

APPENDIX A

PRODUCT PROFILE REPORT

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July 2001

Submitted by

Westat
1650 Research Blvd
Rockville, MD 20850

Submitted under

Contract CPSC-S-00-5205

Submitted to

U.S. Consumer Product Safety Commission
Washington, DC 20207

CPSA 6 (b)(1) Cleared

No Mfrs/Private Labels or
Products Identified

1-30-02
AB

EXECUTIVE SUMMARY

This report provides product profile reports for high chairs and strollers as related to failures of child restraint systems. It is the initial task conducted under CPSC-S-00-5205, which has the objectives of: 1) evaluation of the restraint systems used on strollers and high chairs to determine why restraints fail and 2) identification of critical characteristics and features needed for effective restraint systems. The initial task of the project required development of a separate profile for each product that would detail characteristics of the products relevant to restraint use and failure. This information provided a basis for subsequent tasks concerned with the causes of restraint failure.

The report drew on a wide range of information sources that were integrated to construct profiles of the products. A number of these sources were qualitative or anecdotal. While each source had its limitations, all of the findings considered together provided a reasonable picture of the products and their uses. Information sources included: in-depth incident reports; product samples; store visits; standards documents; technical research reports; focus groups; consumer-oriented internet sites; small-scale field observation; and child development and anthropometric literature.

The product profiles addressed the range of product types, modes of use, characteristics of children using the products, adult caregiver behaviors, restraint system features and problems, and restraint failure incident characteristics. A set of six general scenarios was found to categorize the range of stroller incidents and a set of five general scenarios was found to categorize the range of high chair incidents. These typical incident scenarios provide a basis around which subsequent analyses of the causal basis of restraint system failures can be conducted. The six stroller scenarios found to be related to restraint failure incidents were: (1) stand and fall; (2) lean over side and fall; (3) lean and reach; (4) pitch forward; (5) slip through leg opening; and horizontal slide (with the stroller in an inclined position). The five high chair scenarios found to be related to restraint failure incidents were: (1) push/pull up; (2) turn around; (3) tray release and pitch forward; (4) slip through leg opening; and (5) slide down and entrap. Each of these scenarios is more specifically defined in the report and the at-risk children are characterized.

In addition, a range of adult caretaker use factors was identified that related to the non-use or misadjustment of restraint system features. These provide a further basis for failure analysis and may be used to suggest system improvements. Non-use factors were identified that related to lack of perceived need, nuisance, negative effect on the child, difficulty of strap attachment, and needs related to functional use of the product. Misadjustment factors were identified that related to child actions, clothing, poor user feedback, child comfort and utility, difficulties in restraint adjustment, and child growth.

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PRODUCT PROFILE REPORT

1.0 Introduction And Overview

1.1 Objectives And Approach

The objectives of the work conducted under CPSC-S-00-5205 were: 1) to evaluate the restraint systems used on strollers and high chairs to determine why restraints fail and 2) to identify critical characteristics and features needed for effective restraint systems. The focus was on restraint systems that, while in use, failed to keep children securely contained. Failures of the physical integrity of the restraint or the child-resistance of restraint clasps were beyond the scope of this project. Factors related to adult misuse or nonuse of the restraint system were also considered. The initial task of the project required development of a separate profile for each product that would detail characteristics of the products relevant to restraint use and failure. This information provided a basis for subsequent tasks concerned with the causes of restraint failure. This document reports the findings of the product profile task.

The findings of this report are based on qualitative and anecdotal information obtained from a number of diverse sources such as product literature, consumer comments on web sites, focus groups, incident reports, informal observations and child development data. The product profile task consisted of a number of activities including the following:

- A review of product samples provided by the U.S. Consumer Product Safety Commission (CPSC)
- Store visits to examine additional products and to identify product features of potential interest
- A review of high chair and stroller incident reports provided by CPSC
- A review of standards related to high chairs and strollers
- A review of technical reports addressing high chair and stroller safety
- A search of consumer-oriented internet sites that provided consumer feedback on juvenile product use
- Focus groups of parents and other caretakers of children who are users of high chairs and strollers
- A review of anthropometric and developmental characteristics of children in the at-risk age ranges
- Informal, small-scale field observations of stroller use in various settings

The findings from each of these sources were integrated to construct profiles of the products. While each of the sources had limitations, all of the findings considered together coalesced into a reasonable picture of the products and their uses. The profiles addressed the following:

- Range of product types
- Likely age range of children using the product
- Patterns of product use
- Features of restraint systems, or other product features, related to restraint failure incidents
- Restraint system use and problems
- Incident data involving restraint system failures

This report summarizes what has been learned about the characteristics of the product and the product users that may have relevance in determining the causes of failures of restraint systems and in constructing performance requirements to insure their integrity.

1.2 Definitions

This report addresses *restraint systems* for high chairs and strollers. Restraint systems are understood to include those components of strollers and high chairs that directly or indirectly contribute to the capability to effectively secure children within the products. Examples of these components include restraining straps, restraint bars, footrests, and anchor points. The definition is intentionally broad so that all of the components of a product that might have an influence on restraint can be considered together in evaluating the effectiveness of these elements as a *system*. For example, the feeding tray of a high chair is treated as a component of the restraint system even though product owner's manuals may warn the consumer that the tray is not a restraint device and that restraining straps must be used. Since the tray can serve to restrict children's movements and can provide a surface to push against for standing and can color adult caretakers' perceptions of the need for use of other restraint components, an analysis of the restraint *system* would be incomplete without considering the tray.

While various product features are viewed as components of the restraint system, restraining straps are generally viewed as the *primary restraints*. These straps are anchored to the stroller or high chair body and are intended to limit the range of movement of the child. Primary restraints occur in a variety of configurations. *Waist belts* encircle the child's waist and attach to the seat back on either side of or behind the child. *Three-point restraints* are comprised of a waist belt plus a crotch strap. The crotch strap runs between the child's legs from the waist belt to the chair seat. This strap is intended to prevent the child from sliding down through the waist belt. *Five-point restraints* have waist and crotch attachments but also include shoulder straps. The shoulder straps may be configured to limit forward motion of the torso (if anchored to the seat back) or upward motion from the waist belt (if anchored to the belt).

While restraining straps require a deliberate action on the part of the caregiver to engage them, some products also feature *passive* restraint components. These are restraint features that are in place without any intentional act on the part of the adult caregiver. As used in this report, *passive restraint* specifically refers to the “passive crotch restraint system” now required of high chairs in ASTM F 404-99a (*Standard Consumer Safety Specification for High Chairs*). The high chair passive crotch restraint system is in place (without any required action on the part of the adult caretaker) whenever the tray is in place. This typically is in the form of a vertical bar between the chair seat and the tray. The child’s legs go around either side of this bar to prevent the child from sliding down.

1.3 Structure of the Report

This report is comprised of the following sections:

Section 2.0 provides further detail on the collection of information

Section 3.0 presents the product profile for strollers

Section 4.0 presents the product profile for high chairs

Section 5.0 describes the relationship of the findings of this report to subsequent analyses of the causes of restraint system failure

Section 6.0 provides bibliographic references

Section 7.0 presents appendices to the report that provide additional details

2.0 Information Sources

This section provides an overview of the sources and activities that provided the information for the product profiles.

2.1 Product Samples

Twenty product samples, ten high chairs and ten strollers, were provided by CPSC. Of these, seventeen were related to specific incidents or consumer complaints, while the remaining three were selected because of product features of interest. Taken as a set, these products provided good examples of the key product types and characteristics believed relevant to the restraint failure issue. Appendix A lists the twenty product samples and indicates the associated in-depth investigation report (IDI) where relevant.

The products, and any associated materials (manuals, incident reports) were examined to determine key features, likely modes of use, and the range of differences among products and restraint systems. These products were later analyzed to determine possible causes of restraint system failure. Results of this analysis are detailed in a subsequent report on causes of restraint system failures.

2.2 Store Visits

Visits were made to two major children's product stores, each with extensive collections of high chairs and strollers. The stores were Toys R Us and Buy Buy Baby in Rockville, Maryland. Several product types and features were noted that were of interest but were not represented in the initial set of sample products. As a result of the store visits, two samples were acquired that had not been in the original product sample set (██████████ umbrella stroller and ██████████ high chair). The umbrella stroller was selected because it represented a widely used category of stroller absent from the original product set. Umbrella strollers differ from most other strollers in being lightweight, collapsible to a compact size, lacking a restraint bar, and having a canvas sling seat with little support. Such features might relate to restraint system failures. The ██████████ high chair was selected because it had a five-point restraint system of a type not included in the original product set. A single shoulder strap looped through two slots at the back of the seat and attached at both ends to the waist buckle. Observations from the store visits are incorporated in the product descriptions in Sections 3 and 4.

2.3 Incident Reports

A set of 57 IDI's was provided by CPSC. These included 26 stroller and 31 high chair cases selected for their relevance to the restraint failure problem. Detail in these cases ranged from very sketchy to those with thorough descriptions, measurements, reenactments, and photographs. Each case was reviewed with respect to the nature of the incident, the relevant product and restraint system features, the characteristics and behavior of the child, and the mode of failure. The findings of these reviews are incorporated into the discussions in Sections 3 and 4.

2.4 Standards

Relevant domestic and international standards were reviewed. For the Product Profile Report this served as a source of information regarding product types, important features, users, restraint issues, and performance considerations. These standards were also evaluated with respect to modes of restraint system failure in the project Final Report and are discussed in more detail there. The documents reviewed are listed in Appendix B.

2.5 Technical Reports

Various technical reports related to high chair or stroller restraint system issues were reviewed. While there are a variety of publications of the “safety brochure” type, there were only a limited number of directly relevant technical reports based on data or analysis. These reports are included in Section 6 (Bibliography).

2.6 Internet Sites

An internet search was conducted to gather information regarding high chair and stroller restraint issues. The purpose was to identify the range of products available, their relevant features, and their restraint system types. Consumer comments about problems and successes related to various restraints were also obtained. The internet sites accessed for this report are described in Appendix C. They included consumer sites, manufacturer sites, and safety-related sites.

Descriptions of products were typically not very detailed and most did not include details about the restraint systems. Those product descriptions that did refer to the restraint system usually just noted whether the restraint included a 3-point belt or a 5-point harness, if a high chair included a passive restraint, or if a stroller included a restraint bar. Details about features such as buckle design or method of adjustment were not found.

To have a clearer appreciation for the problem at hand, there was also a search to identify high chairs and strollers that were recently recalled. Once again, there was typically little information regarding specific restraint hazards. Most of the recalled products involved structural design problems (e.g., broken parts, faulty safety locks).

Some insight into everyday use of high chairs and strollers was available from product reviews submitted as consumer comments at some sites. A relatively small proportion of the consumer comments related directly to restraint systems. However these provided useful insights on such aspects as the age of the children, comfort of the restraint, ease of use, adult caregiver expectations of the restraint, and incidents of misuse or non-use.

2.7 Focus Groups

The purpose of the focus groups was to elicit user perceptions regarding modes of product use, restraint use, child behavior, problems with restraint systems, usability issues, safety perceptions, desirable features, and recommendations for improvements. Two focus groups composed of users of high chairs and strollers were conducted. These were composed primarily of parents but included other relatives or friends who provided periodic care and supervision to children. A total of sixteen people took part, all of them employees of the U.S. Consumer Product Safety Commission.¹

Appendix D provides the focus group discussion path used by the moderator to guide the discussion. This discussion path served as a general scheme for addressing the series of issues, not as a strict script for questions. For one focus group, high chairs were discussed first, then strollers. For the other group, this order was reversed.

Appendix E highlights some of the key observations that emerged from the focus groups.

2.8 Anthropometric/Developmental Data

Information was collected regarding the anthropometric and behavioral characteristics of children through the age span of potential interest for restraint failure incidents. This information was drawn from a range of sources. These included child development references, infant/child assessment scales, collections of child population anthropometric measurements, and reviews of child development as related to children's product use.

The primary sources used are included in the Bibliography (Section 6).

2.9 Informal Field Observation

Informal small-scale observations of children in strollers were conducted in various public settings. Observations were made at several indoor and outdoor locations in the Washington, DC area in December 2000; Montgomery Mall, Zany Brainy (a children's toy store), Barnes & Noble bookstore, the Capital Children's Museum, and the National Zoo. The observation periods ranged from 30 to 90 minutes per site.

In this limited effort, there were observations of adult non-use of restraint system components (straps, bars) but no new findings regarding patterns of product or restraint system misuse. A few children were squirming in their seats, but there were no unusual behaviors or escapes from the restraints. The children were generally quite passive in their strollers; this may in part be because the environments in which the strollers were used often were geared towards young children, so they were absorbed in their surroundings. One observation of interest was that there were several incidents of children straining to reach things, which may be a factor in some incidents. This included reaching for dropped objects (e.g., a book), reaching for nearby objects of interest, or twisting and turning to view things.

¹ The CPSC Office of General Counsel approved these focus groups

3.0 Stroller Product Profile

3.1 Stroller Types and Features

Stroller Types

Six primary types of strollers were identified. These were: umbrella strollers; full size single/regular strollers; sit and stand strollers; double/triple strollers; travel systems; and three-wheeled jogger/sport/all-terrain strollers. Typical characteristics of each type of stroller are listed below, along with the approximate cost of each.

Umbrella

- Lightweight (usually under 10 lbs).
- Fold/collapse to a very compact size.
- Usually have a 3-point waist restraint.
- Most do not have restraint bar, although some do.
- Seat is usually canvas sling type with little support.
- Seat usually does not recline to full horizontal position, although some may recline slightly.
- Cost approximately \$15-50

Single/Regular

- Weight of stroller varies greatly.
- Usually have a 3-point waist restraint, but several have 5-point harness.
- Most have a restraint bar or tray. Some are removable for easy ingress or egress.
- Seat usually provides good support.
- Seat usually reclines to full horizontal position with 1 or 2 intermediate recline positions. A few only partially recline and some only have full-sitting or full-recline (horizontal) options.
- Cost approximately \$50-400; most are \$100-200

Sit and stand

- Similar to a regular stroller with a bench seat or standing platform mounted behind the stroller seat.
- Intended for transporting infant/toddler in the stroller seat and an older child on the back (seated or standing).
- Restraints and features of the stroller seat are similar to regular strollers (this research did not address restraints for the bench/platform for the older child).
- Cost approximately \$150

Double/triple stroller

- Either tandem or side-by-side models.
- Umbrella-or standard styles.
- Restraints are similar to comparable single models.
- Cost approximately \$75-450; most are \$150-250

Travel System

- Regular stroller with a removable infant car seat/carrier. The car seat/carrier locks onto the stroller to accommodate infants, and the stroller can be used as a regular stroller after the infant outgrows the car seat/carrier.
- Restraints on the stroller are similar to those on regular strollers.
- Restraints on the infant car seat/carrier are either 3-point or 5-point harnesses, comparable to other infant car seats/carriers on the market.
- Cost approximately \$150-250

3-Wheeled Jogger / Sport/All-Terrain

- Larger than most standard strollers.
- Designed mainly for outdoor activities (e.g., walking, jogging) rather than indoor use (e.g., shopping); some people use sport strollers for their primary stroller.
- Wheels are much larger than typical strollers and usually have inflatable tires. Also, some have 3 wheels instead of 4 wheels.
- Wide range of sizes: smaller sport strollers for walking or slow jogging and larger sport strollers for walking, jogging, or running.
- Most have a 5-point harness.
- Most do not have a restraint bar.
- Seat is usually canvas sling type with little support.
- Seat does not recline to full horizontal position, some may recline slightly.
- Cost approximately \$50-400; most are \$200-300.

Stroller Features

Strollers include a variety of features that might relate, directly or indirectly, to the restraint failure issue. These include:

Primary restraints. Restraint systems include three-point and five-point systems in a wide range of configurations. Three-point systems were composed of a waist strap and a crotch strap. Some restraint designs for infants featured a three-point system composed of two shoulder straps and a crotch strap. Some three-point systems had a crotch strap that ran from the waist belt to the seat pan. Others had a crotch strap that ran from the restraint bar to the seat front. The five-point systems seen for strollers had the shoulder straps attached to the seat back. The attachment point on the seat back varied. Some

attached relatively high up on the seat and others attached at the juncture of the seat back with the seat. With rare exceptions, the crotch straps of restraint systems were not adjustable in terms of length or attachment point.

Restraint bar. The restraint bar is a rigid bar that encircles the child in front of the seat and defines an envelope of free movement. Some strollers have the restraint bar as a permanent feature, others have none, others have it as a removable feature, and some have it permanently attached but able to swing away from the child (for easy access). Sometimes a tray is part of the bar. The bar does not function as a primary restraint in restricting movement of the child since it is typically not very close to the body. It does provide some restraint and may preclude pitching forward or overleaning. In some models, crotch restraints are attached from the restraint bar to the seat front.

Reclining seat. Stroller seats recline to various degrees and many fully recline. Restraint considerations may be different with a child in a prone position, rather than a sitting position. For example, a prone child needs to be constrained from sliding toward the head end of the stroller bed if that can result in tipping the stroller or in the child sliding out of the stroller.

Canopy. Some strollers have a collapsible canopy, which can shield the child from sun or weather. The canopy does not directly relate to child restraint but may indirectly relate to restraint failure incidents. The canopy may prevent the adult from viewing the child actions so that the progression of events that lead to escape and falling go undetected. Some canopies have transparent sections so that the child can be better viewed.

Foot rest. Foot rests are typical on full size strollers, but may not be present on lightweight strollers or jogging strollers. The positioning of the footrests varies greatly. On some models, the footrest extends out from beneath the seat. On others it is much lower, essentially a step built onto the crossmember that connects the front wheel struts. Footrests may have potential significance in affording a surface to stand against and help a child climb out of the restraints.

Cushions. Some strollers have removable seat cushions. If the straps of the primary restraint system feed through the cushion, removability of cushions or straps may have implications for the integrity of the anchoring of the restraint. Restraints that are secured to the cushion rather than the stroller frame may allow more play in the restraint system when the child leans forward.

3.2 Range of Stroller Users and Modes of Stroller Use

The age at which a child is first placed in a stroller depends on the type of stroller and the features it offers. Full-sized single or double strollers with the capability to fully recline and stroller travel systems with infant car seats are suitable for newborns. Stroller types that do not provide much support, such as umbrella strollers or jogging strollers, require the child to be capable of holding the head steady and sitting independently (around 6 months of age). Use continues until approximately age four.

The various kinds of stroller designs lend themselves to different types of use. For example, full size strollers that recline allow the child to sleep, umbrella strollers provide portability, jogging strollers allow use on rougher terrain and at higher speeds, and double strollers allow transport of more than one child. Based on the focus group findings, it appears that it is common for consumers to own several different stroller products to meet these various needs. However, no quantitative information was found on typical product ownership or modes of use.

With the exception of jogging/sport/all terrain types, strollers are basically used to transport children, along with diaper bags and other gear, in a variety of indoor and outdoor environments (malls, grocery stores, parking lots, recreational walking, attractions). Strollers are also used to restrain children when the stroller is stationary, such as when shopping, dining, or visiting. Strollers are used to hold napping children.

Jogging/sport/all terrain strollers are generally used outdoors and on unpaved terrain or at higher speeds than other strollers. While some parents may use them indoors (mall, etc.), they are generally too large and cumbersome for indoor use.

Stroller location and storage practices and stroller maintenance issues were examined to determine whether these factors had any apparent relationship to stroller restraint system failure incidents. No relationship was evident.

3.3 Behavior of Stroller Product Users

The effectiveness of child restraint systems is related to the behaviors of the children who are seated in the strollers and to the actions of the adult caregivers of these children.

Behavior of Children in Strollers

The behavior of the children seated in strollers appears to be related to motion and environment. The perception of caregivers is that children do not squirm or attempt to escape much while the stroller is in motion. This is consistent with the description of stroller incidents reviewed for this project. This may be because the moving child is more interested and engaged in viewing surroundings, or is calmed by the motion, or perhaps just finds it more difficult to maneuver. Children are more likely to complain, squirm, or struggle when the stroller is stationary. They also may engage in leaning and reaching behavior. Children were observed reaching down for dropped objects (e.g., book) or reaching out toward interesting items in the near environment.

Behavior of Adult Caregivers

Adult caregivers do not always use or properly adjust restraint systems. There appears to be a high level of restraint non-use, although it was not possible to quantify this. Adult caregivers have a range of perceptions about the necessity of using the restraint or about the primary purpose of the restraint system. There seems to be more focus on the need to retain the child in the seat during difficult dynamic situations (e.g., going down steps),

rather than as a means to keep the child from falling or escaping. The comfort of the child appears to be a major concern of adult caregivers when using restraint systems. Many are concerned about the restraints being too confining or the straps pinching or cutting into the child.

A wide variety of factors was identified for adult non-use or misadjustment of restraint system features. These include the following:

User Factors

Features

- Lack of perceived need to use restraints
 1. Users perceive the risk as being low because the hazard does not seem very likely or severe.
 2. Users perceive the risk as being low because the previous behavior of the child suggests that the child is unlikely to engage in any behavior that might result in a fall (or serious injury).
 3. There is not a need to use certain components of the restraint system (e.g., straps) because other passive components (e.g., high chair passive crotch restraint, stroller restraint bar) or other active elements (e.g., waist belt, high chair tray) provide adequate protection.
 4. The adult caretaker is confident of providing adequate close supervision so that any emerging incidents are noticed and stopped.

- Nuisance for adult
 1. The restraint system interferes with lifting the child in and out of the product and with accessing the child for other needs (e.g., adjusting clothing, cleaning).
 2. It is difficult to operate elements of the restraint system (e.g., buckles, strap adjustments). Operation may be non-intuitive or may require hand strength or fine motor movements that some users find difficult.
 3. It is difficult to get access to some component of the restraint system, especially if the child is already seated. For example, waist straps may lay across the seat, unless they are intentionally laid out to the sides in advance.
 4. Straps tend to get tangled and twisted.
 5. It is awkward to cope with some restraint system component while holding the child. Examples include adjusting belt length when placing a child in a stroller or removing a high chair tray after lifting out the child.
 6. It is a nuisance to clean components that tend to get dirty and are hard to clean. Woven straps tend to get encrusted with food and do not wipe clean easily. Shoulder straps tend to get food spilled on them frequently. Straps typically are not easy to remove and replace for cleaning.

- Negative effect on child
 1. Some children get upset when confined in a restraint.
 2. Restraints may cause pain or discomfort (e.g., straps cut into skin, pinch points, tightness).
 3. The restraint system interferes with the child's freedom of movement and the utility of the product. For example, it may be difficult for a child to eat in a high chair if he or she is unable to lean forward.

- Difficulty in strap attachment
 1. Once straps are removed from the product (e.g., for cleaning or to allow removal of a seat cushion) it may be difficult to reattach them.

- Non-use of restraints to accomplish temporary functional acts.
 1. Restraints are removed to lift a child from the seat.
 2. The tray from a high chair is removed to clean it.
 3. Restraints are removed to accomplish some child-tending task, such as putting a jacket on the child.

User Factors Related to Misadjustment of Restraint System Features

- Child actions
 1. If the child arches the back or puffs the belly during adjustment there may be too much slack once the child relaxes his or her posture.
 2. If the child squirms it is difficult to make adjustments and determine how adequate they are.

- Clothing rides up after adjustment
 1. Belts tightened sufficiently around a child wearing outerwear may come to fit loosely if the outerwear rides up and the belt becomes positioned underneath the outerwear.

- Poor user feedback
 1. It is difficult to determine if interlocking components are properly engaged (e.g., buckles, trays).
 - 2., It is difficult to tell how much slack is in the straps.

- Need to provide child comfort and utility
 1. Restraint components are kept loose to give the child comfort and freedom of movement
 2. Restraint components are kept loose to allow the child to accomplish functional acts (e.g., eating, coloring).

- Difficulty of adjustment
 1. The means of adjustment is not intuitive and is unclear to the adult caretaker.
 2. It is difficult to make adjustments to an adjustable feature (e.g., awkwardness of threading straps through small slots, finger strength requirements).
 3. Straps tangle and twist.
 4. It is difficult or impossible to make adjustments after the child is seated. For example, the adjustable component may be blocked by a passive restraint bar or be behind the child.
 5. It is awkward to make adjustments while holding the child prior to placing the child in the seat.
 6. There is a need for re-adjustment of the restraint system every time there is a change in the seat adjustment. Seats may adjust in horizontal and vertical dimensions and in incline.

- Child growth
 1. As the child grows, compensating adjustments to the restraint system fail to be made.

3.4 Characteristics of Stroller Incidents Involving Restraint System Failures

Characteristics of stroller incidents that involved failures of the restraint system were identified from published reports and from a review of CPSC in-depth investigations (IDI's) provided by CPSC. Based on these sources and the findings of the other information-gathering activities described above a set of stroller restraint system failure incident scenarios was developed.

Reports with Information on Stroller Restraint System Failures

Several studies of stroller incidents were reviewed to supplement the findings of the CPSC IDI analysis. A limited number of IDI's was reviewed in depth. Therefore, it was felt that technical reports based on larger numbers of incidents might help clarify issues and provide a context in which to view the IDI's.

Coonley and Rutherford (1996) searched National Electronic Injury Surveillance System (NEISS) data for 1995 using the keywords "fell" or "fall." There was an estimated 11,400 emergency room cases involving strollers. The most common pattern of injury for these was "fell out of," although the cases did not indicate whether a restraint system was in use. There were 46 stroller cases. Ten of these encompassed a range of problems with the restraint system. These included the child undoing the restraint or wriggling out, disconnected buckles and loosened straps, child removal of the strap, inability to properly adjust straps, non-use of crotch straps, sharp surfaces, and the absence of a restraint system on the product. In eight cases restraints were available but not in use at the time of the incident.

Ingle, Rutherford, Roegner, Hiser, Meiers, Mills, and Wycliffe-Injety (2000), in a subsequent CPSC report, provided further detail related to stroller injuries. This report was based on a special study of NEISS-reported cases during May-September, 1999, and included a telephone investigation in which the victim's parent or guardian was contacted. This study projected an estimated 13,842 stroller cases for the year. About half the cases (51%) involved falls, and another 26% involved tipovers. The data suggest that while full size strollers represent the largest set of fall cases, the proportion of cases involving umbrella strollers, combination strollers, and multiple-occupant strollers is still substantial. However, the number of cases in categories other than "full size" was small and the coefficient of variation (C.V.) was too high to warrant a projection. A restraint system was determined to be present in about 90% of cases. In about 59% of these cases the restraint system was known to be in use at the time of the incident. In about 39% of these cases it was known that the restraint system was not in use. Three hazard patterns were noted in which the restraint system did not adequately restrain the child. These were: (1) child defeated the restraint and fell out of the stroller; (2) child slipped through the restraint and fell out; and (3) restraint came loose and the child fell out.

Lee, Breeze, Bird, and Page (1994) reviewed information on stroller ("pushchair") injury experience in Great Britain as well as internationally. The findings were consistent with the CPSC reports in that the major injury pattern for strollers involved falls and that while the rate of restraint non-use is difficult to estimate, it is substantial. None the less, the majority of cases appear to occur even though a restraint system was in use. Various other summary descriptions of incidents were provided for various countries, but the small sample sizes make estimates questionable. Lee et al. provided an age distribution for children injured in U.K. incidents, and the primary age range for involvement appears to be about 6 to 18 months old, with the peak around one year old. Most involved children under two years old, and very few involved children three and up. Other data shown from Portugal and the Netherlands were consistent with this. Age also appeared to be related to the specific incident scenario. Children who stood up or climbed up or tried to get out of the stroller averaged 17.0 months of age. Children involved in stroller tipping incidents averaged 20.8 months of age. In contrast, children involved in incidents related to steps, stairs, curbs, or uneven pavement were considerably younger, averaging 12.8 months of age.

Review of CPSC Stroller In-Depth Investigations

Twenty-six CPSC IDI's involving strollers were reviewed. The investigations involved cases in which it was reported that children were able to free themselves from the restraint system. The cases provided a set of example incidents for consideration but should not be viewed as a statistically representative sample. The findings of the review should not be treated statistically. Each report was reviewed with respect to the nature of the incident, the characteristics of the child involved, and other details of the product or incident. A high level summary of the stroller incident cases is presented in Appendix F.

Some of the key points to emerge from the IDI review follow.

- In most cases the stroller seat was in an upright, or slightly reclined, position. A few cases involved the stroller seat in a fully reclined position.
- When the stroller was in the upright position, nearly all cases involved the child standing or leaning. In the exceptions, the child slid down through the belt or leg hole opening.
- The children in these incidents ranged from 3 to 23 months old. However, the age and size of the child was related to the incident type, as discussed below.
- For the most typical scenario, where a child “wriggled out” of a restraint and then stood or leaned, the age range was 7-20 months, but the cases were concentrated in the 8-12 month range. The children typically weighed about 20 pounds (all but one of the cases with known weight were in the 18-24 lb range).
- In the two cases where children slid down and out of an upright stroller seat, the victims were younger and smaller. They were four and six months old and each weighed 16 lbs.
- Children, in cases involving reclined seats, covered a wide range of age (3-23 months) and size (11-30 lb). In two cases tipping of the stroller occurred and both cases involved relatively heavy children (24 and 30 lb).
- In none of these cases was there anything to suggest that the motion of the stroller or the terrain had any bearing on the restraint failure event. In few of the cases where motion was specified was the stroller moving. In one case, the injury was to the child’s hand because the restraint failure allowed the child to lean over the side of the stroller and get a hand in the moving wheel; however, the stroller motion did not appear relevant to the restraint failure itself. Thus it seems that the dynamic aspects of stroller use are not a critical part of the problem. There might be instances where features of the terrain (slope, irregularities, stairs) could interact with restraint system features but there is no evidence of this in the set of cases reviewed. It is not evident whether the predominance of stroller-stationary cases is due to child behavior (less likely to try or to succeed in escaping while in motion), or to adult behavior (more likely to be in proximity), or whether it simply reflects an “exposure” base (children spend more time in stationary strollers).
- A variety of different types of strollers were represented in the set of incidents, including double strollers, umbrella strollers, and jogging strollers. It did not appear that the restraint failure incidents were directly related to the general stroller features (e.g., front or rear seat of a tandem stroller). There may be some indirect relationships of stroller type or feature to restraint failure (e.g., umbrella strollers may tend not to have seat pans that are as deep as the seat of a standard stroller). The primary exception to this is the feature of having a reclining seat, so that the child can lie flat. This feature permitted the incident type described above, where the child slides up or down the flat surface, without effective restraint, and either slides out or causes the product to tip. Another incident involving a reclined seat also involved a rocking feature. It appears that when the child slid along the reclined seat, the rocking feature may have engaged, causing the child to slide down the plane of the seat and become entangled in the footrest.

Summary of Stroller Restraint System Failure Scenarios

Based on the available sources used in this study, including incident reports, technical reports, consumer feedback, and focus groups, a set of stroller incident scenarios was derived. These are listed below, along with the estimated primary age range for each scenario. The “primary age range” is a best estimate of the age of children most likely to be involved in a particular type of incident. Age estimates were based on the incident information and developmental factors. Although the most at-risk age can be estimated, this should not be taken to mean that children outside this range have no risk of such an incident. The scenarios all reflect instances where at least some component of the restraint system (e.g., waist or shoulder straps, restraint bars, crotch straps) were in use. The six scenarios that emerged from review of the available information are:

Stand and Fall. In these cases, the child manages to come to a standing or kneeling position on the seat, and then falls from the stroller. The primary age range for this type of incident is about 8-15 months.

Lean Over Side and Fall. The child leans over the side of the stroller, resulting in a fall, partial fall with suspension from the restraint straps, or tipping of the stroller. The primary age range is about 7-15 months.

Lean and Reach. The child leans sideways or forward and reaches, resulting in the hand contacting a stroller wheel or actuating some stroller mechanism (e.g., wheel lock release). The primary age range is about 7-24 months.

Pitch Forward. The child leans forward in the seat, and pitches out or becomes suspended by some component of the restraint system. The primary age range is about 6-9 months.

Slip Through Leg Opening. The child removes a leg from a leg opening on one side and inserts the leg into the opening on the other side. The action may be intentional or not. The child slides down through the leg hole, resulting in a fall or in head/neck entrapment with the restraint system or stroller features. The primary age range is about 4-9 months.

Horizontal Slide. With the stroller in an inclined (horizontal) position, the child slides along the surface, either toward the head or the foot end. This results in tipping, or a fall over the edge, or entrapment in the restraint. The primary age range is about 6-24 months.

4.0 High Chair Product Profile

4.1 High Chair Types and Features

High Chair Types

High chairs may be distinguished in terms of certain features. A basic high chair may be distinguished from adjustable height high chairs, reclining high chairs, and conversion products. However, the basic mode of use of all of these products is the same. Booster seats, hook-on high chairs, and feeding tables were not included in this review.

The typical characteristics of each type of high chair are listed below, along with the approximate cost.

Basic

- 3-point waist belt or 5-point harness
- Removable, adjustable tray
- Some may have passive restraint
- Cost approximately \$25-180, most around \$30

Adjustable height

- 3-point waist belt or 5-point harness
- Removable, adjustable tray
- Many have passive restraint
- Chair can be adjusted to several heights
- Some have wheels / casters for easy movement
- Cost approximately \$60-130

Reclining chair / adjustable height combination

- 3-point waist belt or 5-point harness
- Removable, adjustable tray
- Most have passive restraint
- Chair can be adjusted to several heights
- Seat can be reclined to make it easier to feed infants or to allow an older child to nap
- Some have wheels / casters for easy movement
- Cost approximately \$60-200, most around \$65-95

Conversion

- Conversion units serve the purposes of multiple products, with the high chair mode being only one function. Example products follow.
 - A high chair seat that can also be used as a hook-on chair for meals away from home. The seat lifts off the high chair base and can be hooked onto a table. The high chair has both adjustable height and reclining seat features.
 - A high chair that can also be used as a battery-powered baby swing. The swing locks for use as a high chair.
 - A high chair converts to a table and chair for toddlers. The high chair does not have adjustable height or reclining seat features.
- Costs from about \$80-130

High Chair Features

High chairs include a variety of features that might relate, directly or indirectly, to the restraint failure issue. These include:

Primary restraints. “Primary restraints” refers to the strap systems intended to confine the movements of the child. Restraint systems are generally three-point or five-point, although occasional systems with only a waist belt were seen. As with strollers, there was a variety of configurations for the strap systems and crotch restraints were generally not adjustable in length or anchor point.

Passive restraint. A high chair “passive restraint” refers to a crotch restraint system that is in place (without any required action on the part of the adult caretaker) whenever the tray is in place. This typically is in the form of a vertical bar between the chair seat and the tray. The child’s legs go around either side of this bar that prevents the child from sliding down. Not all high chairs featured a passive restraint. Some products had a passive crotch bar permanently attached to the seat. Others had a bar attached to the bottom of the tray, so that the restraint was in place whenever the tray was in place. At least one product featured a permanent lap bar/snack tray.

Adjustable tray. Most products offer some ability to adjust the distance of the tray anywhere from two to eight positions. Tray position relates to the degree of movement afforded the child, as well as the ability to use the tray as a surface to push against. Tray position may also relate to the caregiver’s perceived degree of need for an additional restraint (the primary restraint system).

One-handed tray release. Some high chairs provide the ability to remove the tray with one hand. This may have implications for potential incidents where the child falls while the adult caregiver is removing the tray. When the adult has both hands on the tray as it is removed, there is no free hand to restrain or catch the child if he or she should begin to get free of the restraint system.

Adjustable height. Models with adjustable heights may range from two to seven settings. Seat height may relate to the ease of access to the child or the restraint features, as well as being related to injury potential from a fall. Seat height may also affect the relationship between the seat and the footrest. This could effect how useful the footrest is in aiding escape from the restraint system.

Reclining seat. Various products allow the seat to recline to various degrees, usually among three positions. This allows napping in the chair or use by younger infants, both of which might relate to fall scenarios. Most seats recline independently of the tray (which affects the spatial relationship of the seat and the tray) but some are co-mounted so that the tray actually tilts up when the seat is reclined. Reclining may effect the snugness of the tray against the child, the fit of the primary restraint system to the child, and the child's capability for various movements.

Footrest. Products differ with respect to the presence and location of footrests. Footrests may have potential significance in affording a surface to push against in an attempt to stand up.

4.2 Range of High Chair Users and Modes of High Chair Use

The general age of high chair users is about 6 months to 3 years old. Use is appropriate once the child can sit upright unaided (about 6 months, earlier for some) and is eating solid foods. Reclining chairs may be used for younger infants in the reclined mode. Parents generally begin to move children out of high chairs as they become more mobile, resist restraints, and become capable of sitting independently in a booster chair at the table, at 2 to 3 years old. Manufacturers and vendors also may indicate a weight restriction, for use by children who do not exceed 37 pounds. This is slightly above the mean weight for 4 year old (3.5-4.5 years) children, although some 2.5 year olds may exceed this (Snyder et al., 1977). Based on the focus groups, it does not seem that caregivers are particularly aware of restrictions on maximum user size but this may not be very significant if most children are out of the high chair well before reaching this weight.

High chair use is mainly indoors in kitchen and dining areas. While no quantitative information on frequency of use was found, it is a product that is typically in daily use, multiple times per day. The primary use is for feeding and snacking, while the caregiver is in proximity. The high chair is also used to confine the child during activities (playing with toys, watching television), also with the caregiver in proximity. Children also fall asleep in the high chair and are left there to nap. There seems to be a widely recognized belief that there should always be nearby supervision when the child is in a high chair, though also recognition that in real life situations, it is occasionally necessary for the adult to leave the child briefly. In the focus groups, it was generally acknowledged that the child sometimes had to be left briefly but there was not agreement in terms of how frequently or for how long the child might be left alone.

It was evident from user feedback (from internet sites) and focus groups that cleaning is an important aspect of product use. While trays may wipe off easily, cushions may require occasional removal for cleaning. Restraint system elements may also get dirty. The webbing of nylon straps may become encrusted with food, and this may be more of a problem with five-point restraints, since the upper portion is more exposed. Straps may be removed for cleaning or may cease to be used because they get dirty. In some cases, straps may be difficult to re-thread once they are removed. Non-removable straps may be difficult to clean.

4.3 Behavior of High Chair Product Users

The effectiveness of high chair restraint systems is related to the behaviors of the children who are seated in the chairs and to the actions of the adult caregivers of these children.

Behavior of Children in High Chairs

The behavior of children in high chairs is quite variable from child to child and from time to time. Some children frequently squirm and attempt to free themselves while others are passive. Children engage in more escape behavior after they have finished eating or when not otherwise occupied. As children become older, they are allowed to climb in and out of the high chair by themselves.

Behavior of Adult Caregivers

As noted above, caregivers normally remain in close proximity when the child is in a high chair, although they may occasionally leave the child unattended for a few minutes. Incidents described in the IDI's rarely involved a caregiver being far from the child or absent for an extended period.

There is a range of perceptions about the necessity of using the primary restraint system. There is a widespread perception that the tray is functionally part of the restraint system, and some feel that if it is adjusted snugly to the child, it will effectively restrain the child. The presence of passive restraint bars may contribute to this. The presence of the passive restraint appears to be an important factor in consumers' perceptions of high chair safety, and there is some suggestion in the information that was reviewed here that this may be an important purchase consideration.

The child's comfort and freedom are important influences on caregiver behavior with respect to the restraint system. There is some perception that restraint systems, particularly five-point systems, may be too restraining for children when they are eating. There is also a belief that restrictive, cumbersome, or otherwise uncomfortable restraints contribute to squirming and escape behavior by children. There are also difficulties in using the restraints as the child is placed in the chair. The straps often fall over the seat and need to be laid out in the correct position prior to placing the child in the seat. Once seated, chair components may make access to restraint components difficult, and it may be difficult or impossible to adjust straps once the child is in place.

Caregivers appear to differ in whether they remove the tray or not, for ease of egress when removing the child. The passive restraint bar and tray may cause the child's legs to be scraped when being placed in or removed from the chair.

Generic lists of user-factors related to non-use of restraint system features and to mis-adjustment of restraint system features were presented earlier in Section 3.3. Those lists are relevant for the high chair application as well as for strollers.

4.4 Characteristics of High Chair Incidents Involving Restraint System Failures

Characteristics of high chair incidents that involved failures of the restraint system were identified from a review of CPSC in-depth investigations (IDI's) provided by CPSC. Based on these sources and the findings of the other information-gathering activities described above a set of high chair restraint system failure incident scenarios was developed.

Review of CPSC High Chair In-Depth Investigations

Thirty-one CPSC IDI's involving high chairs were reviewed. Cases included scenarios where all or part of the restraint system was in use. For purposes of this report, the feeding tray was considered as part of the restraint system. Although product owner's manuals may warn the consumer that the tray is not intended as a restraint device, it is none the less important to include consideration of the tray in an analysis of a high chair restraint *system*. Since the tray make restrict the child's movements or provide a surface to push up against for standing it may interact with other restraint system elements. A high level summary of the high chair incident cases is presented in Appendix G.

Some of the key points to emerge from the IDI review follow.

- The most common situation (about half the cases) was when the child stood up in the chair seat despite having the passive restraint and/or active restraint system in use. While the details of the children's behaviors are not always clear, cases referred to children wriggling free of a belt, turning to face the rear of the seat, or simply standing up. In all but one of the cases where the child stood up in the chair, the tray was known to be in place. It was not clear whether the tray afforded a surface that the child used to push against. A passive restraint (crotch bar between the tray and seat) was present in only a few of these high chairs.
- In some cases the child fell forward out of the chair while the feeding tray was removed. All of these cases shared the feature that the absence of the tray was momentary (either to remove the child or to clean off the tray). In a few cases the incident occurred despite the restraint straps being used and remaining securely anchored. In the other cases, the strap detached at an anchor point.

- In a number of cases the tray was initially in place, but became disengaged in the course of the incident. One of these cases involved a structural failure, where the chair arm supporting the tray broke off. In several cases the child apparently activated the tray release mechanism with the feet, though not necessarily by intent. In other cases the means of release is not known.
- In one case, the child slipped down in the chair seat, despite the presence of a crotch strap. The child's head became entrapped between the seat and the rear of the tray.
- The age of the victims was typically under a year-and-a-half old. For all but two cases the ages ranged from 6 to 15 months, with weights ranging from 15-24 lbs. Nearly two-thirds of the cases were within the four-month span from 9 through 12 months old. For the most frequent scenario of standing in the chair despite wearing a restraint, and with the tray in place, the ages ranged from 9 to 15 months. Younger children may not be able to pull to a stand, while older children may have better balance and postural control. Where no tray was present, the age range was broader, 6 months to 3 years old, with half of these children being less than 9 months of age. These younger children were not involved in the cases where the tray was initially present and then came off, which might relate to their ability to release or remove the tray.

Summary of High Chair Restraint System Failure Scenarios

Based on all of the available sources used in this study, including the review of incident reports, technical reports, consumer feedback, and focus groups, a set of high chair accident scenarios was derived. These are listed below, along with the estimated primary age range for each scenario. As noted for the stroller summary, the "primary age range" is a best estimate of the age of children most likely to be involved in a particular type of incident. Age estimates were based on the incident information and developmental factors. Although the most at-risk age can be estimated, this should not be taken to mean that children outside this range have no risk of such an incident. The five scenarios that emerged from review of the available information are:

Push/Pull Up. In these cases, the child uses some chair feature to help pull or push him or herself into a standing position. The actions involved may include: (1) pushing the arms against the tray or chair arms; (2) pushing the feet against the footrest; (3) placing the heels on the chair seat; and (4) grasping the seat back by reaching back. The age range for this type of behavior is about 8-15 months.

Turn Around. The child rotates the torso toward the chair back, places one or both knees on the seat, and stands from the kneeling position (possibly by pushing or pulling on chair structures). The age range for this type of behavior is about 9-15 months.

Tray Release and Pitch Forward. The child disengages the tray release mechanism with the feet or hands. With the tray unlatched, the child pitches forward and falls from the chair or hangs by the waist strap or causes the chair to pitch. The age range for this type of incident is about 6-15 months.

Slip Through Leg Opening. The child removes a leg from a leg opening (of the chair structure or harness) on one side and inserts the leg into the opening on the other side. The action may or may not be intentional. The child slides down through the leg hole, resulting in a fall or in head/neck entrapment with the restraint system or feeding tray. The age range is about 6-9 months.

Slide Down and Entrap. The child slips down while remaining in the chair seat. This does not involve inserting both legs through the same leg opening. There may or may not be a crotch strap or other barrier present. The head/neck becomes entrapped between the seat back and the feeding tray. The primary age range is about 6-9 months.

5.0 Determining Causes of Restraint System Failure

Subsequent work will determine the causes of restraint system failures for strollers and high chairs. The findings presented in this Product Profile Report provide the basis upon which the causal analysis will be conducted. The causal analysis will use task analytic techniques, structured around the set of restraint system failure incident scenarios defined for high chairs and strollers. Each scenario analysis will incorporate the findings about the range of product features and product types, the modes of product use, the behaviors and capabilities of children in the at-risk age range, and the behaviors of adult caregivers. Thus, the information compiled in this report serves as the primary data source for subsequent analytic efforts. The causal analysis will also make use of additional information. This includes detailed measurement of product dimensions and other parameters as well as detailed child anthropometric data relevant to particular scenarios. The causal analysis will identify the significant characteristics and features that are needed for effective restraints on strollers and high chairs. Recommendations for improved restraint systems will be derived from this.

6.0 Bibliography

Bayley, N. (1993). *Bayley Scales of Infant Development*, 2nd edition. Lutz, Florida: Psychological Assessment Resources Inc.

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Caplan, F. (1978). *The First Twelve Months of Life: Your Baby's Growth Month by Month*. New York: Bantam Books.

Caplan, F. & Caplan, T. (1978). *The Second Twelve Months of Life: Your Baby's Growth Month by Month*. New York: Bantam Books.

Coonley, J. & Rutherford, G. (1996). *Hazard Sketch: Restraints on Infant Products*. Draft Report. Washington, DC: U.S. Consumer Product Safety Commission.

Couper, R., Monkhouse, W., Busutil, M., Thompson, P. (1994). Stroller Safety. *The Medical Journal of Australia*, 160, 335-338.

Frankenburg, W.K., & Dodds, J.B. (1967). The Denver Developmental Screening Test. *Journal of Pediatrics*, 71, 181-191.

Ingle, R., Rutherford, G., Roegner, R., Hiser, S., Meiers, C., Mills, A., & Wycliffe-Injety, J. (2000). *Injuries Associated with Strollers*. Washington, DC: U.S. Consumer Product Safety Commission

Leach, P. (1985). *Your Baby & Child from Birth to Age Five*. New York: Knopf.

Piper, M.C., & Darrach, J. (1994). *Motor Assessment of the Developing Infant*. Philadelphia, PA: W.B. Saunders [referred to as the *Alberta Infant Motor Scale* or AIMS]

Lee, V., Breeze, R., Bird, R., & Page, M. (1994). *Child Restraints for Nursery Goods: Pushchairs*. Report to The Consumer Safety Unit, U.K. Department of Trade and Industry. Leicestershire, U.K.: Research Institute for Consumer Ergonomics, Loughborough University of Technology.

Ratte, D., Morrison, M., Lerner, N., Denham, S., & Johnson, D. (1990). *Development of Human Factors Criteria for Playground Equipment Safety*. Report to U.S. Consumer Product Safety Commission under Contract CPSC-C-88-1231.

Ridenour, M. (1997). How child resistant are stroller belt buckles? *Perceptual and Motor Skills*, 84, 611-616.

Schneider, L., Lehman, R., Pflug, M., & Owings, C. (1985). *Size and Shape of the Head and Neck from Birth to Four Years*. Report to the U.S. Consumer Product Safety Commission under Contract CPSC-C-83-1250.

Smith, A. & Brookman, M. (1995). *Child Restraints for Nursery Goods: Pushchairs – A Method of Test for the Effectiveness of Integral Harnesses*. Technical Report, The Consumer Safety Unit. London. U.K.: Department of Trade and Industry.

Snyder, R., Schneider, L., Owings, C., Reynolds, H., Golomb, D., & Schork, M. (1977). *Anthropometry of Infants, Children, and Youths to Age 18 for Product Safety Design*. Report UM-HSRI-BI-77-17. Ann Arbor, Michigan: The University of Michigan, Highway Safety Research Institute.

Snyder, R. Spencer, M., Owings, C., & Schneider, L. (1975). *Physical Characteristics of Children As Related to Death and Injury for Consumer Product Design*. Report UM-HSRI-BI-75-5. Ann Arbor, Michigan: The University of Michigan, Highway Safety Research Institute.

7.0 Appendices

Seven appendices are appended to this report. These provide additional detail on methods and findings. The appendices are:

Appendix A: Product Samples Reviewed

Appendix B: Domestic and International Standards

Appendix C: Internet Sources

Appendix D: Focus Group Discussion Path

Appendix E: Highlighted Findings from Focus Groups

Appendix F: Summary of Stroller Incident Cases Reviewed

Appendix G: Summary of High Chair Incident Cases Reviewed

APPENDIX A
PRODUCT SAMPLES REVIEWED

Product Samples Reviewed and Associated CPSC In-Depth Investigations

Product	Sample #	Associated Report
Strollers		
[REDACTED]	00-860-6012	000210HCC3157
	00-860-6140	000824HAA3392
	00-830-3852	000901HAA2795
	00-860-6189	000824HAA3393
	00-800-2347	000907HAA0014
	01-810-3651	000927HAA0082
	01-830-4526	001011HAA2022
	01-830-5076	001011HCC2028
	01-840-6672	010102HAA3124
	-----	No associated incident
High Chairs		
[REDACTED]	00-800-2913	000620HBB0771
	00-830-5353	000615HBB2620
	99-830-3431	980926CCC2854
	01-810-3302	001012HAA0035
	01-840-6272	001129HAA3081
	01-830-4119	001130HAA2120
	01-830-4120	001207HAA2134
	01-830-6672	010103HAA2170
	-----	No associated incident
-----	No associated incident	

APPENDIX B
DOMESTIC AND INTERNATIONAL STANDARDS

Domestic and international standards documents reviewed for this report included the following:

American Standards

ASTM F404-99a: Standard Consumer Safety Performance Specification for High Chairs

ASTM F833-99: Standard Consumer Safety Performance Specification for Carriages and Strollers

International Standards

SOR/85-379 (Canada): Carriages and Strollers Regulations

BS EN 1929-1: 1998 (Britain): Basket Trolleys -- Part 1: Requirements and tests for basket trolleys with or without a child carrying facility

prEN 1929-2: 1998 (Draft) (Britain): Basket Trolleys -- Part 2: Requirements, tests, and inspections for basket trolleys with or without a child carrying facility, intended to be used on passenger conveyors

AS/NZS 2088: 1993 (Australia/New Zealand): Prams and strollers -- Safety requirements

AS 3747-1989 (Australia): Harnesses for use in prams, strollers, and high chairs (including a detachable walking rein)

BS 6684: 1989 (Britain): Safety harnesses (including detachable waling reins) for straining children when in preambulators (baby carriages), push chairs and high chairs and when walking

BS 7409: 1996 (Britain): Safety requirements for wheeled child conveyances

BS EN 12221-1&2: 2000 (Britain): Changing units for domestic use: Safety requirements & Test methods

PrEN 13210: 1998 (Draft) (Britain): Child care articles - Children's safety harnesses and reins: Safety requirements & Test methods

APPENDIX C
INTERNET SOURCES

INTERNET SOURCES

Internet sites accessed for product information and consumer feedback:

epinions.com

babygear.com

consumerreports.com

store.babycenter.com

Sites for specific companies (e.g., Century, Cosco, Evenflo)

Internet sites accessed for product recall information or other safety information

cpsc.gov

babybag.com

consumerreports.com

kidsource.com

safetyalerts.com

APPENDIX D
FOCUS GROUP DISCUSSION PATH

HIGH CHAIR/STROLLER RESTRAINT SYSTEMS FOCUS GROUP PATH

January 25, 2001 CPSC Groups

Purpose, Objective, Scope

- General topic is restraint systems that keep children from falling out of products
- What do we mean by restraint systems? Straps, but also bars, sides, tray, anything you think of as related to keeping the child in the seat
- Focus is on high chairs and strollers. But if you have some relevant insights based on other products, feel free to raise them (e.g., car seats, swings, walkers, backpacks, shopping carts, etc.)
- We are interested in all aspects of restraint system use: what's good, what's bad, ease of use, comfort, non-use, effectiveness, concerns, etc.
- Not a discussion of high chairs and strollers in general, but specifically features that relate to restraint or the prevention of falls.

Focus Group Procedures

- Cross talk, not to/from moderator
- Moderator guides discussion
- Give everyone opportunity
- Being videotaped for offline analysis
- Materials: feel free to use if you want to illustrate a point
 - Sample products
 - Dummies
 - Mock-up for straps
 - Photos

Introduction/Ice Breaker

- Go around to each person in turn. They will tell:
 - Ages of their children
 - Briefly describe a specific problem, incident, or close call you have had with product/restraint system.

Structure

- Your experiences with high chairs
- Your experiences with strollers
- Your thoughts on restraint systems in general

High Chairs

- What children are the users of high chairs?
 - How did you determine when to start/stop use?
 - What is defining moment when you can no longer use the restraint or high chair?
 - How do restraint concerns vary over this age range?
 - Need for restraint
 - Fit of restraint
 - Adequacy of restraint
- Your selection of a high chair
 - What were your considerations in selecting the product you purchased?
 - Restraint considerations in particular
 - Does your product have any special features related to falls or restraint (even if that wasn't a factor in your purchase decision)?
- Lets talk about how you use the high chair [then how child acts]
 - Do you regularly use restraint? All components? Why, why not?
 - What about other users?
 - Any concerns with ease of use, cleaning, removal/re-installation of restraints?
 - Any instances where someone used the product/restraint in unusual or unexpected ways or places?
 - Do you recall if there were instructions on how to use restraint?
 - Did you read them?
 - Confidence you are using correctly?
- Now let's talk about how your child acts in the chair
- Comfortable? Struggling, squirmy? Freedom of motion? Related to restraint?
- Behaviors that could be related to falls or slips
 - Try to stand, slide down, lean over
- Restraint system effectiveness
 - What are your expectations of a restraint system and were they met?
 - If not met, what if anything did you do?
 - What failures or problems did you find?
 - Describe motions involved in escape
 - Describe any lack in straps/bars adjustability/flexibility
 - Can the child stand easily? Why/why not?
 - How critical is the restraint system at various ages? How do problems change?
 - What restraint features do you like/dislike?

- Trays
 - How do you see the role of the tray, regarding restraint?
 - Barrier
 - Aid to boost to a stand
 - Effects on behavior (more squirmy when tray removed?)
 - Are you always near when the tray is off? When not?
 - Security of the tray
 - Reliable latching, feedback
 - Child able to release

Strollers

- What children are the users of strollers?
 - How did you determine when to start/stop use?
 - What is defining moment when you can no longer use the restraint or stroller?
 - How do restraint concerns vary over this age range?
 - Need for restraint
 - Fit of restraint
 - Adequacy of restraint
- Your selection of a stroller
 - What were your considerations in selecting the product you purchased?
 - Restraint considerations in particular
 - Does your product have any special features related to falls or restraint (even if that wasn't a factor in your purchase decision)?
- Let's talk about how you use the stroller [then how child acts]
 - Where/how/for what do you use strollers?
 - Do you regularly use restraint? All components? Why, why not?
 - What about other users?
 - Any concerns with ease of use, cleaning, removal/re-installation of restraints?
 - Any instances where someone used the product/restraint in unusual or unexpected ways or places?
 - Do you recall if there were instructions on how to use restraint?
 - Did you read them?
 - Confidence you are using correctly?
- Now let's talk about how your child acts in the stroller
- Comfortable? Struggling, squirmy? Related to restraint? Related to motion?
- Behaviors that could be related to falls or slips
 - Try to stand, slide down, lean over

Restraint system effectiveness

- What are your expectations of a restraint system and were they met?
 - If not met, what if anything did you do?
- What failures or problems did you find?
 - Describe motions involved in escape
 - Describe any lack in straps/bars adjustability/flexibility
 - Can the child stand easily? Why/why not?
- How critical is the restraint system at various ages? How do problems change?
- What restraint features do you like/dislike?

Harness Systems and Other Restraint Features

- General feelings about likes/dislikes, strengths/weaknesses of restraint systems
- Desirability of 5-point restraints
 - Restraint effectiveness
 - Child discomfort, adult nuisance (for various ages)
- Suggestions for improvements (probes: strap adjustability, anchor points, strap type, buckle mechanism, passive restraints, seat design, range/type of movement allowed)

APPENDIX E
HIGHLIGHTED FINDINGS FROM FOCUS GROUPS

Highlighted Findings From Focus Groups

Two focus groups on high chair and stroller restraint issues were conducted in January 2001. A total of sixteen people took part, all employees of the U.S. Consumer Product Safety Commission. Most were parents of children who were current users of high chairs and strollers, although some were relatives or friends who provided periodic care and supervision. The purpose of the focus groups was to obtain user perceptions regarding modes of product use, restraint use, child behavior, problems with restraint systems, usability issues, safety perceptions, desirable features, and recommendations for improvements.

A great deal of discussion took place over the approximately hour-and-three-quarters of each focus group. This document lists some key points raised during the discussions. There is no attempt to summarize all of the discussion. Much of the discussion confirmed findings from other sources (reports in the literature, incident analyses, consumer feedback through internet sources). The interest here is in highlighting issues that have not been well documented from other sources.

Focus groups are qualitative procedures, and are designed to elicit a range of perceptions and opinions. For a given response, there is no means of knowing to what extent the view may be held by only a few people or by many people. Focus groups do not attempt to arrive at group consensus, although sometimes there may be good agreement on a point. The points raised and highlighted here should therefore be taken as findings of interest to emerge from the discussion, but not as evidence that a given problem or perception is necessarily pervasive.

Highlighted points follow:

High Chair Comments

Range of user ages. The general consensus was that people start using the high chair when the child can sit up by himself and starts eating solid food, around 4-to-6 months old. If the chair tilts back, some may use it earlier for bottle feeding. Use ends when the child is able to sit at the table, is very mobile, challenges the restraints, and has a desire for being with others at the table, around 2-3 years old. Over this age range, the appropriateness of the chair and restraints is seen as an issue. People want a single high chair with the flexibility to use throughout this period. (This may be contrasted to strollers, where the ownership of multiple strollers is seen as routine). The particular concern is with younger users. A system may be thought to work well for a 14 month old, but did not work as well when the child was 7 months old. There was some feeling that it might be desirable to provide multiple harness systems with a chair; the consumer

could select the most appropriate one to use, given the age of the child, the behavior of the individual child, and the adult's preferences. The particular concern with younger children was in "submarining" out of the chair (sliding down the seat and slipping out between the seat and the tray) and for somewhat older children with escaping from the restraints. When the transition between these concerns happens depends on the particular child. One person in the group had problems with the child getting out of the restraints from as young as 4 months old; others never had the problem. The participants generally agreed that the typical age at which the concern transitioned to escaping from restraints was about one year old.

Passive restraint bar. There was a generally favorable reaction to the high chair passive restraint bar. Some indicated they would not buy a high chair without this feature. Most preferred the design where the restraint bar is permanently attached, rather than as an element that drops down from the tray. They preferred to have the bar in place for those periods (even if very brief) when the tray was removed, and also felt that if the child is already in the seat, putting the tray with a bar in place would be more cumbersome. However, one person preferred the idea of the restraint dropping down from the tray. She argued that she never used the chair without the tray in place anyway. She noted that the permanent bar makes it harder to adjust and strap the harness, so it is preferable to strap the child in and then put the tray/restraint in place. It should be noted that much of this discussion of preference was based on speculation, because most individual participants did not have direct familiarity with multiple designs.

There were some negative points about the passive restraint bar. The primary problem was that it was in the way of buckling the straps. One suggestion was that the straps should clip into the restraint bar itself. Another issue was that it makes placing the child in or taking the child out of the chair more difficult, and that the knees may scrape.

Five-point restraint systems. There were mixed feelings about the desirability of five-point restraint systems. Many did not have direct experience with five-point systems other than in car seats. Some thought they were highly desirable, and would not consider purchasing a high chair without one. They felt five-point systems allowed freedom to lean forward without a parallel risk of "submarining." However, others felt quite negatively about them. Five point restraints were felt by some to be cumbersome, unnecessary, an "extra step," "ridiculous," and "way too much work." Particularly for younger children, they felt there were just too many straps. Some indicated that they did not use the five-point systems on their products. One discussant also expressed more fear of head/neck entrapment with a five-point system. One person suggested that providing only a five-point harness with a high chair is too restrictive. Depending on the child and the parents, it may be a good option or not. There should be some option or flexibility in what is provided with the product.

Feeding tray. There was general agreement that the tray is seen as part of the restraint system. Except for older (toddler) children, the tray is generally adjusted fairly snugly to the child to aid in restraint. Some often used the chair without the tray in place (particularly if the child was sleeping, or with the chair pulled up to the table), but typically it was considered as a restraint feature for general use. It prevents over-leaning

as well as other forms of escape. Some problems with trays were noted. One was that they may not always be properly engaged, and that feedback on correct placement was lacking. The reliability of the engagement may change over time with wear as well. This was the primary concern with restraint issues for some people. They want to hear a plainly audible click or get some other feedback that the latch is secure. They routinely double check the latching by pulling on the tray. There also was a concern that on some products, the child may be able to disengage the tray release mechanism, by hand (if the release is on the side) or by foot (if it is under the tray).

People differed in whether they remove the tray prior to placing the child in the seat or removing the child from the seat. Some remove the tray because it is easier to then move the child, and they do not have to lift the child up and over the seat. Also, some find it difficult to get at the belt clasp without removing the tray. Others prefer to lift the child in or out with the tray still in place. For some this was a convenience issue. For others, it was a safety issue; they felt there was a risk until the tray was in place.

One idea briefly discussed was having a feature whereby the tray could swing away from the chair in the horizontal plane. This would allow easier egress and access to straps and buckles. While there was some favorable view of this, it was with the understanding that the tray rotation would have to be horizontal (so that food would not spill) and that it still be easily removable for cleaning.

Foot rest. The footrest sometimes affords a surface for the child to stand against. No important functional role was seen for the footrest. Some speculated it might be there just for “esthetic” reasons (appeals to adult buyer). Where possible, some people fold up the foot rest and tuck it behind the portion of the cushion that hangs down.

Restraint system use. There was divided opinion on the need for and use of restraint system features. Some felt that the tray and passive restraint bar *were* the restraint system, and that straps were unnecessary. Some actually removed the belt from the chair as a nuisance. Others felt that five-point harnesses were critical and should always be used. Some felt the tray was a critical element and always used it; others frequently kept the child in the chair with the three-point restraint buckled but the tray removed. Some felt that the straps were not needed if there was a passive restraint bar.

There was a lot of feeling that many restraint systems are difficult to use. The means of attachment or adjustment may be non-intuitive and difficult to figure out, or awkward to use. The passive restraint bar gets in the way of use. Twisting of straps makes them difficult and uncomfortable for the child. Lack of adjustability in crotch or shoulder straps was a frequent complaint. Also, once the child is placed in the seat, the straps cannot be adjusted; it is “hit or miss” whether you get it right. There was also broad agreement that there is a problem with the straps getting very dirty. In contrast to other components of the high chair, they may be very difficult to clean. Some people remove them for cleaning. One person washes them in the clothes washer. Another described placing the straps in the dishwasher, but found the plastic buckles had melted.

Individual differences among children. Children are seen as very different from one another in their behaviors and in their ability to get free from restraints. Some reported that their child never even tried to escape, through the full user age range; others reported the child routinely getting free of the straps even at four months old. There was a general consensus that children tend to get much “squirmier” once the tray is removed. There was speculation that this is due to the expectancy that they will be removed from the chair. One mother said she intentionally was not removing her child right away after removing the tray, so that this behavior hopefully would not emerge. Some people thought that children seemed to have shorter attention spans when in the high chair; others described children who remained passive, and even slept particularly readily, when in the high chair.

Caretaker supervision. There was a strong opinion that close supervision was necessary whenever the child was in a high chair. However, there was also recognition that, since the groups were composed of CPSC employees, they were likely more concerned about this than other parents. Even so, in the course of discussion it became apparent that short absences (e.g., a minute or so) were not unusual for many of the participants. In part this depended on the child. Some children get upset if the caregiver is out of sight, and others are “escape artists;” an adult is less likely to leave either sort of child, even for a short period. One factor that appeared related to supervision was television viewing. There was a feeling that television had a “narcotic” effect on children, so that if they were engaged with viewing, it was safer to leave them for a while.

Purchase decision factors. No one in the groups ever considered not using a high chair. It was seen as a normal, essential product. The following factors were cited as important for at least some individuals in making a purchase decision: name brand; absence of product recalls; versatility over the user age range (influenced by packaging, reclining feature); enclosed sides; stability (even if you trip over the chair); passive restraint; five-point restraint; brakes on the wheels; collapsibility. Those who mentioned having been influenced by collapsibility also remarked that in fact, they never used this feature and it turned out to be unimportant.

Stroller Comments

Range of user ages. The age of the youngest users depends on the stroller type. The four-in-one product that includes a nested baby carrier can be used from birth. Use is routine up through three years old, but may continue to four and five for situations where there is a lot of walking involved.

Product types and use. The ownership of multiple stroller products was typical for participants in these focus groups, with people owning from one to five strollers. There was a feeling that different products were needed for the various applications, so that consumers owned a full sized stroller along with other products such as jogging strollers, umbrella strollers, or tandem strollers. Participants did not normally use strollers around the house, although they knew of others who did. The uses were mainly for malls,

attractions, and walking. Some reported second hand experience of friends or relatives using strollers in the house because the children fell asleep well in them.

Restraint system use. The perceived risk with strollers was not particularly great, and certainly less than with high chairs. The feeling was that the child was already close to the ground, and the adult was always right there. Routine or occasional non-use of all or part of the barrier system (straps, bars) was high. There was some debate about the actual function of restraint systems for strollers. Are they intended to restrain children who want to get out of the stroller? Or are they intended to keep a child from falling out during dynamic situations (bumps, curbs, rough terrain)? The participants generally appeared to have a higher concern with the latter. One mother said that the other purpose (restraining a child trying to get out) did not even occur to her over months of use until her child got older and tried to get out (around 14 months old). She speculated that because children are not very mobile when they first are placed in strollers, she only saw the restraint as holding the child in while moving along. Even though there was a consensus that the children were more active in trying to get out when the stroller was stationary, the greatest safety concern seemed to be with dynamic situations. In contrast to the high chair case, participants had little first-hand experience of escapes or near escapes. In part, they felt this might be attributable to being at hand to prevent any situation before it starts.

Some people were of the opinion that restraints were not particularly effective in keeping children in the stroller if they were intent on getting out, but that they were important in “buying time” for the caretaker to respond to the situation.

There was mixed feeling about five-point restraints, as with high chairs, although they were viewed more favorably for restraint in dynamic situations (crashes and spills). In this respect, they were seen as more like car seats than high chair restraints. Some participants expressed the opinion that the five-point restraint systems for jogging strollers were not adequate to retain small children. They believed that the shoulder straps were anchored too high on the seat, which placed them too far above the shoulders of smaller children.

Many strollers have a restraint bar around the front of the stroller. There was not consensus on the importance of this. Some felt that it is important to have some barrier in front of children, particularly as you place them in the stroller seat. Others felt the strap system itself was enough. One person reported removing the barrier to make egress easier, so they did not have to lift the child up and over the barrier.

In general, the reported reasons for non-use of stroller restraint systems were: lack of perceived risk; close supervision precludes need; nuisance factor; twisting of straps; ability to train child to sit still when requested. Some also feel that the fussiness of the child provides an “early warning system” that alerts the caretaker before any overt escape attempts occur.

Behavior of children. There was consensus that children are more active and more likely to attempt to get out of the stroller when they are stationary rather than in motion. While standing still, children may get more fussy, or may try to reach for things in the nearby environment. Although many of the participants said they would not leave children unattended in a stroller, others indicated that if the children fell asleep while in the stroller, they left them there.

Some modes of escape or unsafe behavior in strollers were described. There were descriptions of children wriggling themselves upright, pushing up on the available surfaces, and then trying to launch themselves (usually backward) over the side of the stroller. Another described her child as rocking repeatedly in order to slide upward a little in the restraint, eventually getting to a point where the child could turn around and face the seat. Another mother pointed out that older stroller users (e.g., two year olds) are often able to slide down in the seat and get their feet dragging on the ground or in the stroller wheels.

Purchase decision factors. The following factors were cited regarding the purchase of a stroller: brand name; high quality; weight; child comfort; ease of collapsing; multi-use; storage compartment. Safety was not really a consideration, with three exceptions. One was to make a determination that the product had no safety recalls. Another was that there be good feedback (a “click”) from latches when they were engaged. The final was from one discussant who had a particular concern about safety when the stroller was in a reclined position. She made sure that there was some sort of barrier to keep the child from sliding out toward the head end of the surface, particularly for when going up over curbs or inclines. With these exceptions, safety was not a prominent issue for stroller selection. It was pointed out in discussion that, in contrast to high chairs, the packaging for strollers does not emphasize safety issues.

APPENDIX F
SUMMARY OF STROLLER INCIDENT CASES

Summary of Stroller Incident Cases Reviewed

Product	Case	Sample	Age	Wt	Ht	Restraint	Motion	Configuration	Type Incident
	010104HAA3124	Y	6 to 19	unk	unk	5-pt	N/A		Straps too loose
	000210HCC3157	Y	7	18	24	3-pt	Y		Forward lean, suspended
	000824HAA3392	Y	11	18-20	"ave"	2-pt	N		Wriggled out
	000901HAA2795	Y	6	16	50%	3-pt	Unk		Thru leg hole
	000824HAA3393	Y	11	20	29	3-pt	N		Loosened strap
	000907HAA0014	Y	8	20	29	2-pt	N		Side lean, slipped out
	001011HCC2028	Y	9	<22	?	3-pt	Y & N		Forward lean
	001011HAA2022	Y	8	22-23	29-30	3-pt	N		Slipped out
	000927HAA0082	Y	15	20	29	5-pt	N		Slipped out
	971126CWE4171		4	16	25 5	3-pt	Unk		Slid
	980319CCC3714		12	19	27	2-pt (rear)	Y		Maneuvered out of strap
	000210HCC3156		10	?	?	2-pt	Unk		Wriggled out
	000503HCC2512		15	22	30	5-pt	Unk		Wriggled out
	970929CCC1545		3	11	22	2-pt	N	Reclined	Rocker, slid
	000110HCC0261	Y	20	22	32	3-pt	Y		Loosened strap
	991203CCC0144		7	19	28	2-pt	N	Reclined	Slid down, entangle neck
	980514CCC1401		23	30	30	2-pt	N	Reclined	Backed out, tipped
	990615HEP5442		20	24	33-34	3-pt	N		Got out somehow
	990730HEP5441		10	19	28	2-pt	N	Reclined	Got out somehow
	990608HEP9003		10	26	26	2-pt?	N		Got out somehow
	990728HEP1201		8	23	22	unk	N		Got out somehow
	990721HEP0642		17	?	?	3-pt	N		Wriggled out
	990721HEP6401		10	20	28	3-pt	Y?		Got out somehow
	990618HEP2961		11	?	?	2-pt	N		Slid out, stood
	990830HEP6001		10	23	30	unk	N		Squirmed out
	990524HEP3041		10	23	24	2-pt?	N	Reclined	Scooted fwd, tipped, slid

APPENDIX G
SUMMARY OF HIGH CHAIR INCIDENT CASES

Summary of High Chair Incident Cases Reviewed

Product	Case	Sample	Age	Wt	Ht	Restraint	Passive	Removed?	Detached?	Type incident	
	010103HAA2170	Y	16-22	19	28	3-pt	Y			Turned, stood in belt	
	001129HAA3081	Y	7	24	23	3-pt		Y		Leaned, hanging by strap, tipped	
	001130HAA2120	Y	11	16	28	5-pt	Y			Stood in belt	
	001207HAA2134	Y	12	18	30	3-pt				Stood in belt	
	000620HBB0771	Y	9	20	25	2-pt	Y			Stood in belt	
	000615HBB2620	Y	11-13	22	30	3-pt				Twist loose, kneel/stand	
	980926CCC2854	Y	9	19	28	3-pt			Unk	Stood in belt	
	000329HCC3194	(above)	15	22	30	3-pt				Wiggled free, stood	
	001012HAA0035	Y	11	20	28-30	3-pt				Wiggled free, stood	
	000329HCC0515		10-11	18	26	3-pt				Wiggled free, stood	
	000720HCC0845		10	17	22	3-pt	Y			Stood in belt	
	000725HCC3338		13	20	31	3-pt				Stood in belt	
	000503HCC0632		15	20	?	3-pt			Y	Stood, leaned on tray, came off	
	981102CCC6039		6-8	15-18	25-27.5	3-pt				Slips down, head entrapped	
	000307HCC2355		11-13	20.5	29.5	unk				Stood in belt	
	000419HCC2460		12	23	25	3-pt				Stood in belt	
	980928CCC4006		6	18	23	3-pt			Y	Leaned, fell from straps	
	001130HAA2120		11	16	28	5-pt	Y			Stood in belt	
	991013CCN0370		3 yrs	?	?	3-pt			Y	Y	Leaned, improper belt install
	000328HCC2388		12	24	27	3-pt			Y	Y	Belt anchor slid through slot
	990427CCC3313		11	18	30	3-pt			Y	Y	Belt anchor slid through slot
	980527CCC1442		10	20	?	3-pt			Y	Y	Belt anchor slid through slot
	990420CCC2427		8	20.5	28	3-pt			Y	Y	Belt anchor slid through slot
	000308HCC3185		7	19	28	3-pt	Y		Y	Y	Belt anchor came detached
	970602CCC1273		11	21	26	3-pt					Arms broke off hanging by strap
	000503HCC2513		9	19	26	not used	Y				Tray disengaged, fell out
	990120CCC0234		12	22	29	3-pt					Released tray, belt latch popped
	980825CCC2805		?	?	?	2-pt					Tray disengaged, fell out
	990921CCC2656		11	?	?	not used					Released tray, fell out
	990625CCC3384		10	18	?	3-pt					Released tray, belt latch popped
990916CCC3488		8.5	19	27	3-pt					Tray disengaged, belt anchor slid	

APPENDIX B

CAUSES OF HIGH CHAIR AND STROLLER
RESTRAINT SYSTEM FAILURE

PROJECT FINAL REPORT

by

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July 2001

Submitted by

Westat
1650 Research Blvd
Rockville, MD 20850

Submitted under

Contract CPSC-S-00-5205

Submitted to

U.S. Consumer Product Safety Commission
Washington, DC 20207

CPSC 6 (N) Cleared 1-30-01
X No Mfg/Products as XCB
Products Identified

ACKNOWLEDGEMENT

The authors of this report wish to acknowledge the important contributions of project team members to the work reported here. These include Dr. Jane Clark, University of Maryland, and Bari Kotwal, both consultants to the project. Also acknowledged are Dr. Beth Rabinovich, Molly Fogash, Jeremiah Singer, and Dr. Doreen DeLeonardis of the Westat staff.

The authors also wish to thank Carolyn Meiers and other members of the U.S. Consumer Product Safety Commission staff for much valuable support throughout the project.

EXECUTIVE SUMMARY

High chairs and strollers provide restraint systems that are intended to safely retain children within the seat. Failure to retain children in place may result in injuries or deaths from falls, entrapment in product components, or entanglement in restraint belts. Despite the presence of restraint systems on high chairs and strollers, such incidents occur. CPSC estimates that in 1998 more than 15,000 children were treated in U.S. hospital emergency rooms for injuries from falls from high chairs and strollers. Restraint systems may fail to prevent an incident for various reasons. Adult caregivers may not use the restraints or may not adjust them properly. Children may be able to disconnect buckles or loosen straps. Product components may fail or anchor points may release. Children may be able to overcome the restraints despite their proper use and physical integrity. This project focused on restraint systems that, while in use, fail to keep children securely contained. It dealt with the relationship between the physical features of the products and restraint systems and the behavior and anthropometric characteristics of the children who use the products. Consideration was also given to factors that may contribute to adult caregiver non-use or misadjustment of the restraint system. Failures of the physical integrity of the restraint, structural failure or instability of the product, or the child-resistance of restraint clasps were beyond the scope of the project.

The objectives of the work described in this report were to: (a) analyze the causes of high chair and stroller restraint system failures from a human factors system perspective; (b) identify critical characteristics and features of restraint systems; and (c) make recommendations for the design and testing of restraint systems that may improve safety and effectiveness. The project was conducted in two phases. The initial phase developed product profile reports for high chairs and strollers. These profiles detailed the characteristics of the products relevant to restraint use and failure and identified a set of typical incident scenarios for each product type that were associated with restraint system failure. This information provided the basis for the second phase of the project, the causes of restraint system failure. Analytic techniques were used to link product characteristics to certain fundamental movements and actions of the child that were critical to the execution of the various incident scenarios. If the designs of the product and its restraint system are effective they will not afford children the opportunity to successfully make these component movements.

Based on the analysis, a set of recommendations was offered. These included recommendations for design features of high chairs and strollers; recommendations for promoting the proper use of restraint systems by adult caregivers; and suggestions for product standards and testing. These recommendations were offered as having the potential for improving product safety because they address causal problems for restraint failure incidents. However, more thorough development and evaluation of the individual potential countermeasures is required before they can be recommended for adoption. Six general design issues were noted that confront the designers of high chair and stroller restraint systems. High chair and stroller restraint systems must be designed to address the following:

- The cylindrical body shape of children
- The use of thighs as effective levers
- The envelope of permitted movement of the knees and legs
- Maintaining the hip to the chair seat
- Containment of the center of gravity
- Footrests/pushing surfaces

One limitation of current testing methods for evaluating restraint system effectiveness is that they do not include consideration of the important role of the child's thighs. The relationship of product parameters to user thigh length relates to such issues as whether the legs can be drawn into the seat compartment, whether the thighs can be used to exert upward leverage, and whether the child can pivot in the seat. Recommendations were made to develop a test manikin that includes a rigid thigh component.

The wide age range of stroller and high chair users makes the design of effective restraint systems challenging. Stroller users range from about 3 months to about four years old. High chair users range from about 6 months to about three years old. There are substantial changes in size, behavior, and capability over these age ranges. If a restraint system is to be effective, the primary restraints (e.g., belts) and the product features must be treated as a system and must be carefully designed to meet the requirements of the full range of users. The findings of this report suggest that aspects of current practice may not be optimal and that there are a variety of promising countermeasures that may improve restraint system effectiveness.

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1. INTRODUCTION AND OVERVIEW

1.1 Objectives and Approach

1.1.1 Objectives

The objectives of the work conducted for the U.S. Consumer Product Safety Commission (CPSC) under CPSC-S-00-5205 were: 1) to evaluate the restraint systems used on strollers and high chairs to determine why restraints fail and 2) to identify critical characteristics and features needed for effective restraint systems. The focus was on restraint systems that, while in use, failed to keep children securely contained. Factors related to adult misuse or non-use of the restraint system were also considered. Failures of the physical integrity of the restraint or the child-resistance of restraint clasps were beyond the scope of this project.

This project *Final Report* summarizes overall project activity and presents the findings regarding the causes of restraint system failure and related countermeasure recommendations. An interim project document, the *Product Profile Report* (Lerner, Huey, & Kotwal, 2001), provided information on the range of product types and features, modes of product use, characteristics of the children using these products, behavior of the adult caregivers using these products, and characteristics of incidents involving restraint system failures. It presented separate product profiles for high chairs and strollers. This information provided a basis for subsequent efforts to analyze the causal basis of restraint system failures and develop recommendations for improved design and testing of high chair and stroller products. The activities of the initial phases of this project are briefly summarized in Section 1.2; more complete documentation may be found in the *Product Profile Report*. The emphasis in this *Final Report* is on the systematic analytic activities related to understanding and addressing the causes of restraint system failure.

1.1.2 Approach

Central to the analytic effort was the use of task analysis methods. *Task analysis* encompasses a body of systematic techniques for relating human performance to tasks, product systems, and user capabilities. The sequence of project activities resulted in the progressive focusing of the level of analysis to the point where a core set of critical child movements was defined. This produced a manageable number of cases to consider and an appropriate level at which to conduct the task analyses. Figure 1 illustrates this focusing sequence. A great deal of general information about product use and restraint system problems was found through the efforts of the initial project tasks (see Section 1.2). Based on this, factors related to adult caregiver non-use or misuse of high chair and stroller restraint systems became evident. However, the primary interest in this project was in why restraint systems fail to be effective, *given* that they are being used in an appropriate manner. A set of twenty sample products (ten strollers, ten high chairs) was acquired through CPSC in support of the analysis. Fifty seven (57) CPSC in-depth investigations (IDI's) were reviewed, all of which involved high chair or stroller restraint system failures. Taking these specific incident cases and product samples, together with the more general findings, a set of eleven primary incident scenarios was defined. These scenarios encompassed and categorized the typical range of incidents. The review of IDI's and the derivation of the scenarios were detailed in the *Product Profile Report*. The eleven scenarios, in turn, led to the identification of key movements or actions by the child that are necessary for the incidents to occur. Features of the products that afford a given movement provide the opportunity for a particular incident scenario to occur. A product or restraint system design may or may not afford the opportunity for a given

movement by a particular user. Six of these movement affordances appeared critical, taking all of the scenarios into account. Task analysis was conducted on these movement affordances. The task analysis related child behavior, anthropometry, and product dimensions to this central consideration of movement affordance. Section 4 provides a more complete description of this analysis and clarifies the terms. We identified causes of restraint failure as well as design challenges and then developed recommendations from these, relating to product features, dimensions, and performance.

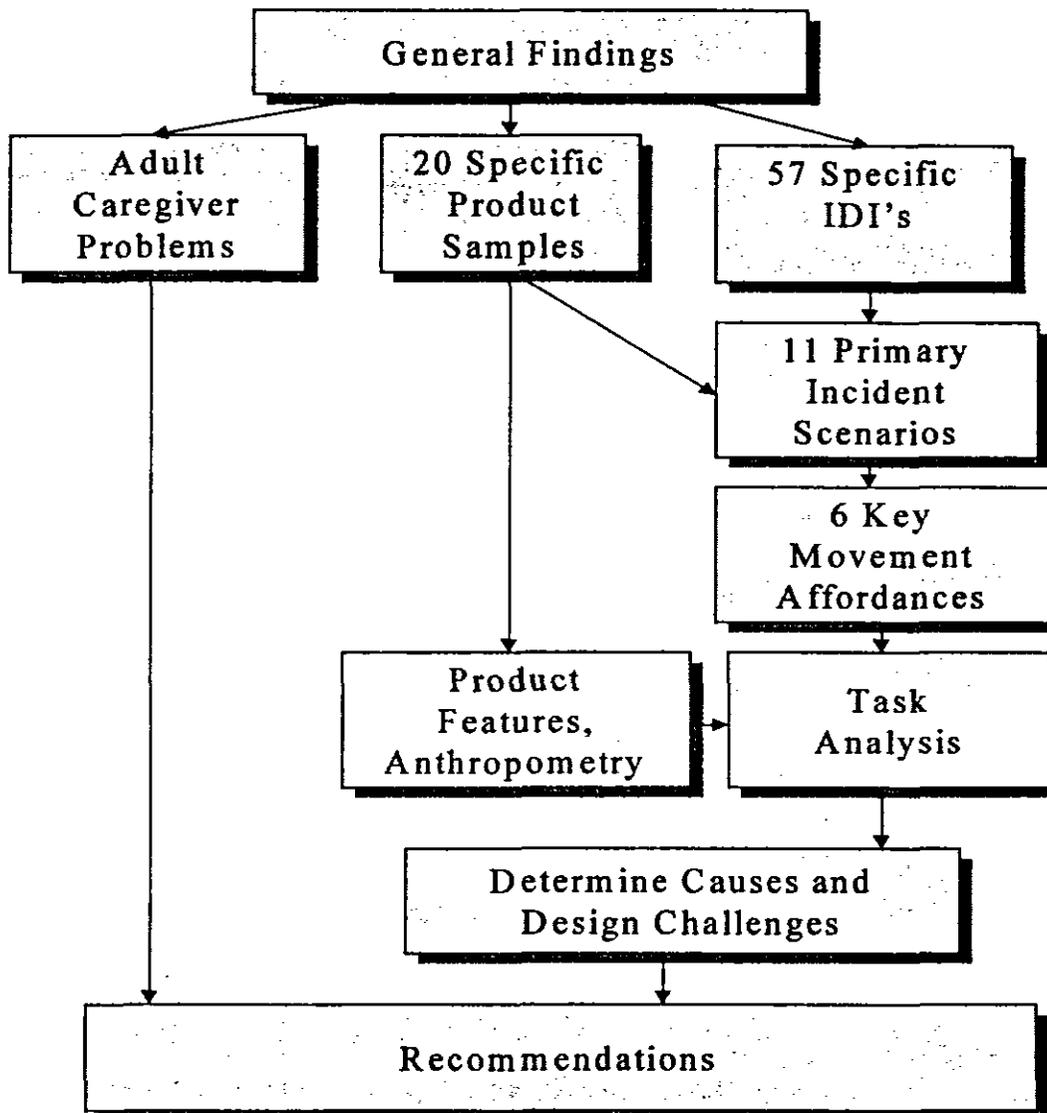


Figure 1. Sequence of Analytic Stages

1.2 Overview of Initial Project Activities and Product Profiles

The initial activities of this project were designed to collect information that could be used to construct product profiles for high chairs and strollers. The product profiles detailed characteristics of the products relevant to restraint use and failure. The details of the effort are documented in the *Product Profile Report* (Lerner et al., 2001).

The report drew on a wide range of information sources. A number of these sources were qualitative or anecdotal. While each source had its limitations, all of the findings considered together provided a reasonable picture of the products and their uses. Information sources included: in-depth incident reports; product samples; store visits; standards documents; technical research reports; focus groups; consumer-oriented internet sites; small-scale field observation; and child development and anthropometric literature. While this information presents a large picture of the products available today, we do not have complete information on the products being used in homes.

The product profiles addressed the range of product types, modes of use, characteristics of children using the products, adult caregiver behaviors, restraint system features and problems, and restraint failure incident characteristics. A set of six general scenarios was found to categorize the range of stroller incidents and a set of five general scenarios was found to categorize the range of high chair incidents. These typical incident scenarios provide a basis around which subsequent analyses of the causal basis of restraint system failures could be conducted. The six stroller scenarios found to be related to restraint failure incidents were: (1) stand and fall; (2) lean over side and fall; (3) lean and reach; (4) pitch forward; (5) slip through leg opening; and (6) horizontal slide (with the stroller in an inclined position). The five high chair scenarios found to be related to restraint failure incidents were: (1) push/pull up; (2) turn around; (3) tray release and pitch forward; (4) slip through leg opening; and (5) slide down and entrap. Each of these scenarios was specifically defined in the report and the at-risk children were characterized. Further description of these scenarios will be provided in Section 4.

In addition, a range of adult caretaker use factors was identified that related to misuse, non-use, or misadjustment of restraint system features. These provided a further basis for failure analysis and suggested system improvements. Non-use factors were identified that related to lack of perceived need, nuisance, negative effect on the child, difficulty of strap attachment, and needs related to functional use of the product. Misadjustment factors were identified that related to child actions, clothing, poor user feedback, child comfort and utility, difficulties in restraint adjustment, and child growth. Section 3 of this report will provide further information on these factors.

Particular findings from the *Product Profile Report* are presented in the course of this *Final Report* as they are relevant to the analyses. Otherwise, greater detail may be found in the original report (Lerner et al., 2000).

1.3 Definitions

Restraint systems are understood to include those components of strollers and high chairs that directly or indirectly contribute to the capability to effectively secure children within the products. Examples of these components include restraining straps, trays and bars, footrests, seats, and anchor points. The definition is intentionally broad so that all of the components of a product that might have an influence on restraint can be considered together in evaluating the effectiveness of these elements as a *system*. For example, the feeding tray (with or without a

crotch restraint) of a high chair is treated as a component of the restraint system even though product owner's manuals may warn the consumer that the tray is not a restraint device and that restraining straps must be used. However, since the tray can serve to restrict children's movements and can provide a surface to push against for standing and can color adult caretakers' perceptions of the need for use of other restraint components, an analysis of the restraint *system* would be incomplete without considering the tray.

While various product features are viewed as components of the restraint system, restraining straps are generally viewed as the *primary restraints*. These straps are anchored to the stroller or high chair body and are intended to limit the range of movement of the child. Primary restraints occur in a variety of configurations. Two-point *waist belts* encircle the child's waist and attach to the seat back on either side of or behind the child. *Three-point restraints* are comprised of a waist belt plus a crotch strap. The crotch strap runs between the child's legs from the waist belt to the chair seat. This strap is intended to prevent the child from sliding down through the waist belt. *Five-point restraints* have waist and crotch attachments but also include shoulder straps. The shoulder straps may be configured to limit forward motion of the torso (if anchored to the seat back only) or upward motion from the waist belt (if anchored to the belt).

While restraining straps require a deliberate action on the part of the adult caregiver to engage them, products also feature *passive restraint* components. These are restraint features that are in place without any intentional act on the part of the adult caregiver. Sometimes this term may be intended to refer specifically to the "passive crotch restraint system" now required of high chairs in ASTM F 404-99a (*Standard Consumer Safety Specification for High Chairs*). The high chair passive crotch restraint system is in place whenever the tray is in place. This typically is in the form of a vertical bar between the seat surface and the tray. The child's legs go around either side of this bar to prevent the child sliding down. The high chair passive crotch restraint system is not the only potential form of passive restraint for high chairs and strollers. Therefore when referring to this component the specific term of *high chair passive crotch restraint system* will be used in order to distinguish it from other possible passive elements. Where other types of passive restraint are discussed, the nature of the system will be specified in similarly specific terms.

2. HIGH CHAIR AND STROLLER PRODUCTS AND THEIR CHARACTERISTICS

2.1 Products, Features, and Dimensions

CPSC provided ten high chairs and ten strollers either previously involved in incidents or selected for specific features. There was no formal sample collection design. Taken together, these products served as examples of the key product types and characteristics believed relevant to the restraint failure issue. Appendix A lists the twenty product samples and indicates the associated CPSC IDI where relevant. The products, and any associated materials (manuals, incident reports), were examined to determine key features, likely modes of use, and the range of differences among products and restraint systems. Although the analysis in this report focused on restraint effectiveness and safety-related concerns, high chairs and strollers are consumer products that also need to successfully meet their functional use requirements. Therefore, consideration included how potential changes to the restraint system might effect the usability, functionality, and perceived value of the products.

We identified a broad set of product features and dimensions of potential interest for the analysis. A comprehensive set of measurements was performed on each stroller and high chair sample. Appendix B illustrates the various measurements taken. These include the location and dimensions of various product elements, such as the seats and the arm rests, description of the functional ranges of adjustable features, such as the seat incline angle and the feeding tray position. The dimensions of openings and other relationships defined by the relative positions of product features such as leg hole openings and the distances from the front edge of the seat to the surface of the footrest.

The set of measurements on all of the product samples was then compiled into a database for review and analysis. Figure 2 is a template that illustrates the format in which the data are presented. Appendix C provides the complete data set. As Figure 2 shows, each product is summarized on a separate page. Product descriptive information (sample ID, make, model) is given, along with a photograph of the product and a schematic of the primary restraint system (discussed further in Section 2.2). This is followed by more than 50 data fields in which various features and dimensions were entered.

2.2 Primary Restraint System Configurations

Although the primary restraints can be generally described as two-point (waist belt), three-point, or five-point, there is a wide range of different configurations within these categories. The primary restraint belts for each product were characterized using schematic diagrams. Alternative design illustrations are available in Appendix B and the configuration for each product may be seen in Appendix C. The examples in Figure 3 illustrate how the schematics in Appendix C describe the belt configuration. Note that the diagrams are not drawn to scale; they represent the primary restraint system components and their interrelationships but are not intended to illustrate dimensions.

21						Belt Characterization:	
Sample ID:							
Make:							
Model:							
Back Depth	0						
Seat Back Width	0	(inside)					
Seat Back Height	0						
Seat Width	0						
Seat Pan Height	0						
Arm Rest Height	0						
Seat Side Opening	0						
Leg Opening (Vertical / Horizontal)		0 / 0		Head Barrier Depth:		0	
				Cantilever Extension:		0	
Seat/Back Angle (Min / Max)		0 / 0 (between 90 and 180 deg.)		Seat Incline (Min / Max)		0 / 0 (between 0 and 90 deg.)	
@ Maximum Recline				Seat/Footrest Angle (Min / Max)			
Back Length:	0	0 / 0 (between 90 and 180 deg.)		Seat Footrest Distance:		0	
Back Depth:	0						
Removable? <input type="checkbox"/>		Crotch Barrier:		Shoulder Strap			
Distance to Back (Min / Max)		0 / 0		Distance to Back (Min / Max)		0 / 0	
Angle (Min / Max)		0 / 0		Depth from Tray Back:		0	
Width:		0		Size of Bar (Depth / Width):		0 / 0	
Depth:		0		Anchor Height (Min / Max):		0 / 0	
Side Release? <input type="checkbox"/>		Crotch Strap		Anchor Separation (Min / Max):		0 / 0	
Depth:		0		Length (Min / Max)		0	
Offset:		0		Anchor to Back (Min / Max)		0 / 0	
Front Release? <input type="checkbox"/>		Length (Min / Max)		0		Waist Belt	
Depth:		0				Anchor Height (Min / Max)	
						0 / 0	
Minimum Rearward Compartment/Wheel Distance:		0		Anchor Separation:		0	
Minimum Forward compartment/Wheel Distance:		0		Circumference (Min / Max)		0 / 0	
Stroller Side Release? <input type="checkbox"/>							

Figure 2. Measurement Template

The left schematic shows a five-point system and the right schematic shows a three-point system. Circles are used to show fixed attachment points; slots indicate where there is an attachment to the seat structure. A square with a directional arrow is used to show a floating attachment point. A “floating” attachment point is one in which the strap components are connected but the point of that connection is free to move in some direction. For example, in the right schematic the waist belt runs through a loop on the end of the crotch strap. This loop has freedom to slide along the waist belt, as indicated by the directional arrow on the square attachment symbol.

The five-point restraint system on the left shows the shoulder belts affixed at one end to the seat back and at the other end to connectors on the waist strap. The waist strap is connected on either side to the seat and the left and right sides connect at a central buckle. The crotch strap is connected at one end to the seat pan and at the other end to the three-way central buckle.

The example on the right shows the crotch strap connected to the waist belt at the front (floating attachment) and the rear of the waist belt. The entire waist belt/crotch strap assembly is tethered to the seat back at a single point.

Appendix C shows multiple diagrams of restraint strap configurations, as well as information on the length (or range of lengths, if adjustable) of each strap component and the location of the anchor points.

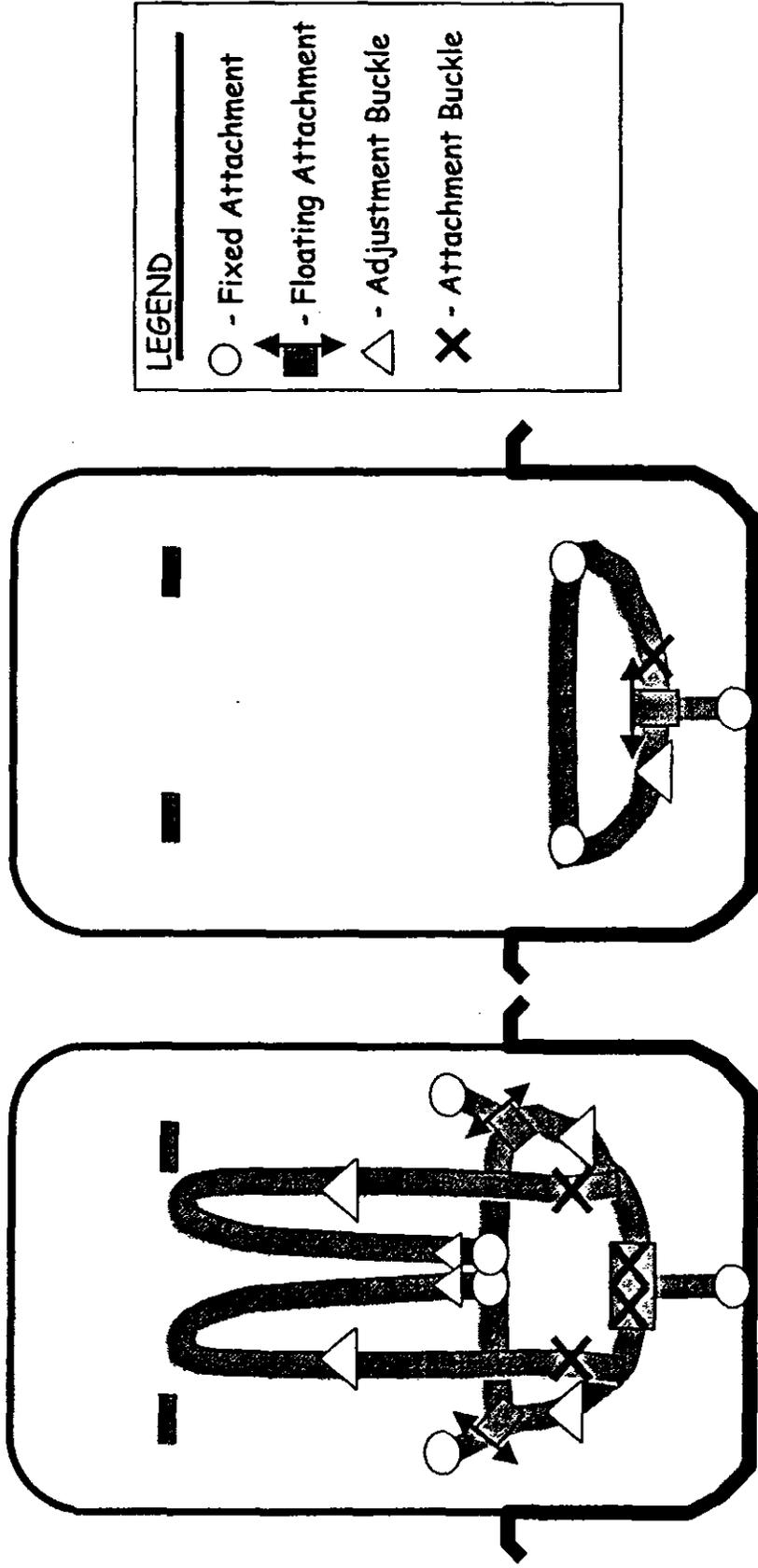


Figure 3. Example Schematics for Restraint Belt Configuration

3. RESTRAINT FAILURE ISSUES RELATED TO ADULT CAREGIVER BEHAVIOR

Although our focus is on restraint failures given proper use, some consideration should be given to the causes of incidents that concern adult caregiver behavior in the non-use or misuse of the restraint system. Although this may be characterized as a behavioral problem, it may be related to the design of the product and its restraint system. Design countermeasures may exist that reduce the likelihood of non-use or misuse.

The issue of non-use or improper use of high chair and stroller restraint systems was initially considered in the *Product Profile Report*. In that report information drawn from a variety of sources (e.g., technical reports, CPSC IDI's, focus groups, consumer-oriented Internet sites) was used to identify factors that contribute to adult caregiver problems in restraint system use. Two sets of adult user factors were developed. One listed factors related to the non-use of restraint systems. The other listed factors related to misadjustment of restraint system features. These sets of adult caregiver factors are reproduced in Appendix D. Reference to this appendix shows that a variety of causes have been identified. Some of these are generic and not closely tied to product features; others are influenced by product design.

Table 1 is derived from consideration of the factors listed in Appendix D. The table lists several general categories of adult caregiver factors: nuisance factors, adjustment to fit, user feedback, child behavior, and perception of need/risk/effort. More complete descriptions of the "user factors" listed in the table may be obtained through Appendix D. For each factor, we have suggested some potential countermeasures that might address that factor are listed. Some of these countermeasures are based on product design features; others are based on safety communication through warning labels or owner's manuals. In some cases, additional comments related to the countermeasure concept are included in the table.

The potential countermeasures in Table 1 are suggested for consideration. They are not intended to be recommendations. Any potential countermeasure must be carefully evaluated in terms of its probable benefit, compromises in product utility or appeal, cost impact, usability, and potential for introducing new hazards. The countermeasures in Table 1 are concepts that have some potential to address the problem factor but they are not necessarily effective or practical. However, the table is instructive in showing that the adult caregiver factors that contribute to restraint system failures do have the potential to be addressed through a variety of means. While it is important to devise child restraint systems that function effectively when used properly, it is also important to design the product so as to encourage consistent and proper use of the restraint system.

Table 1. Adult Caregiver Causal Factors and Potential Countermeasures

User Factor	Potential Countermeasures	Comments
<p>Nuisance Factors</p> <p>Interference with access/egress</p>	<ol style="list-style-type: none"> 1. Single clasp rather than multiple clasps 2. Swing-away or fold-down feature for bars, trays 3. One-handed operation of clasps 4. Retractable belts 5. Fold-down or retractable barriers 	<ul style="list-style-type: none"> • Fold-down barriers refer to bars that can be moved into place from above or beside the child, in the manner of restraint bars on amusement park rides. They must not introduce entrapment hazards.
<p>Difficult to operate</p>	<ol style="list-style-type: none"> 1. Intuitive operation of belts (attachment and adjustment) 2. Reduce requirements for finger strength, fine movement 3. Minimize number of operations (e.g., threading belt through loops, number of attachments) 	<ul style="list-style-type: none"> • Must not compromise child-resistance of latches
<p>Hard to access</p>	<ol style="list-style-type: none"> 1. Locate clasps away from passive restraint bars 2. Straps attach to passive restraint bar 3. Retractable belts 4. Sleeve or holder for strap or buckle 	
<p>Strap tangles, twists</p>	<ol style="list-style-type: none"> 1. Wider or stiffer straps 2. Rotating connections at anchors, clasps, or along straps 	<ul style="list-style-type: none"> • Should not compromise child comfort • Integrity of the restraint material and anchors must remain reliable
<p>Belts get dirty, hard to clean</p>	<ol style="list-style-type: none"> 1. Easily cleaned material. Woven fabric is particularly hard to clean 2. Easily removed and re-installed anchors, so that strap can be taken off for cleaning. 3. On-strap label regarding how to clean, what not to do 	<ul style="list-style-type: none"> • Material should not cause child discomfort or compromise restraint effectiveness. • Re-attachment must be obvious, reliable, and not subject to wear • Cleaning actions that might compromise the strap or clasp (e.g., excessive heat, dishwasher) should be made evident

Table 1. Adult Caregiver Causal Factors and Potential Countermeasures (continued)

User Factor	Potential Countermeasures	Comments
Adjustment of fit	<ol style="list-style-type: none"> 1. Intuitive mechanism for adjustment 2. Range of alternative anchor points 3. Multiple restraint systems included with product to accommodate range of size 4. Crotch strap adjustability 5. Owner's manual treatment of adjustment, including awareness of child actions (arching back, protruding belly), clothing, desired tightness, functional objectives 	<ul style="list-style-type: none"> • Re-attachment must be obvious, reliable, and not subject to wear • Adjustment must be stable and child-resistant • Products may be misassembled and may not work properly; this may not be recognized by the consumer
User feedback	<ol style="list-style-type: none"> 1. Audible feedback when attachments are engaged 2. Tactile feedback when attachments are engaged 3. Active warnings if child is in seat but attachment is not engaged 	<ul style="list-style-type: none"> • Active warnings require battery power and sensors
Child behavior	<ol style="list-style-type: none"> 1. Comfort of straps: padding, width 2. Manual section on how to deal with poor acceptance of restraint 	
Perception of need, risk, effort	<ol style="list-style-type: none"> 1. On-product warnings/instructions, including need for active components 2. Simplify appearance of harness systems 3. On-tray labels indicating this is not a restraint barrier 	

4. TASK ANALYSIS

4.1 Approach to Causal Determination

Restraint failure incidents occur across a broad range of stroller and high chair products, child users, and sequences of behavior. To link this diversity of incidents to specific causal factors and related countermeasures, two analytic issues must be addressed. First, some means must be found for organizing the diversity of incidents into a manageable number of meaningful categories. Second, and related to this, the appropriate level must be found at which to focus the analysis. An appropriate level is one that can result in a manageable, yet comprehensive, number of categories and that can be directly linked to the attributes of the product and the restraint system. The general approach taken to accomplishing this was outlined in Section 1 and shown schematically in Figure 1. Based on the review of IDI's, product samples, and other information, we identified eleven incident scenarios served to encompass and categorize the range of incidents encountered. Any given scenario was based on certain movements or actions of the child being performed. These elemental movements provide a good level for analysis because they may be mapped quite directly to the product features. In doing this analysis, we found that many of the causal factors could be related to a set of more general design challenges. These design challenges provide a structure for the recommendations of Section 6.

4.2 Task Analysis Method

4.2.1 General Approach and Scope of the Task Analysis

Task analysis provides a means of determining the tasks associated with the use of a product in behavioral terms and relating the execution of these behaviors to the characteristics of the products and the product users. The task analysis was based on the behaviors required of a child restrained in a stroller or high chair to accomplish some act that results in a potential fall or other injury incident. The analysis began with the assumption that the restraint system was correctly in use and then considered what factors might lead to restraint system failure despite that use. Thus the child is the product "user" in this analysis and the implied "task" is overcoming the restraint system to accomplish a specified act, such as standing up on the chair seat.

Restraint-related incidents can also occur because of adult caregiver failures to use the restraint system properly, if at all. Problems of restraint use by adult caregivers were treated in Section 3. For the task analysis, however, it is assumed that the restraint system is in proper use. The analysis also assumed the integrity of the physical structure of the product. Thus the analysis did not include consideration of situations where part of the product broke off or where clasps failed to engage properly. The child resistance of buckles and latches was also outside the scope of the analysis. The task analysis focused on the execution of behaviors that relate to defeat of the restraint system and the analysis terminated at the point at which the restraint system was overcome. Once the restraint system has been defeated and the escape movement has become possible, there is a wide range of possible events and related injury outcomes that can ensue. These may be difficult to predict and prevent and may be related to external forces as well as product structure. Thus the focus of the analysis deals with the restraint failure event, not the injury event.

4.2.2 Movement Affordance/Incident Scenario

The task analysis was centered on what are termed *movement affordances*. Certain movements or acts must be accomplished by the child for a particular incident scenario to occur. At issue is whether a product and its restraint system affords the opportunity for that movement to occur. Thus the analysis identified critical movements and examined how product characteristics might act to afford the opportunity for a target-age child to execute a given movement. The movement affordances of interest were derived from a set of key incident scenarios for strollers and high chairs provided in the *Product Profile Report*. For that report, restraint-failure-related IDI's were reviewed and analyzed. The analysis was supplemented by information from other sources such as technical reports and consumer feedback. The stroller incidents encompassed six general incident scenarios and the high chair incidents encompassed five general scenarios. Descriptions of these scenarios are summarized in Table 2. For each scenario a "primary age range" was defined based on the IDI's and developmental considerations. This is the age range of children most likely to be involved in the particular type of incident, although this should not be taken to mean that children outside of this range have no risk of an incident. The definition of the primary incident scenarios and the related child age ranges helped delimit the scope of the subsequent analysis.

We identified a limited number of movements or acts that a child may execute that contribute to the failure of the restraint system under each of these various scenarios. Based on this, a set of primary movement affordances was defined as a basis for the analysis. Each movement affordance was then analyzed independently. The findings presented in Section 4.3 are structured around these movement affordance analyses. In each case, the movement or action was broken into critical components. The components in turn were analyzed with respect to product and restraint characteristics and child behavior. The output of the task analysis is qualitative. In Section 5, anthropometric data and product measurements are incorporated to provide additional quantitative evaluation.

Table 3 lists the movement affordances and maps them to the eleven incident scenarios shown in Table 2. Some movement affordances are related to multiple scenarios. The movement affordances are further explained and broken down into component movements in Section 4.3

4.2.3 Child User Considerations

The task analysis considers the child users of the stroller and high chair products and their developmental characteristics. This includes consideration of both the range of typical product users and the characteristics of children most likely to be involved in restraint failure incidents. Not all stroller and high chair users experience similar injury risks. The product and the restraint system must accommodate all likely users but the restraint system effectiveness needs to be specifically evaluated for the at-risk children under specific scenarios.

The range of high chair and stroller users was addressed in the *Product Profile Report*. The general age of high chair users is about 6 months to 3 years old. Use is appropriate once the child is capable of sitting upright unaided and is eating solid foods. Some high chairs have a reclining feature and may be used with younger infants. Caregivers generally begin to move children out of high chairs as they become more mobile, resist restraints, and become capable of sitting independently in a booster chair at the table (generally about 2 to 3 years old). The primary use of the high chair is for feeding and snacking, so the product and restraint system must

accommodate these behaviors in children throughout the user age range. The high chair may also be used to confine the child during activities such as playing with toys or watching television.

Table 2. Summary of Restraint-Related Incident Scenarios for Strollers and High Chairs

Scenario Type	Description	Primary Age Range
Stroller Scenarios		
1. Stand and Fall	Child manages to come to standing or kneeling position on the seat and then falls from stroller	8-15 months
2. Lean Over Side and Fall	Child leans over the side of the stroller, resulting in fall, partial fall with suspension from restraint straps, or tipping of stroller	7-15 months
3. Lean and Reach	Child leans sideways or forward and reaches, resulting in hand contacting stroller wheel or ground or some stroller mechanism	7-24 months
4. Pitch Forward	Child leans forward in seat and pitches out or becomes entangled in restraint	6-9 months
5. Slip Through Leg Opening	Child removes leg from leg opening on one side and inserts into leg opening on other side; slides down through leg opening	4-9 months
6. Horizontal Slide	With stroller in inclined (horizontal) position, child slides along surface toward head or foot end, resulting in fall, tip, entrapment, or occlusion	6-24 months
High Chair Scenarios		
1. Push/Pull Up	Child uses some chair feature to push or pull up to standing or kneeling position on seat, falls from chair	8-15 months
2. Turn Around	Child rotates torso toward chair back, places knees on seat, then stands, falls	9-15 months
3. Tray Release and Pitch Forward	Child disengages tray release mechanism, pitches forward, falls or is suspended from restraint	6-15 months
4. Slip Through Leg Opening	Child removes leg from leg opening on one side and inserts into leg opening on other side; slides down through leg opening	6-9 months
5. Slide Down and Entrap	Child slips down while remaining in chair seat, head/neck becomes entrapped between seat and tray	6-9 months

Table 3. Relationship of Incident Scenarios and Movement Affordances

Movement Affordance	Stroller and High Chair Incident Scenarios										
	Stroller Stand & Fall	Stroller Lean & Fall	Stroller Lean & Reach	Stroller Pitch Forward	Stroller Slip Thru Leg Opening	Stroller Horizontal Slide	High Chair Push/Pull Up	High Chair Turn Around	High Chair Tray Release & Pitch	High Chair Slip Thru Leg Opening	High Chair Slide Down & Entrap
Push/Pull Up	X						X				
Turn Around	X							X			
Slide Down					X				X		X
Pitch Forward				X					X		
Reaching/Leaning		X	X								
Horizontal Slide						X					