum to 614. Their combined weights come to 1,415. These estimates represent estimates for a four-year period. The annual averages based on these estimates are 137, 63, 154, and 354, respectively.

A weighted estimate of 53,818 is indicated by the 2,222 records of incidents among patients between the ages of 18 months and 4 years involving either the product code 1817 or 1829. The weighted estimate based on the 163,928 records for children between 18 months and 4 years is 4,469,111 or an average over the four years of 1,117,278. The 137 annual average incidents corresponding to the records mentioning balconies, decks, or porches represent approximately 0.01 percent of the 1,117,278 child-involved incidents. The 354 weighted-annual estimated incidents, based on the 61 records identified above, represents approximately 0.032 percent of the estimated 1,117,278 annual child-involved incidents.

Conclusions

The above identification and classification of injuries by category is not intended to be an exhaustive analysis of the details of the NEISS data for injuries resulting from children between the ages of 18 months and 4 years of age climbing guards. The goal of the examination was to provide a basis for the assessment of the usability of the NEISS data to identify such injuries. Because the NEISS data system has no product code corresponding precisely to guards on balconies and other elevated walking surfaces, the study adopted an approach consisting of the use of a combination of product codes to serve as a proxy for the concept of the guards in searches of the NEISS data system. Two searches of the narrative entries of the resulting records were conducted. The first made use of synonyms for the term “climb.” The second made use of a selection of words with definitions that seem to correspond to the meaning of the term “guard.” The use of these definitions was, of necessity, literal and may have excluded (or alternatively included) records with words that were used inconsistently with the definitions presented above. No adjustment was made for such cases. This latter search also included terms for falling, jumping or slipping to denote the nature of the incident causing action.

Constructing the methodology and examination of the results revealed some areas where modification of the NEISS system could provide better definition for insights into guard-climbing injuries among children. A brief discussion of these insights and suggestions follows.

The first issue encountered during the analysis is that no product code corresponding precisely to a “guard” exists. The closest existing product code category, (1829) “Handrails, railings or banisters,” is a more broad-spectrum term that allows the inclusion of assemblies on stairs, ramps and places that might not be on elevated walking surfaces. While the nature of the NEISS system may make it necessary to use broad terms in order to limit the number of product codes in the system, this may make more narrowly focused studies problematic. The addition of a specific guard category might help clarify the circumstances surrounding any guard climbing incident.

An initial search indicated that 2,222 records reflect injuries to children between the ages of 18 months and 4 years and contain either the product codes for the category “Handrails, railings or banisters” or the category “Porches, balconies, open side floors and floor openings.” A search of these records for synonyms for climbing was used as a proxy for situations involving a guard-related injury. It yielded 27 records. Some records contained narrative descriptions that indicated the climbing actually involved some other object, such as a chair, a piece of playground equipment or steps or stairs The description lead to the conclusion that these incidents are unrelated to injuries related to climbing of guards. Other records indicated climbing on a banister, rail or railing.

An additional search of the 2,222 records for narrative entries that contain the words fall or fell, jump, leap, standing on, straddle, and mention rail, railing, balustrade or baluster yielded 312 records. An examination of these records identified 75 that appear to indicate the patient jumped, leaped, fell or slipped from a rail or railing. Unfortunately, most of these records did not indicate how the patient got onto the rail assembly. References to climbing or one of its synonyms were relatively sparse. A subsequent analysis of the 75 records indicated that 14 occurred at locations that were not identified as a home or daycare facility and may not involve guards on balconies or similar locations. The amount of details in the narrative descriptions of the remaining 61 records varied greatly. Additionally, many of the records included entries for only one product code – “Handrails, railings or banisters.” When narratives of such records do not go beyond stating that the patient fell off a railing and indicating that the victim sustained some type of injury, it is difficult to identify the nature or setting of the fall.

Based on weighting factors contained in the NEISS data system, the 20 records reflecting a fall off, over or from a rail or railing correspond to an estimated 548 similar incidents in the underlying population (27.4 multiplier). The 61 records associated with incidents identified as occurring in the home, daycare or an unknown place likewise correspond to 1,415 estimated incidents (23.2 multiplier). These figures represent about 0.01 percent and 0.032 percent, respectively, of the incidents estimated to have occurred among patients between the ages of 18 months and 4 years in the years 2002 through 2005.

Some degree of uncertainty is associated with these weighted estimates. The first type of uncertainty stems from the use of statistical sampling and is unavoidable with any approach short of a census of the entire population of hospitals. CPSC provides a statistical method to establish upper and lower bounds on weighted estimates of the NEISS data. The magnitude of uncertainty can be seen in the confidence interval of the estimates. Using the “fractional n approach” to compute the variance produces a 95 percent confidence interval of ± 301 with a lower bound of 247 and upper bound of 849 incidences for the 548 estimated incidences. The interpretation of the interval is that this interval would include the average result of all possible samples 95 percent of the time. Converting these figure to an annual average basis produced an estimate of 137 with lower and upper bounds of 62 and 212, respectively.

The other type of uncertainty is related to the lack, at times, of sufficient descriptive details in the records and the subsequent classification of incidents in this study based on that information.

The ability to isolate specific details is a significant factor in understanding the mechanism of the type of incident being reported. One possible enhancement to the NEISS system would entail the addition of some type of code that would identify the precipitating action of an injury-producing incident, such as “climbing.” Another improvement would entail the use of more precise wording. The response to an inquiry to the CPSC indicated that no further definition of the terms included in the product code listing of the *NEISS Product Code Comparability Table* or the *NEISS Coding Manual* exists. Product Code 1829 contains no definition other than that provided in the title - Handrails, railings or banisters. In addition, the terms rail or railing can be vague. The selection of the 1829 code and the use of the term rail or railing without further details can fail to communicate the exact circumstance of the incident. The resulting vagueness encountered by readers of the data might contribute to interpretations that result in controversy. One solution would be to create an additional reference document with expanded definitions for terms contained in or related to the product codes contained in the other documents. This reference could be a helpful resource for both data entry and subsequent analysis. Additionally, encouraging the inclusion of more details in narrative descriptions, when possible, could further enhance the usability of the data.

NEISS documentation indicates that follow-up investigations are often required to gather additional information because the NEISS surveillance data reflects only product involvement not causation. Follow-up investigations can make use of telephone interviews and on-site investigations. This type of follow-up investigation could well shed light on the full circumstances surrounding the reported incidents, reduce much of the associated uncertainty and perhaps produce a clearer picture of the number of incidents resulting from climbing on guards.

The comments in this section are not meant as a criticism of NEISS. Collecting and maintaining the amount of data in the system is a substantial undertaking. The comments are meant as suggestions for perhaps reducing some ambiguity in the data and improving its usability from the perspective of this study.

NEISS Case Numbers

The following tables contain the case numbers corresponding to the data records identified during the course of the NEISS data examination. The first table contains a breakdown of the NEISS case numbers by the categories that were contained in the tabulation of 312 rail or railing related records presented in the text of the report. Immediately following is a listing by category of the 61 records related to incidents occurring in a home, daycare facility or an unknown location involving a jump, leap, fall, slip from a rail or railing.

Table B 6
Case Numbers of 312 Rail or Railing Related incident Records in NEISS Tabulation

Stairs and steps	Swinging or hanging on	Sliding on or down	Unknown or unclear	Jumped or fell into	Misc./ Other	Jumps
20321953	20442816	40445098	20528174	20116393	20336853	20150907
20339843	20903544	40503776	21002460	20136095	21056551	20418787
20405815	30757220	50723382	30225318	20216789	21115944	20433374
20407320	31122317		30607831	20421746	30130566	20434923
20410901	40203383		31051158	20432652	30142326	20456411
20522902	40548817		40413016	20561822	30201138	20512248
20600425	40743637		40417772	20601338	30209110	20533101
20624232	40847984		40626537	20624080	30243154	20603128
20628721	40916498		41222144	20639200	30302327	20644268
20655141	50823853		50514692	20651847	30321020	20655117
20712583			50845394	20700012	30350637	20709149
20722416			51015461	20730185	30410727	20721324
20829164			51135208	20740419	30413643	20745250
20934103				20849692	30555414	20747826
20936404				20903128	30728339	20824307
21035208				20910091	30732196	20947550
21035301				20915196	30904572	21035185
21112358				20952769	31060980	21244651
21213203				21016545	31105835	30149086
21220354				21221621	31114644	30348875
30111361				30112521	40141214	30401885
30425333				30151841	40435014	30408454
30431984				30330496	40507264	30434904
30555450				30403295	40722612	30437507
30709926				30517768	40845978	30448799
30848751				30534271	40961785	30503924
30850438				30552166	41231148	30537449
30923781				30601099	50123891	30550764
31034567				30656005	50546285	30647328
31039184				30701557	50630926	30758889
40140115				30719234	50736325	30834250
40232092				30827320	50817176	30837045
40242544				30833165	50836513	30940596
40306041				30917141	50907582	30949442
40345428				31010131		30954444
40633645				31011767		30956517

Stairs and steps	Swinging or hanging on	Sliding on or down	Unknown or unclear	Jumped or fell into	Misc./ Other	Jumps
40644658				31032760		31014124
40649112				31043862		31039255
40715833				31047090		31131155
40731850				31057458		31211476
40743676				31059624		40330781
40807172				31128719		40350322
40807428				31130166		40354381
40838033				31227701		40401215
40905173				31232962		40403961
40930950				40208963		40535648
40935361				40308033		40550500
41038517				40335550		40601219
41039317				40411701		40652824
41246987				40431403		40924391
50112935				40438363		41002222
50136749				40540660		41004724
50153990				40604544		41115146
50226530				40613161		41154384
50228931				40619636		50106287
50311382				40700256		50116891
50322920				40702049		50242706
50415024				40723890		50342433
50425012				40747998		50401414
50535310				40754774		50549537
50537954				40809107		50553652
50615936				40835497		50608194
50714012				40946984		50615241
50758974				40947699		50640385
50800130				40964682		50640770
50806971				41013370		50663602
50818853				41108887		50723823
50908846				41157993		50753170
50917578				41158417		50839566
50937900				41204126		50924471
50947937				41210066		51012559
51007952				41228745		51123191
51037543				41229263		51128516
51142301				41235896		51129921

Stairs and steps	Swinging or hanging on	Sliding on or down	Unknown or unclear	Jumped or fell into	Misc./ Other	Jumps
51201404				50100645		51132281
51250155				50136768		
60106824				50242507		
				50316719		
				50339316		
				50350503		
				50405838		
				50416886		
				50452788		
				50508394		
				50522045		
				50531410		
				50550675		
				50613398		
				50654190		
				50717683		
				50742955		
				50754354		
				50838603		
				50903071		
				50913341		
				50944915		
				51008704		
				51044066		
				51054310		
				51141728		

Table B 7
Case Number of 61 Railing or Rail Related Records Involving a Fall, Jump, Slip from a Rail, or Railing

Deck, Patio, Porch or Balcony Mentioned	Little Detail Presented in Narrative	More Detail Presented in Narrative
20433374	20456411	20644268
20434923	20533101	21035185
20512248	20603128	30434904
20655117	20947550	30437507
20745250	21244651	30837045
20747826	30149086	30949442
20824307	30401885	30954444
30348875	30408454	31014124
30550764	30956517	31211476
30758889	31131155	40350322
31039255	40403961	40354381
40401215	40535648	40601219
40550500	41002222	40652824
40924391	41004724	50106287
50608194	41115146	50401414
50640770	41154384	50549537
50723823	50342433	50553652
50924471	50640385	50663602
51123191	50753170	50839566
51132281		51012559
		51128516
		51129921

Appendix C

Peer Review

Peer Review Summary

In October 2007 the National Ornamental & Miscellaneous Metals Association released *Review Of Fall Safety Of Children Between The Ages 18 Months And 4 Years In Relation To Guards And Climbing In The Built Environment*. This appendix provides a formal peer review of this document, which was conducted in April of 2008. The appendix is organized into three sections. First, this section presents a brief summary of the peer review process. Following this section, the text of the three peer reviews is provided in their entirety. Finally, the Curriculum Vitae of each reviewer is presented.

The peer review was envisioned as a means of providing the reader with the perspective of experts in disciplines relevant to the subject matter of this report. The project team identified potential candidates with backgrounds relevant to the subject of this study. The potential areas of expertise included child development, biomechanics, epidemiology, and statistics. Ultimately three candidates with suitable backgrounds were identified and their participation solicited. They are:

- Arthur K. McDonald - Mr. McDonald is a former Director of the Division of Hazard and Injury Data Systems, US Consumer Product Safety Commission (CPSC). He is currently a consultant to the National Center for Statistics and Analysis, National Highway Traffic Safety Administration

- Christine A. Readdick - Dr. Readdick is an Associate Professor of Child Development at Florida State University.

- Kimberly E. Stone - Dr. Stone completed an academic research fellowship and Masters in Public Health at Johns Hopkins University in 2006. She is currently residing in England.

Mr. McDonald was selected for his intimate knowledge of the NEISS data system; thus the focus of Mr. McDonalds' review is the material in the report related to the examination of NEISS data described in Appendix B and summarized elsewhere in the report and abstract.

Both Dr. Readdick and Dr. Stone have backgrounds in relevant childhood-related research. Dr. Readdick's works include *Achieving Great Heights: The climbing child,* cited in this report. Dr. Stone's published research includes *Childhood injuries and deaths due to falls from windows*. The focus of the reviews conducted by Dr. Readdick and Dr. Stone includes other sections of the report dealing with Peer-Reviewed Studies and Background Information.

Arthur K McDonald
16512 Montecrest Lane
Darnestown, MD 20878

April 17, 2008

Thomas Kenney
Vice President – Engineering and Research
NAHB
400 Prince Georges Boulevard
Upper Marlbore, MD 20774

Dear Mr. Kenney:

This letter provides my review of the document, "Review of Fall Safety of Children Between the Ages of 18 Months and 4 Years in Relation to Guards and Climbing in the Built Environment" December 2007 Edition. This review will focus on the statistical analysis presented in Appendix B and the use of this analysis in the main report.

The analysis presented in Appendix B uses injury data for 2002-2005 from the National Electronic Injury Surveillance System (NEISS) collected and maintained by the US Consumer Product Safety Commission (CPSC). The analysis generally uses these data in an appropriate manner to develop estimates of the annual number of injuries associated with children falling from railings and guards. This review will contain three major sections. The first section will provide a detailed critique of the procedures used in Appendix B. The second section will discuss the use of the statistical data from Appendix B in the body of the report. The final section will provide the results of my analysis of the 2006 NEISS injury data that has recently been published. This analysis uses similar techniques to those used in Appendix B but enlarges the scope to ensure that relevant cases are identified.

Section 1

This section will provide a detailed review of each part of Appendix B. The parts of this section will have the same title as the corresponding part of the report:

Introduction (Page B-1)

This part provides a useful and appropriate definition of the purpose of the report and a general description of the NEISS data system used in the report.

Some readers might not realize that the analysis in Appendix B reflects the data in the basic NEISS sample that includes only consumer product related injuries and that these data represent a different data set than the "All Injury NEISS" data set also collected by CPSC but disseminated by researchers at the US Centers for Disease Control. Injuries associated with falls from guards would be included in the basic NEISS and the most of the analysis is not affected by the consumer product limitation. . However, many injuries to children including motor vehicle injuries, intentional injuries and food-related injuries are not included in the basic NEISS. These injuries are included in the "All Injury NEISS" also operated by the CPSC with financial support from government agencies with responsibility for the other product areas. One consequence of this is that the percentages of all injuries published in Appendix B and in the document reflect the percentage of all consumer product related injuries not the percentage of all injuries.

Data Examination (Pages B-2 to B-3)

The term guardrail mentioned in the NEISS coding manual as not reportable refers to a highway guardrail that is not considered a consumer product and injuries associated with guardrails are not generally reportable in the basic NEISS for that reason. Injuries associated with other products under the jurisdiction of other Federal agencies such as firearms, food and automobiles are also not reportable in the basic NEISS. However, injuries associated with guards used in building structures should be reported using the railing code or possibly using other product codes that identify products such as floors, balconies or stairs that were also involved in the injury incident.

The choice of the two codes (1829 railings and 1817 porches) in the search for cases described in Appendix B is a reasonable choice, although I see no reason at this point to limit the search by product code. This search identified 2,222 cases in the four year period 2002-2005 under these two product codes.

The remainder of the section provides good background information with interesting and accurate statistics on the sample counts and estimates for the number of injuries treated in hospital emergency departments in several different product areas.

Examination of NEISS Records for Climbing of Guards (Pages B-3 to B-4)

The challenge for an analyst using the NEISS to develop an estimate of the number of injuries associated with any hazard is to devise a strategy to identify the sample cases that fit the hazard pattern. The usual approach is to use the coded variables and character string searches of the narratives to identify a relatively small set of cases and read each of these cases to identify a final set of sample cases that appear to fit the hazard pattern. This final set of cases is used to generate the national estimates. That is the process followed in Appendix B. The most difficult part of the process is identification of the keywords used to filter the cases. It is helpful to see the attempts to use different verbs (climb, fall, etc.) and nouns (rail, guard, baluster, etc.) in this process.

This part reflects the efforts to identify injuries associated with children climbing on guards by using a character string search of the 2,222 railing and porch cases for the word 'climb' and synonyms. Only 27 cases were identified and most of these cases were out of scope because the scenarios did not involve climbing on the type of guards of interest in this study. It appears that this attempt to identify cases was not successful because the short narratives describing the incidents usually used the word 'fall' to describe the incident sequence and not the word 'climb' that might have described the cause of the incident.

Second Examination of NEISS Records (Pages B-4 to B-5)

A second examination of the 2,222 records previously identified used two search strategies. The first search of these records identified 312 records with a keyword such as "rail", "baluster", or "balustrade". The word "banister" was not used despite its similarity to the words used because of its likely use as a stair rail and not a guard. The choice of words to use in the search is complicated by the fact that the words in the NEISS narrative are often the words used by the victim or family members to describe the incident and may not fit the technical definition of the words. A second search of these 312 records identified 75 of these 312 records that also had a keyword such as 'fell' or 'jump'. These 75 records formed the basis for the subsequent analysis. This approach is sensible and appropriate although each character string search has the potential to exclude relevant cases that lack any of the specified keywords. Keyword searching is a powerful tool to filter large numbers of cases to identify specific cases of interest. Keyword searching may miss some cases if an incident is described with an unanticipated combination of words or if the coder misspells a keyword.

Records Reflecting Jumps, Falls or Slips From a Rail or Railing (Pages B-5 to B-6)

This part reflects the results of the case-by-case review of the 75 records identified in the last section. This review is a necessary and appropriate step and identified 61 cases that occurred in homes, daycare or unknown locations and are included in the final analysis of these data.

Weighting Records to National Estimates (pages B-6 to B-7)

The weights for the 61 cases identified for the four years of analysis were added to produce an average annual national estimate of 354 injuries This number appears to be a useful estimate and results from a reasonable analysis of the data. The statement that this estimate of 354 injuries is 0.032 percent of the estimated annual total of 1,117,278 child ED treatments is true but seems to provide information that is redundant and useful only to demonstrate that the estimated number of injuries after falling from guards is a small percentage of the total number of injuries in this age group. It should also be noted that the percentage applies only to all child consumer product related ED treatments and would be even lower if all child injury ED treatments or all child injuries were included in the denominator..

Conclusions (Pages B-7 to B-10)

The first part of this section contains some appropriate caveats about the analysis and the necessarily limited results attainable from character string searches of short narrative summaries. The study did achieve its goal of showing the feasibility of using the NEISS data to identify injuries to children between the ages of 18 months and 4 years from climbing on guards.

The author makes several recommendations that would enhance the utility of the NEISS for conducting studies such as this in the future. These recommendations involve such issues as the use of more specific product codes including a code for the guards that are the subject of this study, collection of more detail in the narrative section of the record and coding of the precipitating action for the injury incidents. These recommendations are sensible and appropriate from the analyst's point of view. There is currently an effort to code the precipitating action for a subset of the cases in the system. However, the set of precipitating event codes does not include the level of specificity necessary to support this study. Addition of new precipitating event codes would not improve the data unless the hospital records contain the detail necessary to support these codes. The CPSC must work with the participating hospitals to improve the level of detail in the basic emergency department records before significant progress could be made to implement any of these recommendations. The effort to improve the level of detail must coexist with efforts to streamline data collection in the hospitals and must recognize that the hospitals' basic mission to treat injuries and save lives will always have priority over data collection.

This part includes a paragraph discussing the sample variation inherent in any estimate produced from a probability sample such as the NEISS. The sampling variance is an issue when considering the NEISS estimates but measurements of the sample variance are unreliable when the estimates are small. CPSC policy does not permit publication of variances when the estimate is less than 1,200 and in this example the four-year estimate is 548. Also it appears that the analyst converted the confidence interval for a four-year estimate to a confidence interval for one year by dividing the upper and lower limits by four, which would not be an appropriate technique to estimate the single year confidence interval. Some mention of the variance is appropriate but I would omit the calculation since it is not an important part of the presentation.

The suggestion to conduct follow-up investigations to collect additional details on specific cases is an excellent suggestion. These investigations can be conducted by telephone and can provide useful additional details. Such investigations have been conducted by the CPSC for special studies in many different product areas and have provided the basis for many useful analyses. Generally another Federal agency would have to contact CPSC and provide the funding if the project involved a product such as building guards that was not in the CPSC operating plan.

NEISS Case Numbers (Pages B-10 to B-14)

This part provides the case information that allows the reader to reproduce the author's results. This is an important and valuable part of the report.

Section 2

This section will provide a review of the use of the findings from Appendix B in the main body of the document.

The Abstract (page I) and the Executive Summary (Page IV) present the injury data for climbing and falling from guards as 0.032 percent of all injuries to children 18 months to 4 years of age resulting in emergency room treatment. This statement is supported by the work in Appendix B and the narrative on pages 6 and 7.

However, this percentage seems unnecessarily obscure and the reader would be better informed by the equivalent national estimate of the number (354) of children of this age treated annually for this type of falls. The reader also should be reminded that injuries treated in hospital emergency rooms are only part of the total injury experience. There are other injuries treated in clinics, homes, doctor's office and possibly some cases that result in death with no treatment at all.

The percentage (0.032%) is the percent of product related injuries treated in hospital emergency departments. The percentage would be even smaller if the denominator included other injuries treated in hospital emergency departments such as motor vehicle injuries, food injuries and intentional injuries.

A summary of the results from Section B is presented on pages 6 and 7 of the main document. This summary is generally an accurate representation of the information in Appendix B.. There are several minor points that should be clarified.

The major finding is the annual estimate of 354 injuries treated in hospital emergency departments not the percent of 0.032 of "all" injuries that is repeated in this section. It is true that the estimated 354 injuries is a very small percentage of the total number of emergency department treated injuries for this age group.

The narrative fields in the NEISS data records are not the 'hospital administrators interpretation and annotation of the event' and the narrative is never left blank. The narrative fields are the most detailed verbatim description of the injury incident entered on the emergency department record by any of the ER staff including physicians, nurses or clerks. The narrative field may be brief and vague, but it is part of every NEISS record and the best description of the injury incident available from the hospital record.

Section 3

This section provides my analysis of the recently available 2006 injury data and shows that a slightly different analytical approach provides similar results to the findings presented in Appendix B and used in the document.

The website https://xapps.cpsc.gov/NEISSQuery/home.do maintained by the CPSC provides the raw data for NEISS which includes records of emergency department treatments from a national probability sample of hospital emergency room treated consumer product related injuries. The site provides sample counts, estimates and raw data for use by analysts addressing any consumer product safety issue.

The data used in the document under review were retrieved from this site and covered the years 2002 through 2005. The CPSC web site now includes the data for 2006 and my review looked only at the data for 2006. My analysis took a slightly broader approach to the analysis, but found results consistent with the results found in Appendix B and used in the document.

There were 363,616 product related injury reports for 2006 in the database. These reports covered an estimated 13,200,000 product related injuries treated in US hospital emergency departments in 2006. There were 41,689 product-related injury reports for children 18 months through 4 years of age. These reports covered an estimated 1,150,622 product related injuries for children in this age group for 2006.

Each of the 41,689 data records contains certain coded data variables and a short narrative description of how the injury occurred. The information in these records is taken directly from the hospital emergency department reports and these data records include only information collected during the normal course of injury treatment in a hospital emergency department.

The main challenge for this analysis is to review these records and identify the records associated with children injured after climbing and falling from guard rails. Once the relevant cases are identified, a national estimate can be generated by summing the weights for the cases identified. There are three major steps in the process to identify cases of interest. The analysis in Appendix B used all three methods. The first step was to limit the search of the injuries to children and restricting the search to two product codes (1829 Handrails, railings, …and 1817 Porches, balconies, …). The second step was to screen the cases identified with these codes to identify cases where the victim had fallen and the product was identified as a railing or guard by using a limited set of character strings to search for possible cases. The third step was to read the cases identified in steps 1 and 2 and identify the cases of interest.

My search of the 2006 cases limited the search to children but included all cases without regard to product. The subsequent steps were used to identify the cases of interest from all cases in the NEISS sample. Step 2 was simplified by searching only for cases with keywords associated with guards such as 'guard', 'rail', 'banister', 'baluster', etc. This initial review identified 329 cases for further analysis. After quickly eliminating obvious false positive cases with keywords such as lifeguard and bedrail, there were 180 cases left to review to identify the cases of interest. After reading the 180 cases, 30 cases were identified where the victim appeared to have fallen off some type of railing or banister. Twenty-eight of the 30 cases had been coded as product 1829 or 1817. So the search strategy of including all product codes only identified two additional cases and both of those cases involved railings that could have been coded as 1829. The cases identified from this review of the 2006 cases are listed below:

DAD TRIED TO GRAB CHILD WHEN SHE WAS FALLING OFF BANISTER / SHE TRIPPED OVER RUG
FELL FROM RAIL 1 FLOOR ONTO CARPETED FLOOR DX: CHI W/ VOMIT
FELL OFF PORCH RAILING SCRAPPING EYEBROW ON THE WOOD " LAC'
PT WAS CHASING GRANDMA AND LEANED OVER BALCONY RAILING AND FELL FROM BA L
PT WAS @ HOME CLIMBING ON RAILING OF THE PORCH FELL ONTO FACE. SWELLING TO LIP. D
PATIENT FELL FROM 2ND STORY BALCONY, OR OFF 2ND STORY BANISTER, LANDED ON CA
FELL FROM PORCH OF TRAILER HOME 3-4' & HIT HEAD ON BIKE D-CONTUSION D2 -CHI D3 DI

2YOF FELL FROM DECK RAILING 5FT SUPERFICIAL LAC UPPER LIP CONTUSION LOW ER LIP
PATIENT FELL 8-9 FT WHILE LEANING OVER STAIR RAILING OUTSIDE APARTMENT, LANDED
NO APPARENT INJURIES-FELL 9 FEET OVER BANISTER TO FLOOR-@ HOME
JUMPED OFF RAILING. DX CHEEK ABRASION
LOWER ARM CONTUSED, FELL OFF RAILING
PT FELL OFF STAIR RAILING- NO LOC, BUT HAS ARM DEFORMITY DX: RT DISTAL RADIAL & U
FELL OFF RAILING & HIT HEAD, CHI
PT FELL 7 FT OVER BANISTER OF STAIRS. DX: TRAUMATIC BRAIN INJURY MILD.
PATIENT FELL OFF RAILING ON PORCH AT HOME, FELL ON CEMENT; CHEEK HEMATO MA, BRU
PT FELL CLIMBING ON A BANISTER AND FELL OFF . DX SHOULDER FX
4 YOM WAS CLIMBING A BANNISTER AND FELL CAUSING RIGHT ELBOW FRACTURE
PT JUMPED OVER DECK RAILING AND HIT KNEE ON METAL PIECE OF A POST. DX: 4.0 CM. LAC
FELL OFF RAILING AND HIT HEAD ON CONCRETE. DX HEAD INJURY - CONCUSSION
PT FELL OVER 2ND FLOOR RAILING AND LANDED ON WOOD FLOOR. DX: SKULL FX.
SWINGING ON RAILING AND FELL THREE FEEET AND LAC HEAD
PT FELL FROM A BANISTER/ LAC TO TONGUE
DENTAL INJURY AND CUT LIP WHEN FELL OFF HAND RAILING
FELL OFF A BANISTER TIB/FIB FX
CLIMBING ON DECK RAILING AND FELL 1 CM LOWER LIP LACERATION
@ HOME @ TOP OF STAIRS LEANING ON RAILING & FELL APX 10-12', UNSURE IF LANDED ON C
FELL OVER BANNISTER ONTO HARDWOOD FLOOR STEPS. DX HEMATOMA HEAD
FELL DOWN STAIRS OVER RAILING. DX ABRASION HEAD
FELL DOWN STAIRS OVER 2ND STORY BANNISTER, HIT CHIN ON RAILING, MANDIBL E FX

All these cases happened at home or in unknown locations. The estimate associated with these cases is 579 injuries treated in hospital emergency rooms for similar injuries in 2006. Nine of these injuries were associated with banisters that were not included in the analysis provided in Appendix B. When these cases were eliminated, we were left with 21 cases and an estimate of 369 that is very close to the annual estimate of 354 injuries provided in Appendix B. There are several factors that can account for differences in the annual estimates for different years:

- Sampling variation
- Different interpretations of whether a case should be counted
- Normal year to year differences in injury totals
- Changes in the level of detail in the source documents from some hospitals in different years

It is also important to note that any estimate that relies on this kind of character string searching through incomplete source documents is likely to be lower than the number of incidents that might be identified through a complete count of incidents from a thorough census of all emergency department visits..

The most important point is that despite the slightly different approach and the factors listed above, the estimates from my analysis of the 2006 data and the analysis in Appendix B provide remarkably similar estimates.

In general, the analysis in Appendix B and its use in the document, "Review of Fall Safety of Children Between the Ages of 18 Months and 4 Years in Relation to Guards and Climbing in the Built Environment" December 2007 Edition are appropriate uses of the NEISS and the presentation is an accurate description of the information.

Sincerely,

Arthur K McDonald
Consultant
Former Director – Division of Hazard and Injury Data Systems,
US Consumer Product Safety Commission

A Peer Review of

“Review of Fall Safety between the Ages of 18 Months and Four Years in Relation to Guards and Climbing in the Built Environment”

April 17, 2008

At the behest of NOMMA (The National Ornamental & Miscellaneous Metals Association) researchers Hedge, Kenney, and Davis (2007) have assessed what is currently known about the safety of young children in relation to guards in a residential setting. The research team has provided a comprehensive assessment, comprised of a presentation of building code requirements for guards (U.S., Canada, Australia, and New Zealand), a critical review of published, peer-reviewed research articles regarding children’s development and climbing skills, and critique of child fall and injury data garnered from the U.S Consumer Product Safety Commission.

In Executive Summary, the authors conclude that “Results from either the research studies or the injury data are neither specific enough to constitute a solid basis for building code requirements” (p. 1v). I concur, after multiple readings and reflection. In general, building codes for design and installation of guards are varied; no study of children’s climbing has been conducted under natural circumstances in children’s own homes, much less homes with the guard design features of interest; and CPSC data is largely devoid of the contextual information which would allow the reader to know where, with whom, and under what circumstances an injury in the home occurred.

Nonetheless, it is still possible to assert from the research available, as the authors do, that a higher guard is better than a lower one, that design features such as a hard-to-grasp railing, vertical members, and openings too small for bare toes or shoes are best. And continued research is rightfully called for regarding children's safety and consideration, as given here to characteristics of the child, the built environment, as well as elements of the family caregiving system including appropriate child supervision.

I do have some encouragements beyond those offered by the authors. I will center most of these remarks around young children themselves. First of all, we must remember that children are not only uniquely and physiologically capable of climbing, based on their abilities to rotate their arms up and over their heads (as do other species which climb) but also that when one is small, even more elements of the built and natural environment "pull for" or "afford" climbing, because there are simply more things taller than the child herself--from bookshelves to sides of cribs to guard rails. In saying this, I am simply underscoring the fact that the ability and need to climb cannot be realistically eliminated.

Further, my lifetime of experience with caregivers tells me that adults tend to underestimate children's physical prowess, as well as children's abilities to protect themselves. From this perspective, future research is needed to capture the extent of children's climbing experience vis-à-vis accidents from falls. My hunch is that children who have ample, if not safe, opportunities for climbing will be better able to protect themselves and be underrepresented in accident data.

Given that children (some) begin climbing before they walk and before their first birthday, I also recommend that future examination of CPSC fall data capture accidents from at least 12 months on.

Certainly this review provides a strong rationale for education in families and communities regarding children's children's climbing abilities and could perhaps contribute to a public health dialogue regarding simple and inexpensive means of retrofitting residences built before the most recent standards for guard rails, with taller guard rails with smaller openings and vertical railings as a means of reducing death and injury, in the way that New York reduced accidents by installing steel metal screens on window openings. In my mind, beyond the contribution of the active child and a less than perfect built environment, the most important ingredient in the prevention of accidents entails the contribution of vigilant adult supervision; it is not simply an issue of educating the child.

Little children are simply dependent on attentive adults for protection and security. Accordingly, parents need to be informed under what circumstances a fall from climbing is "waiting to happen". That many accidents affect the poor and ethnic minority children disproportionately places a burden of care on low-income residential property owners and managers to abate risk (install more effective guard rails) and inform residents about known risks that cannot be eliminated and therefore will require increased adult vigilance. Relative to this same point, as when I teach child guidance, property owners and parents alike need to provide "legitimate" objects for climbing so that the issue becomes one of promoting children's climbing of appropriate objects in the home environment (indoors and out), rather than trying to prevent climbing from occurring at all.

For those of us who have shuddered to discover a preschooler flawlessly scaling a chain link fence in a matter of seconds, the research cited in this review and conducted by Rabinovich et al (1994) should be of considerable interest to NOMMA. If indeed, future research with larger and representative samples of young children confirm that an ornamental iron guard with vertical members 3 and one-half inches apart and a 45-inch gap between members (and at least 48 inches in height) is a significant deterrent to children's climbing of and falls from guard rails, then this may become the standard element recommended in new home construction. In the case of the climbing young child, materiality in the form of metal may be one of the most important deterrents to climbability of guard rails.

In sum, Hedge, Kenney, and Davis have remained close to all of their data (building codes, child climbing performance, and reports of accidents from falls) and not overstated in any way the conclusions that they have reached or recommendations they have made. Certainly, the recommendations to improve consistency of language in building code standards, to conduct research of children climbing naturally in their home environments, and to revise Consumer Product Safety Commission hospital accident report forms to capture more social and physical environmental features surrounding each incident are not only accurate but demonstrably warranted in this excellent report.

Respectfully completed and submitted by Dr. Christine A. Readdick

April 17, 2008

Thomas Kenney , P.E.
Vice President Engineering & Research
NAHB Research Center
400 Prince George's Blvd.
Upper Marlboro, MD 20774

Dear Mr. Kenney:

Per your request, I have completed a review of your report entitled "Review Of Fall Safety Of Children Between The Ages 18 Months And 4 Years In Relation To Guards And Climbing In The Built Environment"-December 2007 Edition. I completed this review from the perspective of a pediatrician with experience in designing and conducting research in injury prevention, specifically falls from windows. I focused my review on the following sections of the report: pp.6-7 (US Fall Injury Data), pp.26-40 (Children's Interaction with the Built Environment) and Appendix B (NEISS Injury Data Analysis). I have also included comments on the Abstract, Executive Summary and the Conclusions.

The Abstract presents a summary of the purposes of the report, which include the summary of code requirements, critical review of the literature on guard research and injury data and analysis of available injury statistics. The objectives are clearly stated and remain consistent throughout the report. Although these issues were addressed later in the report, the fact that the term "guard" is not defined in the abstract is confusing. Additionally, the 0.032% injury rate for falls from guards stated in the abstract has no meaning initially because it is not reported in a "per population per year" format nor is it placed into context by comparing to other statistics, such as homicides or motor vehicle collision data.

The Executive Summary clearly defines who commissioned the report and its purpose. The term "guard" is defined more explicitly in this section. When discussing injury data, it would have been helpful to include the name of the data set used in the analysis in the summary. When discussing the literature review, the credibility of the review would be strengthened by discussing the inclusion/exclusion criteria and what search terms and databases were used. The literature review was quite broad and the limitations of conducting such a review should have been acknowledged. The literature review encompasses a vast amount of information, including child development, guard design and injury data. Inclusion of dates of review and the amount of time spent reviewing literature would have put the scope of the review in perspective.

Based on my knowledge of the literature, the review of the epidemiology of falls from heights is fairly complete, however there were several studies from the 1970's and 1980's that were not discussed (see Stone etal in your report for references). Discussing and referencing the original New York window fall literature[9] would have strengthened the review. The report mentions that many of the studies, especially in the review of fencing design and climbability of structures, had quite small sample sizes. I am not sure it would be possible, but was the possibility of pooling data and conducting a metanalysis considered? Also, please make sure you check the completeness of your reference list. There was one study that you quoted that was not mentioned in your reference list.

It was stressed that the literature reports fall incidences in localized areas and that these rates are considerably higher than that derived from the NEISS data. Reasons for this are not fully discussed. One possibility is that the research is carried out in areas with high incidences of this, which is certainly true considering that most research is carried out in urban areas with high buildings. I would argue that the NEISS may underestimate the true burden of falls from guards for several reasons. One reason which was stated, is that the coding of the NEISS is not conducive to identifying these falls. Also, since little research has been done on the target area of falling from a guard, the fall rates reported in the literature (mostly stairs and windows), does not reflect the actual incidence of falls from guards. Also, many injuries resulting from falls from guards may be treated in urgent care centers, primary care providers' offices or not brought to medical attention for a variety of reasons. Even though these falls may be less severe since the victims are not seen in an emergency room or hospital, they may still contribute substantially to the economic burden of injury in medical costs and lost income[10].

Appendix B, though lengthy, provided an excellent review of how the injury data was obtained from the NEISS Data Set. It allows the reader to replicate the process of obtaining the data. It also emphasizes the possible changes that could be made to the coding process to allow cleaner use of the data. The inclusion of all the case numbers could possibly have been deleted from the report but available on request. It would also be helpful to compare these rates to other, established rates for other injuries.

The conclusions regarding a lack of data regarding guard design features is certainly appropriate. Emphasis is appropriately placed on the fact that there is no research regarding "guards" as defined in this report. However, attention should be paid to the fact that the age of the child seems to be an important factor, since most falls occur in ages 1 to 4, and the fact that after the age of four it seems that few fencing designs can prevent climbing. Examining the fencing designs deemed "unclimbable" by younger children should certainly provide a starting point for guard design.

One concern I have is that emphasis is placed on the child climbing over the guard and falling. There was no mention of the possibility of a child attempting to climb a guard and falling while failing to climb it. In the studies conducted regarding climbability of guards, great attention was paid to preventing children from falling during the study and

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[9] Spiegel etal. Children Can't Fly: A Program to Prevent Childhood Morbidity and Mortality from Window Falls. Am J of Public Health; 1977;67:1143-1146.
[10] Zaloshnja etal, The Costs of Unintentional Home Injuries, Am J of Prev Med; 2005;28:88-94.

they did not report if falls occurred when children failed to climb the guard. It is certainly possible that falling backward from the guard could cause as much injury as falling over the guard, and this should be considered when designing guards.

The American Academy of Pediatrics' policy statement on prevention of falls is appropriately cited when discussing the importance of injury prevention[11]. There is also an impressive amount of literature in the health education literature regarding health promotion and education, as well as the interaction between legislation and individual and community education. I encourage you to read articles by Andrea Gielen, ScD on this topic. Another report of interest is the report "Built Environment, Healthy Communities, Healthy Homes, Healthy People" which reports on a symposium sponsored by the NIEHS. While it is true that counseling can increase some injury prevention behaviors, the most effective injury prevention strategies are those that involve legislation and passive protection[12]

I hope this review has been helpful to your organization. If you have any questions, please feel free to contact me at kimstonemd@yahoo.com.

Sincerely,

Kimberly E. Stone, MD, MPH
Fellow, American Academy of Pediatrics
Member, Section on Injury and Poison Prevention

[11] Bull etal, Falls from Heights: Roofs, Windows and Balconies, Pediatrics; 2001;107:1188-1191.
[12] Sleet, D, Schieber, R and Gilchrist, J. Health Promotion Policy and Politics: Lessons from Childhood Injury Prevention, Health Promotion Practice, 2003;4:103-108.

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Employment History

- Consultant, National Center for Statistics and Analysis, National Highway Traffic Safety Adninistration — 2004-Present
- Director, Division of Hazard and Injury Data Systems, US Consumer Product Safety Commission (CPSC) — 1980-2004
- Special Assistant to Associate Executive Director, CPSC — 1976-1980
- Statistician, Office of Planning and Evaluation, CPSC — 1974-1976
- Mathematician, US Public Health Service, DHHS — 1969-1974
- Commissioned Officer, US Public Health Service, Department of Health and Human Services (DHHS) — 1967-1969
- Teaching Fellow - Mathematics, Boston University — 1964-1967

Education

- Master of Philosophy (Mathematical Statistics) - George Washington University 1970
- Master of Arts (Mathematics) - Boston University 1967
- Bachelor of Arts (Mathematics) Bowdoin College 1964

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EDUCATION

Ph.D. THE FLORIDA STATE UNIVERSITY, Tallahassee, Florida, 1988.
Major: Child Development.
Dissertation: The Effects of Cooperation, Competition, and Friendship on Children's Social Comparisons.

M.S. THE UNIVERSITY OF GEORGIA, Athens, Georgia, 1976.
Major: Child and Family Development.
Thesis: Social Comparison Processes in Mother-Child-Sibling Interaction: Effects on Mother-Child-Sibling and Child-Peer Interaction.

B.A. MEMORY UNIVERSITY, Atlanta, Georgia, 1968.
Major: Elementary Education.

ADDITIONAL EDUCATION

Westminster Choir College, Princeton, New Jersey, July 1980. Coursework in Introductory Orff-Schulwerk completed.

Virginia Polytechnic Institute and State University, Dulles, Virginia, July-August 1979. Coursework in Measurement and Instrumentation completed.

The Pennsylvania State University, University Park, Pennsylvania, 1976-1977. Ph.D. candidacy approved, 1977. Coursework in Individual Development and Family Studies completed.

Weber State College, Ogden, Utah, 1971-1973. Coursework in Child Development completed.

Goethe Institute, Schwabisch Hall, Germany, March-May, 1970. Basic German language certificate awarded.

PROFESSIONAL EXPERIENCE

Associate Professor - Department of Family and Child Sciences. 5/94-present; Assistant Professor 12/88 - 5/94; (Adjunct Instructor 10/87-12/88). College of Human Sciences, Florida State University, Tallahassee, Florida 32306

Assistant Professor - Department of Education. 8/79 - 8/81 (Instructor 8/78 - 8/79). Director, Onica Prall Child Development Center. 12/79-5/81 (Head Teacher 9/78 - 12/79). Hood College, Frederick, Maryland 21701

Assistant Professor - Department of Child and Family Studies. Director, The Children's School. 9/77 - 6/78. Weber State College, Ogden, Utah 84401

Graduate Teaching Assistant - The Cognitive Development Program, Laboratory for Early Education, Division of Individual and Family Studies. 9/76 - 6/77. College of Human Development, The Pennsylvania State University, State College, Pennsylvania 16802

Graduate Teaching Assistant - The Infant Center, McPhaul Child Development Center. 9/75 - 12/75. Graduate Research Assistant. 9/74 - 9/75. Department of Child and Family Development, The University of Georgia, Athens, Georgia 30602

Substitute Teacher - Kodiak Borough Schools. 2/74 - 8/74. Kodiak, Alaska 99615

Lecturer - Family Life Department. 1/73 - 8/73. Head Teacher, The Children's School. Weber State College, Ogden, Utah 84401

Educational Coordinator - Project Head Start. 9/71 - 6/72. Teacher. 9/72 - 12/72. Ogden, Utah 84401

Director/Head Teacher - Utah Migrant Council Summer Day Care Center. 6/71 - 8/71. Layton, Utah 84041

Substitute Teacher - U.S. Army Schools, Europe. 3/70 - 6/70. Schwabisch Hall, Germany

Teacher - St. Simons Elementary School. 8/69 - 11/69. St. Simons Island, Georgia 31522

Teacher - James Mayson Elementary School. 1/69 - 6/69. Atlanta, Georgia 30321

Teacher - Peyton Forest Elementary School. 8/68 - 12/68. Atlanta, Georgia 30311

PROFESSIONAL MEMBERSHIPS

Groves Conference on Marriage and the Family *(invited member)*
American Association of Family and Consumer Sciences
International Federation of Home Economics
National Association for the Education of Young Children
Southern Early Childhood Association
Early Childhood Association of Florida
Society for Research in Child Development
Concerned Educators Allied for a Safe Environment
Association for Childhood Education International
National Council on Family Relations
National Organization of Child Development Laboratory Schools
Jean Piaget Society
World Organization for Early Childhood Education *(invited member)*
The American Association for the Child's Right to Play (IPA/USA)

PROFESSIONAL ACTIVITIES

President-Elect, Groves Conference on Marriage and Family, 11-07-6-08; President, 2008-2011.

2008 Ireland Conference Chair, Groves Conference on Marriage and Family, 2006-2008.

Membership Chair, Groves Conference on Marriage and Family, 4/05-4/08.

Editorial Consultant, *Dimensions of Early Childhood*, Southern Early Childhood Association, 12/93-present.

Past President, Leon Association for the Education for the Education of Young Children, 5/05-06. (President-Elect 3/02-5/03; President 5/03-05/05).

Member, Publications Committee, Early Childhood Association of Florida, 8/02-present (Chair 8/02-8/04).

Editorial Consultant, *Young Children*, National Association for the Education of Young Children, 11/95-12/98.

Faculty Advisor, The Florida State University Association for the Education of Young Children, 9/88-4/99.

Faculty Advisor, Kappa Omicron Nu, Florida State University, 9/90-8/92; 9/00-5/04.

HONORS AND AWARDS

Centennial Laureate, College of Human Sciences, The Florida State University, 2005.

2005 Advocacy Award, The Early Childhood Association of Florida and the Leon Association for the Education of Young Children.

Business Associate Award, American Business Women's Association, Tallahassee, 1995.

Teaching Incentive Award, College of Human Sciences, The Florida State University, 1994-1995.

College Teaching Fellow, College of Human Sciences, The Florida State University, 1985-1986.

Delta Kappa Gamma, Honor Society in Education, 1989.

Omicron Nu, Honor Society in Home Economics, 1986.

Gamma Sigma Delta, Honor Society in Agriculture, 1976.

Kappa Delta Epsilon, Honor Society in Education, 1986.

FUNDED RESEARCH ACTIVITIES

Mary Francis Hanline and Christine Readdick, Preservice Preparation of Highly Qualified Early Intervention Specialists, U.S. Department of Education, $249,000, Fall 2007.

Christine Readdick, Child Care Center Noise: Measurement, Effects, and Recommendations, Florida State University COFRS Award, $13,000, Summer 2007.

Mary Francis Hanline and Christine Readdick, Preservice Preparation of Highly Qualified Early Intervention Specialists, U.S. Department of Education, $249,000, Fall 2006.

Mary Francis Hanline and Christine Readdick, Preservice Preparation of Highly Qualified Early Intervention Specialists, U.S. Department of Education, $249,000, Fall 2005.

Mary Francis Hanline and Christine Readdick, Preservice Preparation of Highly Qualified Early Intervention Specialists. U.S. Department of Education, $249,000, Fall 2004.

Mary Francis Hanline and Christine Readdick. Preservice Preparation of Highly Qualified Early Intervention Specialists. U.S. Department of Education, $249,999, Fall 2003.

Catherine Black and Christine Readdick. The Effects of Costuming on YoungChildren's Story Retelling Abilities. College of Human Sciences Research Initiation Award, $1,000, Spring 2003.

Christine Readdick. Noise Abatement: A Missing First Step in Early Literacy Programs. Florida Children's Forum, $10,000, Fall 2002.

Christine Readdick (Principal Investigator) and Penny Ralston. The Gwen Cherry Child Development Center Community Partnership Project, Florida Department of Education, $18,900, Summer 2002.

Christine Readdick. Foster Grandparents: Key to Intergenerational Programming at Gwen Cherry Child Development Center. Leon County School Readiness Coalition, $1,500, Spring 2002.

Christine Readdick and Brittany Birkin. "Reading to Your Bunny": Family Literacy at Gwen Cherry. Kids Incorporated of the Big Bend Caring for Kids Mini-Grant, $300, Spring 2002.

Christine Readdick (Principal Investigator) and Penny Ralston. The Gwen Cherry Child Development Center Community Partnership Project, Florida Department of Education, $37,000, Fall 2001.

Christine Readdick (Principal Investigator) and Penny Ralston. The Gwen Cherry Child Development Center Community Partnership Project, Florida Department of Education, $393,000, Fall 2000.

Christine Readdick (Principal Investigator), David Wright, and Penny Ralston. The Gwen Cherry Child Development Center Community Partnership Project, Florida Department of Education, $630,000.00, Fall 1999.

Christine Readdick (Principal Investigator), Catherine Black, Kaye Grise, and Jeanne Heitmeyer. Florida's Children: Sun Protection. Florida State University, College of Human Sciences RIAP Grant, $2,000, Spring 1998.

E. Wayne Hill, Ronald L. Mullis (Principal Investigators), Christine Readdick, and Connor Walters-Chapman: Parent and Adolescent Caring Connections. Lilly Endowment, Inc. $35,000, Fall 1993.

E. Wayne Hill (Principal Investigator), Ronald L. Mullis, Christine Readdick, and Connor Walters-Chapman. An Intergenerational Comparative Study of Parent and Adolescent Attachments. College of Human Sciences Individual Research Initiative, $8,000, Fall 1993.

Jeanne Heitmeyer (Principal Investigator), Kay Grise, and Christine Readdick. Selection, Acquisition, and Care of Children's Clothing in Single-Parent and Dual-Parent Families. Kappa Omicron Nu Research Grant, $1,000, Spring 1992.

Betty Jo Troeger (Principal Investigator) and Christine Readdick. Development of the ART Scale: A Measure of Children's Drawing Skills. Florida State University COFRs Grant, $7,500, Summer 1990.

Christine Readdick (Principal Investigator). Adolescent Caregiving of Siblings and Non-Siblings. Florida State University Council on Research and Creativity First Year Assistant Professor Award, $1,000, Summer 1989.

REFEREED PUBLICATIONS Note. *Master's student, **doctoral student.

Fairbrother, J.T., Readdick, C. A., Shea, J.B (Winter 2008). A human factors approach to the forensic investigation of a portable crib collapse. *Ergonomics in Design.*

Purvis-Montford, E.*, & Readdick, C. A., (in press). Puzzlemaking and part-whole perception of two- and four-year-old children. *Early Child Development and Care.* Analysis of variance and descriptive statistical analysis techniques indicated that older preschoolers were more successful puzzlemakers and had greater part-whole perception abilities, than younger preschoolers, among 100 subjects tested; children reported by their parents as spending more time playing with puzzles at home were more skillful puzzlemakers.

Levy-Tacher, E.* & Readdick, C.A. (2006). The relation between aggression and creativity among second graders. *Creativity Research Journal, 18*(3), 261-267. Pearson product moment correlations suggested a positive relationship between verbal aggession and fluency, flexibility, and originality of the Verbal Torrance Test of Creative Thinking (TTCT), between threats of aggression and verbal flexibility, and between physical aggression and figural flexibility (Figural TTCT) among 32 young children observed and tested in their elementary school.

Readdick, C.A. (2006). Noise and its management in early childhood settings. *Dimensions of Early Childhood*, *34*(1)*,* 17-22.
Outlines the science of hearing, reviews research on the effects of noise on the human young and measurements of noise in early care and education environments, and recommends means for reducing physical and social environmental noise in these settings.

Readdick, C.A. & Schaller, R.* (2005). Summer camp and self-esteem of school-age inner-city children. *Journal of Perceptual and Motor Skills, 101,* 121-130.
T-tests indicated significant increases in 68 school-age inner-city children's overall self-esteem and perceptions of popularity from beginning to end of a brief summer camp. E.O. Wilson's theory of *biophilia* is used as an organizer of qualitative data collected through selected child interview and participant observation to explain the possible contribution of nature to self-esteem.

Readdick, C.A. (2005). Is its just me or is it noisy in here? Sound management in early care and education settings. *Texas Child Care Quarterly, 28*(4), 4-42.
Provides a brief sound survey to be used by educaregivers to identify sources and intensity of noise in the child care environment and offers simple noise abatement strategies.

Marty, A.**, Readdick, C.A. & Walters, C. (2005). Supporting secure parent-child Attachments: The role of the non-parental caregiver. *Early Child Development and Care, 175*(3), 271-283.
The theory of attachment of Bowlby, the bioecological theory of Bronfenbrenner, and a review of the scientific literature regarding parent-child attachment and non-parental caregiver-child attachment combined with best practices in early care and education provide a practical framework for the consideration of the role of the non-parental caregiver in the promotion and support of secure parent-child attachments during infancy and toddlerhood.

Lazar, R.* & Readdick, C.A. (2004). Environmental education in a Florida sinkhole. *Children Our Concern, 27*(1), 11-15.
Presents Florida's hundreds of thousands of sinkholes as compelling and scientifically significant geological structures appropriate for safe, hands-on exploration and offers activities for learning for preschool and school-age children.

Thackeray, A. M.* & Readdick, C.A. (2003). Preschoolers' anatomical knowledge of salient and non-salient sexual and non-sexual body parts. *Journal of Research in Childhood Education, 18* (2), 141-148
Analysis of variance and descriptive statistical procedures indicated that 99 four-year-old children demonstrated greater knowledge of salient than non-salient body parts and that most used slang terms or failed to label sexual body parts of a same-gender anatomically correct doll.

Black, C., Grise, K. S., Heitmeyer, J. R., & Readdick, C. A. (2001). Sun protection: Knowledge, attitude and perceived behavior of parents and observed dress of preschool children. *Journal of Family & Consumer Sciences Research Journal, 30* (1), 93-109.
Description statistics indicated that among 100 preschoolers observed during summertime outdoor play at selected childcare centers few wore sun protective apparel counter to their parents'/guardians' high and significantly, positively correlated sun protection knowledge, attitudes, and perceived behaviors. Contemporaneous observations in 15 retail stores revealed a limited supply of sun protective apparel products for children.

Readdick, C.A. & Chapman, P. (2000). Preschoolers' perception of time out. *Journal of Research in Childhood Education, 15* (1), 81-87.
Chi square analysis indicated largely negative self-attributions expressed by 42 preschoolers subsequent to a time-out experience, including feeling alone, disliked by one's teacher, and ignored by one's peers.

Readdick, C.A. & Chapman, P. (2002). Preschoolers' perception of time out. In M.L. Patten (Ed.) *Evaluation and psychological research: A cross section of journal articles for analysis and evaluation*. Los Angeles, CA: Pyrczak Publishing.

Readdick, C. A. & Douglas, K. (2000). More than line leader and door holder: Engaging young children in real work in the early childhood setting. *Young Children, 55* (6), 63-70.
Develops an ecological perspective for the consideration of children's work with adults, reviews literature on children's work, and offers recommendations for inclusion of opportunities for child work in early childhood settings, based on interviews with 81 child care directors and descriptive statistical analyses.

Hill, E. W., Mullis, R. L., Readdick, C. A., & Walters, C. M. (2000). Intergenerational perceptions of attachment and prosocial behavior. *Marriage & Family Review, 30* (1/2), 59-72.
Multivariate analyses of variance and paired T-tests indicated perceptions of maternal attachment were greater for female adolescents than mothers and greater for maternal grandmothers than mothers among 117 family triads. Mothers reported greater prosocial behavior than adolescents and grandmothers.

Mullis, R. L., Hill, E. W., & Readdick, C. A. (1999). Attachment and social support among adolescents. *Journal of Genetic Psychology, 160* (4), 500-502.
Multivariate analyses of variance indicated that high perceived social support from friends and relatives is associated with perceived attachment to mothers, especially for younger adolescents, among a sample of 615 male and female adolescent, ages 15-21.

Readdick, C. A. & Park, J.*, (1998). Achieving great heights: The climbing child. *Young Children, 53* (6), 14-19.
Reviews research regarding development of climbing abilities in early childhood, develops rationale for the inclusion of opportunities for climbing in early childhood environments, and offers recommendations for caregiver activity and environmental design.

Readdick, C.A. & Mullis, R.L. (1997). Adolescents and adults at the mall: Dyadic interactions*. Adolescence, 32* (126), 313-322.
Chi square analysis indicated differences in conversation and shopping evidence between 865 teen-teen dyads and 190 teen-adult dyads as well as several gender and racial differences in within teen-teen dyad comparisons.

Heitmeyer, J.R., Grise, K.S., & Readdick, C.A. (1997). Selection and acquisition of children's clothing in single-parent and dual-parent families. *Journal of Fashion Marketing and Management, 1* (4), 333-341.
One-way analysis of variance procedures were employed to reveal only differences in lack of money and in method of payment for purchase of children's clothing between 247 single-and dual-parent families with school-age (K-12) children.

Hill, E.W., Mullis, R.L., Readdick, C.A., & Walters-Chapman, C.M. (1996). Family connections and altruism: Intergenerational perceptions. *Family Science Review, 9* (3,4), 249-261.
Analysis of variance and Pearson product moment correlations were used to indicate neither perceptions of maternal nor paternal attachment in one generation was predictive of that of any other generation for 33 triads of adolescent daughters, mothers, and maternal grandmothers.

Readdick, C.A., Grise, K.S., Heitmeyer J.R., & Furst, M.H. (1996). Elementary school-age children and their clothing: The development of self-perception and management of appearance. *Journal of Perceptual and Motor Skills, 82,* 383-394.
Descriptive and chi square statistics indicated that the 223 children in kindergarten through grade 5 expressed highly positive feelings about their school clothing, that younger children had more positive appraisals of their own clothes, as compared to their friends' clothes, than older children, and that older children were more involved in clothing purchase and care than younger children.

Readdick, C.A. (1995). Young children's symbol making tools and factors affecting their selection use: An international survey. *International Journal of Early Years Education, 3*(1), 93-100.
Descriptive statistics indicated standard size pencils and crayons are most frequently available drawing and writing tools for young children in 41 countries worldwide and that commercial tool availability was associated with human development indices within countries.

Readdick, C.A. (1994). Toddlers and preschoolers drawing with primary and standard pencils, markers, and crayons. *Journal of Research in Childhood Education, 9*(1), 68-74.
T-tests and Pearson product moment correlations were used to demonstrate the similarity of grips and drawings produced with standard and primary instrument and the relationship of early manipulative experience at home, such as cutting with scissors, to children's more mature drawing performances and products.

Zeegers, S.K., Readdick, C.A., & Hansen-Gandy, S. (1994). Day care children's establishment of territory to experience privacy. *Children's Environments, 11* (4), 265-271.
Interviews with 100 randomly selected preschoolers in 10 child care centers indicated that the majority of young children select special places for themselves, establishing territory as a means for achieving privacy in their group child care settings.

Ghazvini, A.S.* & Readdick, C.A. (1994). Parent-caregiver communication and quality of care in diverse child care settings. *Early Childhood Research Quarterly, 9*, 207-222.
Analysis of variance and Pearson product moment correlations were used to demonstrate that the frequency and importance of one-way, two-way, and three-way communications as perceived by 201 parents and 41 caregivers are related to assessments of quality in 12 child care centers.

Readdick, C.A. & Mullis, R.L. (1994). The Playground Improvement Project: A model for university and community collaboration. *International Play Journal, 2,* 155-163. Affords university and child care center personnel a structure for working together to enhance the safety and quality of outdoor play environments, based on survey and three years of work with 33 child care centers.

Readdick, C.A. & Walters-Chapman, C. (1994). Designing and arranging child care environments to promote parent-child attachment. *Texas Child Care, 18*(2), 2-7. Provides a framework derived from theory, research, and practice for consideration of the role of the caregiver promoting parent-child attachment through design and arrangement of child care environments.

Readdick, C.A. & Bartlett, P.M. (1994). Vertical learning environments: Extending young children's opportunities for play and learning in the early childhood classroom. *Childhood Education, 71*(2), 86-90.
Offers a constructivist perspective and pedagogical framework for the use of vertical surfaces arranged with 2- and 3-D objects that afford children opportunities for perception, manipulation, interaction, construction of knowledge, and representation.

Bradbard, M.R., Brown, E.G., Endsley, R.C., & Readdick, C.A. (1994). Parents' selection of proprietary day care centers for their children: A study of three southeastern university communities. *Child & Youth Care Forum, 23*(1), 55-72. Analysis of variance and Pearson product moment correlations were employed to reveal that neither demographic variables of 145 parents nor day care selection variables were associated with parents' selection of better quality day care in 25 centers.

Readdick, C.A. (1993). Solitary pursuits: Supporting children's privacy needs in early childhood settings. *Young Children, 49* (1), 60-64.
Reviews literature on privacy and addresses why children need privacy, how children seek privacy, factors influencing children's privacy needs, and how adults can support children's privacy needs.

Readdick, C.A. & Walters-Chapman, C. (1993). Is play the centerpiece of your early childhood curriculum? *Early Child Development and Care, 81*,123-129. Presents early childhood educators with the values, means for identification, and techniques to support practice, pretend, and constructive play.

Readdick, C.A. (1987). Schools for the American nanny: Training in-home child care specialists. *Young Children, 42*(4), 72-79.
Describes the role of the nanny, presents programs of training of eleven accredited nanny schools, and offers recommendations for elevating professionalism in the in-home child care field.

Readdick, C.A., Goldbeck, S.L., Klein, E.L., & Cartwright, C.A. (1984). The child-parent-teacher conference: A setting for child development. *Young Children, 39,* 67-73. Presents a rationale and working model for including children in parent-teacher conferences and methods for helping children to become progressively active decision-makers within the conference setting.

Readdick, C.A., Goldbeck, S.L., Klein, E.L., & Cartwright, C.A. (1984). The child-parent-teacher conference: A setting for child development. In J. Brown (Ed.), *Administering Programs for Young Children*. Washington, D.C.: NAEYC.

Endsley, R.C., Bradbard, M.R., & Readdick, C.A. (1984). High-quality proprietary day-care: Predictors of parents' choices. *Journal of Family Issues, 5*(1), 131-152. Stepwise regression analyses were conducted to show that level of husband's education and dissatisfaction with previous day care arrangements were among significant predictors of 257 parents selecting a quality program in 18 licensed centers.

Bradbard, M.R., Endsley, R.C., & Readdick, C.A. (1983). How and why parents select profit-making day care programs: A study of two southeastern college communities. *Child Care Quarterly, 12(*2), 160-169.
Interviews with 86 parents whose children attend six profit-making day care centers indicated parents more likely to receive initial information about day care from friends and neighbors and to visit prior to enrollment only the one program their child attended.

Santrock, J.W., Readdick, C.A., & Pollard, L. (1980). Social comparison in sibling and peer relations. *The Journal of Genetic Psychology, 137*, 91-107.
Analysis of variance procedures were performed to indicate that the social behavior of 40 5-to-8 year-old boys was most disrupted when they received fewer rewards from their mother in an experimental setting than their brother and that, after "low" social comparison experiences with a peer confederate; 20 6-to-8 year-old girls engaged in more negative behavior and less socially competent behavior with their sisters.

REFEREED PUBLICATIONS
PENDING REVIEW

Gilbert, P.** & Readdick, C.A. (under review). Marital satisfaction in forgiving and unforgiving families. *Journal of Marital and Family Therapy*.

Hessell, S.* & Readdick, C.A. (under review). Parent and teacher perceptions of children's multiple intelligences. *Journal of Research in Childhood Education.*

Zeegers, S. K.** & Readdick, C. A. (under review). A content analysis of the *Journal of Home Economics*, 1909-1994: A legacy of concerns for children. *Family & Consumer Sciences Research Journal.*

Readdick, C.A. & Birkin, B.O.* (under review). Development of climbing in two young children with Down syndrome. *Journal of Perceptual and Motor Skills.*

Readdick, C. A., & Alexander, E. K.* (under review). Social support networks and parenting stress of stay-at-home mothers. *Parenting: Science and Practice.*

Mercer, N.W.* & Readdick, C. A. (under review). Developmentally appropriate naptime practices for young children in group settings. *Young Children.*

Lee, K.G.*, & Readdick, C.A. (under review). Locus of control and self-esteem in hospitalized children with cancer and sickle cell anemia. *Child: Care, Health & Development.*

Readdick, C.A., Gatz, A.O., & Chatterjee-Graf, S. (under review). A longitudinal assay of noise in one early care and education setting. *Early Childhood Research Quarterly.*

Jianhong, R.** & Readdick, C.A. (under review). Ethnic identity, self-esteem and depression among young Chinese adolescents residing in the United States. *Journal of Early Adolescence.*

ARTICLES IN PREPARATION

Readdick, C.A. & Huffman, C. (in preparation). The Baby House: A design for the Gwen Cherry Child Development Center Community Partnership Project.

Taliano, K. & Readdick, C.A. (in preparation). Young school-age boys' running a foot race and making social comparisons with friends and non-friends. *Child Development.*

Readdick, C. A. (in preparation). Child care center design and programming for the 21st century: A synthesis of home, school, and orphanage.

Readdick, C. A. (in preparation). The affordances of modeling compounds for manipulation, construction of physical knowledge, and creativity.

Thackeray, A. D.** & Readdick, C. A. (in preparation). Children's relational perceptions of God.

Readdick, C. A., & Smith, L. T.*, (in preparation). The effects of cooperation, competition, and friendship on young children's communicative behavior.

Readdick, C. A., & Fritzen, R. S.*, (under review). Supersitters: Adolescents who provide extensive care for siblings and non-siblings.

Saxby, E.** & Readdick, C. A. (in preparation). Adolescent community service involvement

Gatz, A., Peterson, G., Hicks, M. & Readdick, C. A. (in preparation). The Parent Attachment Scale: A construct validity study.

Lampkin, C.* & Readdick, C.A. (in preparation). Bedtime rituals and behaviors: Relationship to young children's temperament, social acceptance, and social competence.

Lin, H.*, & Readdick, C.A. (in preparation). Creativity and academic achievement among Chinese and American preschoolers.

Hall, L.S.*, & Readdick, C.A. (in preparation). The mother-daughter relationship as context for the development of adolescent daughter's body image, self-esteem, and weight preoccupation.

Readdick, C.A, & Troeger, B.J. (in preparation). The effects of cooperation, competition, and friendship on the artistic merit of children's drawings.

Readdick, C.A. (in preparation). Sibling and non-sibling caregiving experiences of adolescents.

NONREFEREED PUBLICATIONS (INVITED)

Readdick, C.A. (2004). Foster Grandparents: Making a case for paid intergenerational volunteers. *Journal of Intergenerational Relationships*, 2, (1).

Readdick, C.A. (2003). Is it just me or is it noisy in here? Sound and its management in early childhood education and care settings. Florida Children's Forum.

Readdick, C.A. (2003). Noise and its management in early childhood settings: A technical assistance manual. Florida Children's Forum Technical Assistance Paper Series.

BOOK CHAPTERS UNDER REVIEW

Readdick, C. A. & Douglas, K. (under review). Engaging young children in real work. In Nimmo. J. (Ed). *In real life: Connecting young children to the wider world of adults in the community*. Teachers College Press.

BOOKS UNDER REVIEW

Readdick, C.A. (under review). *What can baby do?* Peachtree Press.

Readdick, C. A. (under review). *One girl's day: A specimen record of behavior*, Oxford University Press.

Readdick, H. & Readdick, C.A. (under review). *Good day sun*, Houghton Mifflin.

Readdick, C. A., Winegard, N. & Valenza, V. (under review). *It's in the Bag: Single portion cooking with young children*, Southern Early ChildhoodAssociation.

Readdick, C.A. & Mercer, N.W. (under review). *More it's in the bag: Single portion cooking with young children*, (under review) Southern Early Childhood Association.

Readdick, C.A. & Coble, D. N. (under review). *Where does it grow? A first book of foods and cooking for young children*, Pleasant Company Publications.

BOOKS IN PREPARATION

Readdick, C. A. & Douglas, K. *Arts and crafts for young children.*

Readdick, C.A. *Paying attention to children: A child study guide.*

Readdick, C.A. *Child guidance for democratic living in a changing world.*

Mullis, R.L., Mullis, A. & Readdick, C.A. *Middle childhood: Development in context from five through twelve years of age*.

VIDEOTAPES IN PREPARATION

Readdick, C. A. & Purvis-Montford, E. (in preparation). Teachable Moments.

Readdick, C. A. & Purvis-Montford, E. (in preparation). Transitions.

Readdick, C. A. & Purvis-Montford, E. (in preparation). Trust.

VIDEO TAPE REVIEWS

Readdick, C.A. (1995). Different and the same by Susan Linn, *Dimensions of Early Childhood.*

BOOK REVIEWS

Readdick, C.A. (in press). *Collaborative treatment of traumatized children and teens: The trauma systems therapy approach.* By Genn N. Saxe, B. Heidi Ellis, & Julie B. Kaplow, in *Traumatology.*

Readdick, C.A. (Fall 2005). Extracting lessons on VPK from *Bowling alone: The collapse and revival of American community*, by Robert D. Putnam, in *Florida's Child, 5*(2), 26-27.

Readdick, C.A. (Summer 2005). *Starting out right: A guide to promoting children's reading success*, edited by M. Susan Burns, Peg Griffin, & Catherine E. Snow, in *Florida's Child, 5*(1), 29-30.

Readdick, C.A. (Spring 2005). Taking one step at a time: A review of *When your child has a disability: The complete sourcebook of daily and medical care*, edited by Mark L. Batshaw, in *Florida's Child, 4*(4), 29-31.

Readdick, C.A. (Winter 2005). *Leave no child behind: Preparing today's youth for tomorrow's world*, by James P. Comer, in *Florida's Child, 4*(3), 29,31.

Readdick, C.A. (Fall 2004). *All work and no play—How educational reforms are harming our preschoolers*, by Sharna Olfman, in *Florida's Child, 4*(2), 30-31.

Readdick, C.A. (Summer 2004). Just talk, Florida: Reflections on *Meaningful differences in the everyday experience of young American children* and *The social world of children learning to talk*, by Betty Hart and Todd R. Risley, in *Florida's Child, 4*(1), 29-31*.*

Readdick, C. A. (Winter 2004). *The first three years & beyond: Brain development and social policy*, by Edward Zigler, in *Florida's Child, 3* (3), 25.

Readdick, C. A. (Fall 2003). *Time to care: Redesigning child care to promote education, support families, and build communities*, by Joan Lombardi in *Florida's Child, 3* (2), 31.

Readdick, C.A. (1997). *Literacies lost: When students move from a progressive middle school to a traditional high school*, by M. Cyrene Wells in the *Journal of Adolescence, 20*, 343-349.

Readdick, C.A. (1996). *Child play: Its importance for human development*, by Peter Slade in *The American Journal of Family Therapy, 24* (2), Summer 1996.

Readdick, C. A. (1995). *How to talk to your kids about really important things*, by Charles E. Schaefer & Teresa Foy DiGeronimo in *The American Journal of Family Therapy, 23* (1), Spring 1995.

INTERNATIONAL REFEREED PRESENTATIONS

Readdick, C.A. The geosystem and globalization: Differential effects of the natural environment on child and family well-being. Groves Conference on Marriage and Family, Ireland, June 2008.

Readdick, C. A. & Robinson, J.K. Oklahoma City eastside children's neighborhood mappings: Representations of risk and resilience in the physical and social environments. Groves International Conference on Marriage and the Family, Oklahoma City, Oklahoma, May 2004.

Readdick, C. A. Escuela Ricardo Diaz Rodriguez: Young children and the "natural elements". Groves International Conference on Marriage and the Family, Miami, Florida, June 2003.

Readdick, C. A. & Thackeray, A. D. Children's relational perceptions of God: Stories and portraits of selected preschoolers, school-agers, and adolescents. Groves International Conference on Marriage and the Family, Chautaugua, New York, June 2002.

Readdick, C. A. & Alexander, E. K. Social support networks and parenting stress of stay-at-home mothers. Groves International Conference on Marriage and the Family, Ashville, North Carolina, June 2000.

Levy-Tachter, E. & Readdick, C.A. The relationship of creativity and aggression in selected second graders. Annual Symposium of the Jean Piaget Society, Mexico City, June 1999.

Grise, K. S., Black, C., Heitmeyer, J. R., & Readdick, C. A. Sun protective clothing for young children in preschool settings. International Textile and Apparel Association Annual Meeting, Santa Fe, November 1999.

Readdick, C. A., Children's work and play in declining economies. Groves International Conference on Marriage and the Family, Digby, Nova Scotia, June 1997.

Heitmeyer, J.R., Grise, K.S., & Readdick, C.A. Selection and acquisition of children's clothing in single-parent and dual-parent families. International Textile and Apparel Association, Annual Meeting, Pasadena, November 1995.

Readdick, C.A., Heitmeyer, J.R., & Grise, K.S. Elementary school-age children and their clothing: The development of appearance management and perception abilities. International Textile and Apparel Association Annual Meeting, Minneapolis, November 1994.

Readdick, C.A. An international survey of children's symbol- making tools and factors influencing their selection and use. International Federation of Home Economics Congress. Hanover, Germany. July 1992.

Readdick, C.A., Goldbeck, S.L., Klein, E.A., & Cartwright, C. Including the child in parent-teacher conferences. The 58th Annual International Council on Exceptional Children Convention, Philadelphia, Pennsylvania, April 1980.

Willis, S.L., Goldbeck, S.L., & Readdick, C.A. Assessing children's involvement in a Piagetian-based classroom. Jean Piaget Society Eighth Annual Symposium, Philadelphia, May 1978.

INVITED INTERNATIONAL PRESENTATION

Readdick, C. A. Building a community partnership: The Gwen Cherry Child Development Center. Universidad Nacionale, Heredia, Costa Rica, June 2000.

NATIONAL REFEREED PRESENTATIONS

Readdick, C.A. & Hanline, M.F. (under review). Who wants to be an early intervention specialist?: Student demographics, knowledge, and values. U.S. Department of Education, Office of Special Education Programs, Project Directors' Conference, Washington, DC, July 2008.

Readdick, C.A. & Hanline, M.F. Preparation of highly qualified early intervention personnel at Florida State University. U.S. Department of Education, Office of Special Education Programs, Project Directors' Conference, Washington, DC, July 2005.

Readdick, C. A. Noise abatement: A necessary first step in early language development and literacy. National Association for the Education of Young Children, Chicago, IL, November 2003.

Readdick, C. A. Content and function of children's social comparison statements as influenced by incentive, friendship status, age, and gender. Society for Research in Child Development Biannual Conference, Albuquerque, NM, April 1999.

Hill, E. W., Mullis, R. M., Readdick, C. A., & Walters, C. M. Intergenerational perceptions of attachment and prosocial behavior. National Council on Family Relations Annual Conference, Washington, D.C., November 1997.

Walters-Chapman, C.M., Readdick, C.A., Hill, E.W., Mullis, R.L., & Bush, C. Female adolescents' perceptions of parental behavior and social support as factors in parental support. National Council on Family Relations Annual Conference, Portland, November 1995.

Readdick, C.A., Mullis, A.K., Eldridge, L., Goldbeck, S.L., Klein, E.A, Mize, J. & Fu, V. The problem of the match: Overcoming cognitive barriers to learning developmentally appropriate practice. National Association for the Education of Young Children Annual Conference, Atlanta, November 1994.

Troeger, B.J. & Readdick, C.A. The ART Scale: A measurement for assessing the artistic merit of children's drawings. National Art Education Association Annual Conference, Chicago, April 1993.

Bradbard, M.R., Endsley, R.C., Brown, E.G., & Readdick, C.A. How and why parents select profit-making day care for school-age children: A study of three communities. National Council on Family Relations Annual Conference, Orlando, November 1992.

Readdick, C.A. That fat primary pencil: Should we be writing it off? National Association for the Education of Young Children Annual Conference, Atlanta, November 1989.

Readdick, C.A., & Bartlett, P.M. A Piagetian reconsideration of bulletin boards in the early childhood classroom: Vertical learning environments for child construction of knowledge and representation. National Association for the Education of Young Children Annual Conference, Detroit, November 1981.

Peters, D.L., Klein, E.A., Readdick, C.A., & Goldbeck, S.L. Where to look for the child in early childhood education. National Association for the Education of Young Children Annual Conference, New York, November 1978.

REGIONAL REFEREED PRESENTATIONS

Readdick, C.A. & Douglas, K. More than line leader and door holder: Engaging young children in real work in the early childhood setting. Southern Early Childhood Association Annual Conference, Louisville, March 1998.

Readdick, C.A. Little tools for little hands: Selecting crayons, markers, and pencils for young children. Southern Early Childhood Association Annual Meeting, Orlando, March 1995.

Readdick, C.A. Social comparison processes in mother-child sibling interaction: Effects on the child's social competence. Southeastern Psychological Association 22nd Annual Meeting, New Orleans, March 1976.

Readdick, C.A. Social comparison in maternal sibling interaction: A preliminary report. Inter-Institutional Conference on Child and Family Development, Athens, Georgia, November 1975.

STATE REFEREED PRESENTATIONS

Readdick, C.A. Reducing noise and promoting early language development in early care and education settings. Early Childhood Conference of Florida, Orlando, FL, September, October 2004.

Readdick, C. A. & Winegard, N. More it's in the bag: Single portion cooking with young children. Early Childhood Conference of Florida, Orlando, Fl, September 2003.

Readdick, C. A. Noise abatement: A missing first step in early literacy programs. Florida Children's Forum Leadership Conference, Orlando, FL, November 2002.

Winegard, N. & Readdick, C. A. Developmentally appropriate naptime practices. Early Childhood Association of Florida Conference, Orlando, September 1998.

Readdick, C.A., Valenza, V. & Winegard, N. It's in the bag: Single-portion cooking with young children. Early Childhood Association of Florida Conference, Orlando, September 1997.

Readdick, C.A. & Park, J. Climbing: Skills and activities for young children. Early Childhood Association of Florida Conference, Orlando, September, 1996.

Readdick, C. A. The child-parent-teacher conference: A setting for child development. Florida Association for Childhood Education International Annual Conference, Tallahassee, March 1989.

STATE INVITED PRESENTATION

Readdick, C.A. Designing classroom environments. Florida Partnership for School Readiness Quality Initiative Symposium, Tampa, FL January 2005.

LOCAL REFEREED PRESENTATIONS

Readdick, C.A., Levy-Tacher, E. & McCants, M. (under review). What can little children do with modeling clay, play dough, and Model Magic? Seventeenth Annual Early Childhood Conference, Tallahassee, FL, 2008.

McCants, M. & Readdick, C.A. Celebrations: The ties that bind us together. Sixteenth Annual Early Childhood Conference, Tallahassee, FL, February 2007.

Readdick, C.A. Talking with young children: The key to reading success. Fourteenth Annual Early Childhood Conference, Tallahassee, FL, March 2005.

Readdick, C. A. & McCants, M. Playmaking: The art and craft of the professional educaregiver. Twelfth Annual Early Childhood Conference, Tallahassee, March 2003.

Readdick, C. A. & Montford, E.P. Transitions: From terrible to terrific. Twelfth Annual Early Childhood Conference, Tallahassee, March 2003.

Readdick, C. A. & Montford, E. P. Making pancakes with preschoolers and Piaget. Eleventh Annual Early Childhood Conference, Tallahassee, March 2002.

Readdick, C. A. & McCants, M. "It's a beautiful day in the neighborhood": Finding friends, making mentors. Eleventh Annual Early Childhood Conference, Tallahassee, March 2002.

Readdick, C. A. Blowing more bubbles for fun and discovery learning. Tenth Annual Early Childhood Conference, Tallahassee, March 2001.

Readdick, C. A. & Fritzen, R. S. Nursery rhymes for language and laughter. Ninth Annual Early Childhood Conference, Tallahassee, March 2000.

Readdick, C. A. & Fritzen, R. S. Ten-minute fieldtrips. Ninth Annual Early Childhood Conference, Tallahassee, March 2000.

Readdick, C. A. I can blow a bubble! Eighth Annual Early Childhood Conference. Tallahassee, March 1999.

Readdick, C.A. Letting little children do real work. Seventh Annual Early Childhood Conference. Tallahassee, April 1998.

Readdick, C.A. and Park, J. Prescription for healthy skin: Helping Florida's children be sun safe. Sixth Annual Early Childhood Conference. Tallahassee, March 1997.

Readdick, C.A. The climbing child: What we should know and do. Leon Association for the Education of Young Children Annual Conference, Tallahassee, April 1996.

Readdick, C.A. Plants for play in children's outdoor environments. Third Annual Early Childhood Conference, Leon Coalition for Young Children, Tallahassee, May 1994.

Readdick, C.A. More than swinging and sliding: Transforming your playground into an outdoor classroom. Second Annual Early Childhood Conference, Leon Coalition for Young Children, Tallahassee, April 1993.

Readdick, C.A. Buttons, blocks, and beads: Basics for fine-motor development, drawing, and writing. Leon Association for the Education of Young Children, Tallahassee, April 1989.

INVITED PRESENTATIONS

“Managing young children’s diverse needs for sleep.” Beginning Steps Preschool, Tallahassee, October 2006.

“All children are special: Make a place in your program for each child.” with Mary Francis Hanline. Leon Association for the Education of Young Children, Tallahassee, October 2003.

“Tea cakes, wheelbarrow rides, and long johns: Drawing on our own childhood experiences to derive best practices for work with young children.” Elder Care Services, Tallahassee, October 2001.

“Babies are for holding and other bits of wisdom.” Elder Care Services, Tallahassee, March 2001.

“Social skills building with preschoolers.” Tallahassee Community College Extended Studies Program, April 2000.

“Dictator or shepherd: Which parent is best for young children?” Annsworth Academy, Tallahassee, March 2000.

“What to say and do as a volunteer with children.” Kids in the ‘Hood. Tallahassee Parks and Recreation, August, September 1998.

“Vertical learning environments: Expanding opportunities for learning beyond the table top.” Tallahassee Community College Extended Studies Program, May 1998.

“It’s in the Bag: Single portion food preparation.” Leon Association for the Education of Young Children. Tallahassee, January 1998.

“Collecting, hauling, and dumping: Like 2 and growing.” Leon County Early Intervention Program, Tallahassee, November 1996.

“Developmentally appropriate relationships, activities, and environments in early and middle childhood.” Bethel Christian Academy, Tallahassee, August 1996.

“Small symbol-making tools for small children: Developmentally appropriate practice.” Faith Presbyterian Preschool, Tallahassee, January 1996.

"How parents can help their children be creative." Big Bend Community Coordinated Child Care, Tallahassee, June 1995.

"Looking closely at children: Developing observation and recording skills." Capital Area Community Action Head Start, Tallahassee, August 1994.

"Paying attention to children: Issues in child development." Restructuring Home Economics for the 21st Century, College of Human Sciences, Tallahassee, June 1994.

"Basics for fine motor development, drawing, and writing: Selecting child-sized marking tools and other manipulatives." Conference on Children, Waycross College, Waycross, Georgia, February 1994.

"Positive child guidance tips for parents." YMCA Children Playhouse, February 1994.

"Conducting developmentally appropriate field trips with young children." Leon Association for the Education of Young Children, Tallahassee, November 1993.

"Creating outdoor learning environments." Capital Area Community Action Head Start, Tallahassee, August 1993.

"Peacemaking in the family." First Presbyterian Church, Tallahassee, February 1993.

"Children's art and writing." Capital Area Community Action Head Start, Tallahassee, August 1992.

"Six through twelve year olds: Continuity and change." Advent Episcopal Church, Tallahassee, May 1992.

"Child growth and development: Appropriate teaching practices for your child." Capital Area Community Action Head Start, Tallahassee, January 1991.

"Developmentally appropriate teaching practices." School Board of Okaloosa County, Fort Walton Beach, June 1991.

"A descriptive study of toddlers and preschoolers drawing and writing." Florida Home Economics Association District B, Tallahassee, October 1990.

"Understanding child abuse and neglect." Delta Kappa Gamma Tallahassee, March 1988.

GUEST LECTURES

“Using ethnographic techniques to determine child well-being.” HOE 6931, Proseminar, Fall 2007.

“Oh, so babies can climb before they walk! and other discoveries.” HOE 6931, Proseminar, Fall 2006.

“Discovering the competencies of young children through observation.” HOE 6931, Proseminar, Fall 2005.

“A contemporary view of children and families.” The Family Experience: Deconstruction and Construction, Museum of Fine Arts, Florida State University, Summer 2006.

“Never underestimate the competence of little children.” HOE 6931, Proseminar, 2004.

“Tailoring the environment, materials, and activities according to the developmental status and competencies of the individual.” HOE 6931, Proseminar, 2002.

“Applying Science Developmentally: The Gwen Cherry Child Development Center Community Partnership Project.” HOE 6931, Proseminar, 2000.

“Communicating through print media.” HOE 4054, The Educative Process, 1999.

“Developmentally appropriate practice: Middle school and high school-age contexts.” CHD 4250, Contexts for Middle Childhood/Adolescent Development, 1999.

“Promoting language development: Birth to age 8.” CHD 4225, Contexts for Early Childhood Development, 1999.

“Interdisciplinary solutions: Sun protection for young children.” HOE 6938, Proseminar, 1998.

“Working on behalf of children and families in the ‘near’ and ‘far’ environments.” HOE 3050, Development and Trends in Human Sciences, 1997.

"The touch and go of teaching teens." HEE 4941 Student Teaching Seminar, 1996.

“Writing for professional publications.” HOE 6938, Proseminar, 1996.

"Adolescents in Families: Demographic trends and parenting styles." CHD 4240, Adolescent Development, 1995.

"Hypotheses testing in the field." HOE 6017, Research Methods, 1993.

"Writing for the lay audience." HOE 6917, Research Communications, 1991.

"Writing for the public." HOE 6917, Research Communications, 1991.

"Curiosity and child proofing." CHD 3220, Child Growth and Development, 1990.

"Conducting an observational research project with children." HOE 6017, Research Methods, 1990.

"Social comparison as a social cognitive mechanism for the construction of self." CHD 6930, Seminar in Child Development, 1990.

"Conducting an observational research study." HOE 6917, Research Methods, 1989.

"An ecological model of adolescent development." CHD 4240, Adolescent Development, 1989.

COURSES TAUGHT

Florida State University

Child Growth and Development
Child Guidance
Adolescent Development
Adolescent Development and Sexuality
Techniques and Issues in Child Study
Practicum in Child Development: Infancy
Practicum in Child Development: Preschool
Practicum in Child Development: School-Age
Readings in Family and Child Sciences
Contexts of Early Childhood Development
Contexts of School-Age Child and Adolescent Development
Children's Environments: Design and Measurement
Seminar in Child Development: Child Care Issues and Advocacy
Seminar in Child Development: Child Development Issues
Seminar in Child Development: Globalization and Child Wellbeing
Internship in Child Development
Directed Independent Study
Supervised Teaching
Honors Thesis
Thesis
Dissertation
Special Project
Readings in Child Development

Hood College

Child Development
Creative Learning Experiences
Guiding the Behavior of Young Children
Integrating the Early Childhood Curriculum through the Language Arts

Weber State College

Developmental Planning for Young Children
Working with Parents
Learning with Your Child
Early Childhood Education
Organization and Planning of the Preschool Classroom

ADMINISTRATION

Project Director, Gwen Cherry Child Development Center Community Partnership Project, 1999-2002.

Acting Director, Child Development Center, The Family Institute, Florida State University, 1994-2005.

Director, The Sidwell Preschool, Home and Family Life Department, Florida State University, 1987-1991.

Director, Onica Prall Child Development Center, Education Department. Hood College,1979-1981.

Director, The Children's School. School of Education. Weber State College, 1977-1978.

Educational Coordinator, Project Head Start. Ogden, Utah. 1971-1971.

Director, Utah Migrant Council Summer Day Care Center Layton, Utah. 1971.

COMMITTEES

University

Ad Hoc University Smoking Cessation Policy Committee, 2006-present.
University Committee on Faculty Sabbaticals, 2007-2009, 2005-2007, 2003-2005.
Refund Committee, 1998-2003; 1991-1994.
College of Human Sciences Faculty Senate Alternate, 2006-2008, 1999-2001,1994-1996.
Equal Opportunity Committee, 1991-1992.
Teacher Education Advisory Committee, 1991-1999.
College of Human Sciences, Commencement Marshall, 1993-1996.
Ad Hoc University Child Care Committee, 1994-2004.

College

CHS Dean Search Committee, 2006.
Graduate Faculty Status Committee, 2005-present.
Faculty Advisory Committee, 2000-2006, 1996-1999,1991-1995.
Promotion and Tenure, 1997-2000.
Dean's Advisory Committee, 1990-1991.
Curriculum Committee, 1989-1990.
External Development Task Force, 1993-1994
Ad Hoc Recognition Committee, 1993-1994.
CHS Capital Campaign Undergraduate Scholarships Committee, 1994-1997.
Ad Hoc Committee on Research Perspectives, 1994-1995.

Department

Executive Committee, 2006-2007, 2005-2006, 2003-2004, 1995-1999, Chair 1997-1998.
Undergraduate Curriculum Committee, 1995-2003, Chair 1997-1998.
Child Development Curriculum Committee, 1989-1992.
Promotion and Tenure Committee, 1992-1999.
Eminent Scholar Committee, Chairperson, 2000-2002, 1988-1995.

GRADUATE STUDENTS

Major Professor

Dissertation

Hamlin-Glover, D. (in progress). Marriage and Family Therapy.

Levy-Tachter, E. (in progress). Child Development.

Rainey, S. (in progress). Marriage and Family Therapy.

Zahn, S. (in progress). Marriage and Family Therapy.

Marty, A. (2006). Non-parental child care and toddler-mother attachment.

Taliano, K. (2005). Social comparison behavior of young school-age boys.

Gilbert, P. (2004). Marital satisfaction in forgiving and unforgiving families.

Saxby, E. (2000). Adolescent community service involvement.

Thackeray, A. (2000). Young children's relational perceptions of God.

Zeegers, S. (2000). Children's issues in the Journal of Home Economics (1909-1994): A content analysis.

Elk, C. (1999). Adolescent perceptions of parental attachment and MDMA (Ecstasy) use.

Doctoral

Harrington, M. Family Relations.

Keller, K. Family Relations.

Master's Thesis

Brock, L. (in progress). Child Development.

Jianhong, R. (2006). Ethnic identity and psychological adjustment of young adolescents born in China and living in the United States.

Hessel, S. (2004). "Parent and teacher perceptions of school-agechildren's multiple intelligences."

Zhu, Y. (2000). "Grandparenting style, grandparent-parent relationship, and child social competence among selected Chinese families."

Olivieri, B. (1999). "Development of movement patterns in climbing: Two children with Down Syndrome."

Winegard, N. (1998). "Caregiver, parent, and child perceptions of naptime."

Schaller, R. (1998). "Effects of summer camp on self-esteem of school-age, inner-city children."

Alexander, L. (1997). "Social support, stress, and coping among mothers of preschoolers."

Newland, R. (1997). "Social support and self-esteem in early, middle, and late adolescent cancer patients."

Levy-Tachter, E. (1997). "The relationship between creativity and aggression in selected second graders."

Dotolo, A. (1997). "The relationship between anatomical knowledge, self-esteem, and self-concept in selected preschool children."

Park, J. (1997). "Preschoolers' movement patterns while climbing three stationary structures: Slopes, stairs, and ladder."

Purvis, E. (1997). "The relationship between chronological age and spatial reasoning with puzzlemaking strategies in selected preschool children."

Fritzen, R. (1995). "Supersitters: Adolescents caring for siblings and non-siblings."

Lampkin, C. (1995). "Bedtime rituals and behaviors: Relationship with young children's social acceptance and social competence."

Gibbs, K.K. (1995). "Self concept and locus of control in children hospitalized with cancer."

Lin, H. (1994). "The relationship between teaching methods and preschool children's academic achievement and creativity in the People's Republic of China and in the United States."

McGinnis, M. (1994). "The relationship of physical attractiveness, teacher-child attachment, and social competence among preschool children."

Smith, L.T. (1992). "The effects of cooperation, competition, and friendship on children's communicative competence."

Springsteel, A.M. (1992). "The relationship of young children's physical developmental history, physical competence, and peer social acceptance."

Hall, L.S. (1992). "The mother-daughter relationship as context for the development of daughters' body image, self-esteem, and weight preoccupation."

Ducar, K.A. (1992). "The relation of caregiver self-perceived roles and caregiver-child attachments in family day care."

Ghazvini, A.S. (1992). "Perceived frequency and importance of communication patterns by caregivers and parents in subsidized, contracted subsidized, and nonsubsidized child care settings."

<u>Master's Project</u>

Capley, M. (in progress). Child Development.

Washington, N. (in progress). Family Relations.

Kelley, K. (2001). "Preschoolers' perceptions of emotion/color associations.

Lazar, B. (1998). "Environmental education in a Florida sinkhole."

<u>Senior Honors Thesis</u>

Tracy, C. (1993). "Recycle centers: Promoting hands-on learning in the classroom."

Committee Member

Doctoral

Kang, J.H. Art Education.

Chen, Y.S. Communication.

Hoffman, E. Child Development.

Hueber, J. Child Development.

Kalifeh, P. Educational Leadership.

Lin, M. Early Childhood Education.

Seo, H. Family Relations.

Gentry, E. Marriage and Family Therapy.

Moran, D. Marriage and Family Therapy.

Staier, T. (2007). Marriage and Family Therapy.

McKay, K. (2006). Family Relations.

Darden, F. (2006). Communication Disorders.

Birkin, B. (2004). Child Development.

Staing, T. (2004). Marriage and Family Therapy.

McWey, L. (2002). Marriage and Family Therapy.

Spaniol-Mathews, P. (2001). History.

Parducci, A. (2001). Family Relations.

Gatz, A. (2000). Family Relations.

Yu, Y. (2000). Child Development.

Anderson, D. (2000). Child Development.

Park, J. (2000). Child Development.

Myers, R. (2000). Early Childhood Education.

Fontaine, N. (1997). Early Childhood Education.

Ghazvini, A. S. (1997). Child Development.

Ardley, J. (1997). Early Childhood Education.

Littlejohn-Blake, S.M. (1996). Family Relations.

Willmott, K.E. (1994). Early Childhood Education.

Master's Thesis

Incze, C. (2005). Communication Disorders.

Gordon, D. (2001). Child Development.

Prokos, N. (1998). Child Development.

Lin, Y.L. (1997). Child Development.

Trotter, D. (1997). Family and Consumer Science Education.

Flowers, N. (1997). Child Development.

Knothe, R. (1997). Child Development.

Saxby, E. (1997). Child Development.

Zeegers, S.K. (1994). Home Economics Education.

Boudreau, C. (1992). Child Development.

Tacon, A. (1991). Child Development.

Master's Project

Lauw, C. (2006). Child Development.

Birkin, B. (1999). Child Development.

Pericelli, M. (1998). Child Development.

Hicks, W. (1996). Child Development.

Finley, T. (1996). Child Development.

Bergman, A. (1996). Child Development.

Nalls, K. (1995). Child Development.

McBride, K. (1994). Child Development.

Jones, L. (1992). Child Development.

Smith, J. (1991). Child Development.

Galloway, M. (1991). Child Development.

Senior Honor's Thesis

Lee, N. (2003). Psychology.

Presbylick, E. (1998). Psychology.

Kicklighter, C. (1994). Communication.

Drewes, A. (1991). Psychology.

Weissberg, L. (1990). Psychology.

SERVICE

National

Ad Hoc Reviewer, *Traumatology*, Russell Sage Publishers, 2007.
Ad Hoc Reviewer, *Research on Social Work Practice,* Sage Publications, 2006.
Consultant, Binney & Smith, The Crayola Company, Tallahassee, FL, December 2002.
Member, National Advisory Committee on Early Care and Education, The Institute for Women's Policy Research, Washington, DC 2001 – 2005.
Consultant, Binney & Smith, The Crayola Company, Easton, PA, June 2001.
Consultant, Schwartz, Cooper, Greenberger & Krauss, Chicago, IL, August 2001.
Consultant, Binney & Smith, The Crayola Company, Bethlehem, PA, October 1998.
Consultant, Binney & Smith, The Crayola Company, Bethlehem, PA, May 1997.
Participant/Representative for Florida State University, National Summary Meeting, Stresses on Research and Education at Colleges and Universities. NSF National Science Board and NAS Government-University-Industry Round Table (GUIRR) Washington, D.C., December 1993.
Consultant, Binney & Smith, Easton, PA, June 1989.
Consultant, Child Development Advisory Committee, Binney & Smith, The Crayola Company, New York, April 1989.

State

Steering Committee, Parents' and Children's Day, 2003-2006.

Associate, Florida Inter-University Center for Child and Family Studies, 1994-present.

Critical Review Committee, 30-Hour Introductory Child Care Training Module, Child Care and Prevention, Department of Health and Rehabilitative Services, 1994.

Critical Review Committee, Family Day Care 30-hour Training Module, Child Care and Prevention, Department of Health and Rehabilitative Services, 1991.

Expert Witness, provided testimony and materials on regulatable features of quality in child care, including caregiver training, adult child ratio, and indoor square footage, in support of Child Care Plus Bill, Florida Legislature, March 1991.

Local

Chair, Tallahassee-Leon County Steering Committee, Parent' and Children's Day 2004, 2003.

Board of Directors, School for the Arts and Sciences, Tallahassee, 2005-2008, 2002-2005.

Board of Directors (President 1995-1998), Kids, Inc. (formerly Big Bend Community Coordinated Child Care), Tallahassee, 1991-2004.

Board of Advisors, Florida State University Alumni Village Child Development Center, 1993-2004.

Advisory Committee, YMCA Children's Playhouse, Tallahassee, 1994-1996.

School Advisory Committee, Leon Early Intervention Pre-Kindergarten Program, Little Chaires School, Tallahassee, 1993-1997.

Faculty Advisor, Alpha Chi Omega Sorority, 1994-2000.

Planning Committee, Faculty Luncheon Series, Presbyterian University Center, Tallahassee, 1994-1995, 1998-1999, 1999-2000, 2004-2005, 2007-2008.

Family Columnist, Tallahassee Democrat, Tallahassee, March 1995-1999.

Parenting Columnist, Tallahassee Democrat, Tallahassee, March 1986-February 1987.

REVIEWER

Textbooks

Adolescence, McGraw-Hill, June 1997.

Adolescence: Continuity, Change, and Diversity, Third Edition, Mayfield Publishing Company, October 1996.

A Child's World, Seventh Edition, McGraw-Hill, Inc. October 1994.

Adolescence, Third Edition, Harcourt Brace College Publishers, July 1994.

Adolescence, A Contemporary View, Third Edition, Harcourt Brace, February 1993.

Adolescence, Steps to the Future, Mayfield Publishing Company, April 1989.

CURRICULUM VITAE
Kimberly Elaine Stone, MD, MPH

Date: December 4, 2007

Contact Information:

Home
4 Woodby Drive
Sunningdale Berkshire
SL5 9RD
United Kingdom
Email: kimstonemd@yahoo.com

US Mailing Address:
c/o Jeffrey Pearson
Consumer Europe Maidenhead
PO Box 950
New Brunswick, NJ 08903

Education and Training:

Years	Institution	Degree/Program
1988-1991	University of Pennsylvania Philadelphia, Pennsylvania	Bachelor of Arts
1992-1996	University of Cincinnati Cincinnati, Ohio	Doctor of Medicine
1996-1999	Children's Hospital Medical Center Cincinnati, Ohio	Internship/Residency Pediatrics
2003-2006	The Johns Hopkins University School of Medicine Baltimore, Maryland	Fellow, General Pediatric Academic Development
2004-2005	Johns Hopkins University Bloomberg School of Public Health Baltimore, Maryland	Master of Public Health

Honors:

1991	University of Pennsylvania	Graduated Magna Cum Laude
1996	University of Cincinnati	Class Valedictorian
1995		Alpha Omega Alpha Honor Society
1996		Carl Wiehl Exellence in Pediatrics Award
1996		American Medical Women Association's Outstanding Student Award
1996		Dr. and Mrs. Robert E. Ott Award
1996		Stella Feis Hoffheimer Award
1992-1996		Daughters of the American Revolution Scholarship
2005	Johns Hopkins University	Delta Omega Honor Society
2005		Injury Certificate

Professional Experience:

1999-2001	Eastgate Pediatrics, Southern Ohio Health Services Network Pediatrician Center Director
2001	Columbus Children's Hospital Pediatric Clinics Clinical Instructor
2001-2002	Columbus Children's Hospital Urgent Care Assistant Professor, Pediatrics
2005-Nov 2007	Greater Baltimore Medical Center Pediatric Hospitalist and Emergency Care Physician
Sep 2006-Nov 2007	Sheppard Pratt Hospital Pediatric and Primary Care Consultant

Research Activities:

Peer Reviewed Scientific Articles

Stone KE, Lanphear BP, Pomerantz WJ and Khoury J. Childhood injuries and deaths due to falls from windows. *J Urban Health*. 2000;77(1):26-33.

Stone, KE, Burrell, L, Higman, S, McFarlane, E, Fuddy, L, Sia, C and Duggan, AK. Agreement of injury reporting between primary care medical record and maternal interview for children age 0-3 years: implications for research and clinical care. *Ambulatory Pediatrics*. 2006;6(2):91-95.

Stone KE, Eastman EM, Gielen AC, Squires B, Hicks G, Kaplin D, Serwint, JR. Home Safety in Inner Cities: Prevalence and Feasibility of Use in Inner-City Housing. *Pediatrics.* 2007;120(2):e1-e346-353.

Published Abstracts

Stone KE, Duggan AK, Burrell L, Sia, C. Can Home Visitation in Early Childhood Reduce Injuries? *Pediatric Research Abstract Issue*, 2004 April 55(4): Abstract #1982. Presented at the Pediatric Academic Societies' Annual Meeting, May 4, 2004, San Francisco, CA.

Review Articles/Non Peer-Review

Stone, Kimberly E., Lead Screening in Maryland. *The Maryland Family Doctor.* 2004 41(1):12-13.

Stone, Kimberly E., Home Safety – It's No Accident. *Healthy Start Newsletter.* August 2005.

Stone, Kimberly E. and Serwint, Janet R. Otitis Externa. Pediatrics in Review. 2007;28(2):77-78.

Research Presentations

Can Home Visitation in Early Childhood Reduce Injuries? *Presented at the Ambulatory Pediatric Association Region IV Meeting,* January 17, 2004.

Can Home Visitation in Early Childhood Reduce Injuries? *Presented at the Pediatric Academic Societies National Meeting*, San Francisco, California, May 3, 2004.

Safety in the City: Environmental Appropriatness of Safety Supplies in Low-Income, Urban Populations, *Presented at the Ambulatory Pediatric Association Region IV Meeting,* Charlottesville, VA, January 14, 2006.

Extramural Sponsorship:

Research Support

July 2004-June 2006
Project Title: "Design, Implementation and Evaluation of an Injury Prevention Protocol in an Established Home Visitation Program"
Funding Agency: Thomas Wilson Sanitarium of Baltimore City
Total Direct Costs: $19,922
Role: Principal Investigator

Training Support

2003-present
5 D14 HP 00118
Faculty Development in Primary Care Award Training Grant
Health Resources and Services Administration, Bureau of Health Professions
(Stipend and Tuition Support)

Educational Activities:

Clinical Teaching

2000-2001 University of Cincinnati College of Medicine
Preceptor, 1st year medical student Clinical Pediatrics Rotation.

- Provided opportunity for first year medical students to experience pediatric practice in a private office setting.

2001-2002 Columbus Children's Hospital
Clinical Instructor

- Supervised residents and medical students 1-2 days per week
- Attending physician at Case Conference quarterly

2003-present Harriet Lane Primary Care Clinic
Preceptor

- Provide clinical supervision to pediatric residents and medical students two ½ days per week.
- Contribute to primary care curriculum design
- Lead weekly small group evidence-based didactic sessions.
- Participate in monthly journal clubs and case conferences.
- Assist with development and implementation of structured clinical observation tool.
- Lead corporate fund-raising for "Share the Spirit" campaign, which provides holiday gifts for the clinic's neediest families.

Workshops and Presentations

Case Conference Presentation: "The Child Who Refuses to Walk"
Johns Hopkins Children's Center, October 2003

"Giving Back by Giving Feedback:
Ambulatory Pediatric Association Regional Meeting
Charlottesville, VA, January 14, 2006

"Giving Back by Giving Feedback
Pediatric Academic Societies Workshop Presentation
San Francisco, CA May 2, 2006

Clinical Activities:

Medical Licensure

2003-present	Maryland	D0059764
1997-2004	Ohio	35-07-3530-S(inactive)

Board Certifications

1999-present	Diplomate, American Board of Pediatrics Recertification Completed October 2006 Renewal December 2013

Clinical Certifications

1996-present	Pediatric Advanced Life Support
November 2001	Advanced Pediatric Life Support

Clinical Service Responsibilities

2003-2006	Inpatient Fellow for Harriet Lane Clinic 3 weeks per year
2003-2006	Harriet Lane Clinic Preceptor Two ½ day sessions per week

Professional Societies:

1996-present	Fellow, American Academy of Pediatrics
1999-present	Member, Section on Injury and Poisoning and Prevention
2001-2002	Ohio Chapter Regional Coding Advisor (2001-2002)
2003-2007	Member, Ambulatory Pediatric Association
2004-2005	Member, American Public Health Association Section on Injury Prevention

NAHB RESEARCH CENTER

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Upper Marlboro, Maryland 20774-8731
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http://www.nahbrc.org