PROJECT REPORT

Human Factors Review of Restraint Failures on Mobile Amusement Rides

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Executive Summary

In fiscal year 2004, staff from the U.S. Consumer Product Safety Commission Division of Human Factors initiated a project to examine restraint failures associated with mobile amusement rides. The staff reviewed available incident data associated with apparent restraint failures on mobile amusement rides, identified scenarios associated with restraint-failure incidents, and identified contributing factors to those failures or incidents.

An estimated 2,800 to 4,300 non-occupational emergency-room-treated injuries were associated with mobile amusement rides for each year from 1997 through 2003. The proportion associated with restraint failures is unknown. Ten to seventeen documented deaths for the years 1987 to 2001, or no more than about one death every year, involved a mobile amusement ride. The number associated with restraint failures is unknown, but is likely to be considerably smaller.

The available incident data suggests that most restraint-failure incidents involve either the restraint system unexpectedly opening during the ride cycle or the rider deliberately defeating the restraint system. Restraint or latch designs that allow operators to readily identify the status of the restraint as either open or closed may address some incidents associated with the restraints unexpectedly opening. The most effective preventive measure, however, would be to require redundant or secondary restraints on all rides from which a rider could be thrown if the primary restraint unexpectedly opened. This would likely be effective at preventing all incidents associated with this scenario, whether due to a component failure or not.

Preventing incidents associated with riders defeating restraint systems would be considerably more difficult, and would require making the rides essentially rider-proof. Many of these incidents seem to involve very young riders, who have limited cognitive development and are unlikely to recognize the consequences of their actions. Specific recommendations for injury prevention would require more detailed analyses of rides, restraints, and the particular methods employed by riders to escape. Secondary restraints may slow riders' escape and provide the operator with more time to stop the ride, and reducing the time for a ride to stop would limit the time available to a rider to escape after being detected. It is unclear, however, how effective these measures would have been at preventing the incidents on record.

Introduction

Reports of riders falling or being thrown from amusement rides have prompted the staff of the U.S. Consumer Product Safety Commission (CPSC) to examine the adequacy of ride-restraint systems. Specifically, staff from the CPSC Division of Human Factors ("the staff") initiated a project in fiscal year 2004 to examine apparent restraint failures on mobile amusement rides. Restraint failures on amusement rides may be particularly hazardous because the rides often involve high speeds and sudden changes in direction.

The primary objectives of this project were to determine whether the restraint systems on mobile amusement rides are sufficient to protect riders, and if necessary, to determine what steps could be taken to improve the safety of deficient systems. To make these determinations, the staff reviewed incident data associated with restraint failures on mobile amusement rides, identified primary hazard patterns or scenarios associated with those incidents, and identified possible factors that contributed to the failures or incidents.

An amusement ride is any device, or combination of devices or elements, that carries, conveys, or directs one or more people along, around, over, or through a fixed or restricted route or within a defined area, primarily for amusement or entertainment.[1] As specified in Section 3(a)(1) of the Consumer Product Safety Act (15 U.S.C. § 2052(a)(1)), the CPSC currently has jurisdiction over mobile, or portable, amusement rides; that is, amusement rides that can be moved as part of carnivals, fairs, festivals, or other events. Fixed-site rides, which are commonly found in amusement parks, theme parks, or similar locations, are not under CPSC jurisdiction.

What constitutes a *restraint failure* may be open to interpretation. Amusement-ride restraints are intended to inhibit or restrict the movement of the rider while on the amusement ride.[2] From this, one might infer that a restraint has failed any time the rider's movements are not restricted or inhibited. Complete immobilization of the rider, however, is clearly not feasible, so some degree of movement is permissible. Any incident in which the rider falls or is thrown from the ride would seem relevant, yet incidents involving the rider being thrown from his or her seat while remaining on the ride would also seem relevant. Some rides require the rider to be prone on the ride, and would therefore lack seats. Also, a ride that lacks a restraint and allows a rider to be thrown could be considered relevant since the ride has failed, by omission, to restrain the rider. Hence, the staff considers a restraint failure to have occurred any time the rider leaves the intended riding position during the ride cycle. For example, a restraint has not failed simply because a rider lets go of a safety bar, even if the manufacturer of that ride intends for the rider to hold the bar for the

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[1] Based on the definition of "amusement ride or amusement device" in ASTM F 747 – 97, *Standard Terminology Relating to Amusement Rides and Devices*, and on the description of products under the jurisdiction of the CPSC specified in Section 3(a)(1) of the Consumer Product Safety Act (15 U.S.C. § 2052(a)(1)).

[2] Based on the definition of "restraint" in ASTM F 2291 – 04, *Standard Practice for Design of Amusement Rides and Devices*.

entire ride cycle. If, however, the rider leaves the seat or other riding position after letting go of that safety bar, the staff considers a restraint failure to have occurred. All incidents consistent with the above are considered to be within the scope of this project.

The types of amusement rides addressed in this study include all "dry" mobile amusement rides (i.e., water slides and similar amusements are excluded) *except* inflatable rides, coin-operated rides or attractions that are typically found in restaurants and shopping centers, alpine slides,[3] mechanical bulls, and playground equipment. Rider-directed amusement rides, such as go-carts and bumper cars, are also considered outside the scope of this project.

[3] An alpine slide is a slide or chute that is constructed on, and follows the natural contours of, the ground

Annual Injuries and Deaths

Based on National Electronic Injury Surveillance System (NEISS) estimates, about 2,800 to 4,300 non-occupational emergency-room-treated injuries were associated with mobile amusement rides for each year from 1997 through 2003 (Levenson, 2004). Most injuries were to people between 5 and 44 years of age, and females were injured more often than males (Levenson, 2002). The limited detail available in the NEISS data do not enable staff from the CPSC Directorate for Epidemiology to provide annual estimates of injuries associated with restraint failures on mobile amusement rides. The available data, however, suggests that injuries associated with restraint failures may represent a relatively small percentage of the total annual estimates.[4]

The CPSC has received reports of 55 deaths associated with both fixed-site and mobile amusement rides from 1987 to 2001; 10 involved mobile rides and seven involved rides for which the site could not be identified (Levenson, 2004). These counts suggest that the number of mobile-amusement-ride-related deaths each year is, on average, likely to be less than one. The number associated with restraint failures is unknown, but is likely to be considerably smaller. For 2002 through 2004, the CPSC has received reports of nine additional deaths associated with amusement rides, but reporting for these years is incomplete (Levenson, 2004). One of these reports involved a ride for which the site could not be identified, and may therefore have involved a mobile ride.

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[4] See *Hazard Patterns: Restraint Failure Data Sources* on page 9 of this report.

Market and Product Information

According to the Outdoor Amusement Business Association (OABA) (2004a), about 500 carnivals travel the U.S. each year, ranging in size from one or two mobile rides to more than a hundred. About 300 to 500 million people visit carnivals, fairs, and festivals each year,[5] and more than half of these people participate on mobile amusement rides (OABA, 2004c).

Amusement rides, including mobile ones, vary widely in design, and there is limited agreement among manufacturers on general ride categories or types. However, amusement rides within the scope of this project can generally be separated into roller coasters and flat rides. According to ASTM F 747 – 97, *Standard Terminology Relating to Amusement Rides and Devices*, a flat ride is "an amusement ride that operates on a single level whether over a controlled, fixed course or track, or confined to a limited area of operation." More common use of the term seems to include any dry, non-rider-operated amusement ride other than roller coasters, including whirling or spinning rides, swinging rides, trains, pendulum rides, and similar rides. However, as mentioned earlier, these particular ride descriptors are not used consistently.

There appears to be no readily available information on the specific restraint systems used on mobile amusement rides. Staff from the CPSC Directorate for Economic Analysis was unable to locate information on the types of restraint systems in use on rides, or on general restraint designs. When describing the restraints in use, the available incident data[4] refer primarily to lap bars and seatbelts, and less often to chains, crotch straps, ropes, shoulder harnesses, body harnesses, and security cages. These data typically provide very little detail about these restraint systems beyond this general description. Some data include photos of the restraints, and sample images appear in Appendix A.

[5] Three separate estimates appear on the Outdoor Amusement Business Association's website: 300 million (OABA, 2004a), 350 million (OABA, 2004b), and 500 million (OABA, 2004c).

Amusement Ride Standards

There are no mandatory federal standards for amusement rides. ASTM International[6] publishes the only nationally recognized U.S. voluntary standards for amusement rides. The ASTM Committee F24 on Amusement Rides and Devices currently has jurisdiction of 15 active standards that cover test methods, specifications and terminology, design and manufacture, maintenance and inspection, and operations for amusement rides and devices. The following table lists these standards:

	Designation	Title
Test Methods	F 846 – 92(2003)	Standard Guide for Testing Performance of Amusement Rides and Devices
	F 1957 – 99 (2004)	Standard Test Method for Composite Foam Hardness-Durometer Hardness
	F 2137 – 04	Standard Practice for Measuring the Dynamic Characteristics of Amusement Rides and Devices
Specifications and Terminology	F 698 – 94(2000)	Standard Specification for Physical Information to be Provided for Amusement Rides and Devices
	F 747 – 97	Standard Terminology Relating to Amusement Rides and Devices
	F 1950 – 99	Standard Specification for Physical Information to be Transferred With Used Amusement Rides and Devices
Design and Manufacture	F 1159 – 03a	Standard Practice for Design and Manufacture of Patron Directed, Artificial Climbing Walls, Dry Slide, Coin Operated and Purposeful Water Immersion Amusement Rides and Devices and Air-Supported Structures
	F 1193 – 04b	Standard Practice for Amusement Ride and Device Manufacturer Quality Assurance Program and Manufacturing Requirements
	F 2291 – 04a	Standard Practice for Design of Amusement Rides and Devices
Maintenance and Inspection	F 853 – 04	Standard Practice for Maintenance Procedures for Amusement Rides and Devices
	F 893 – 04	Standard Guide for Inspection of Amusement Rides and Devices

[6] Formerly known as the American Society for Testing and Materials.

	Designation	Title
Operations	F 770 – 93(2000)	Standard Practice for Operation Procedures for Amusement Rides and Devices
	F 1305 – 94(2002)	Standard Guide for Classification of Amusement Ride and Device Related Injuries and Illnesses
Special Rides/ Attractions	F 2007 – 00	Standard Practice for the Classification, Design, Manufacture, and Operation of Concession Go-Carts and Facilities
	F 2374 – 04	Standard Practice for Design, Manufacture, Operation, and Maintenance of Inflatable Amusement Devices

These standards do not distinguish between fixed-site and mobile amusement rides, and thus apply to both types of rides. Of these standards, only ASTM F 2291, *Standard Practice for Design of Amusement Rides and Devices*, specifies rider restraint requirements.

The specific requirements for a given ride or device are dependent on the results of a Ride Analysis, which is specified in Section 5.1 of ASTM F 2291 – 04 and includes a Patron Restraint and Containment Analysis, a Patron Clearance Envelope Analysis, and Failure Analyses on the safety related systems of the ride or device. The Ride Analysis must assess the suitability of design for the intended patrons, including anthropomorphic factors that relate to age and physical size, and must both identify the most significant factors that may affect patron safety and include mitigation for each factor. The standard does not define "most significant," and does not identify mitigation that would be considered appropriate.

The Patron Restraint and Containment Analysis (PRCA) must be done in accordance with Section 6 of the standard, which specifies patron restraint, clearance envelope, and containment design criteria. Unless the PRCA indicates otherwise, restraints must be provided on an amusement ride if it is reasonably foreseeable that riders could be lifted or ejected from their riding positions during the ride cycle, or if the ride is a "kiddie" ride that lacks a fully enclosed compartment.[7] However, the PRCA may indicate the need for restraints for other reasons.

The standard identifies five different classes of restraints that may be required on an amusement ride. The restraint class that is required on a specific ride is based, in part, on the sustained acceleration levels of the ride. Those rides that exhibit greater accelerations in directions that tend to lift or eject a rider generally require a higher class of restraint. For example, for two rides with similar sustained horizontal

[7] "Kiddie" rides are rides designed primarily for children up to 12 years of age. A "fully enclosed compartment" is defined as a compartment whose openings will not permit passage of a 4-inch diameter sphere (Section 6.3.3).

accelerations, a ride that accelerates downward and would tend to cause the rider to rise in his or her seat would generally require a higher-class restraint than a ride that does not accelerate downward. Class-1 restraints are defined as unrestrained, but restraint criteria are specified for each of the remaining four classes of restraints (Class 2 through Class 5). These criteria are shown in the following chart:[8]

	Class 2	Class 3	Class 4	Class 5
Number of riders per restraint				
Individual or collective	•	•		
Individual			•	•
Final latching position relative to rider				
Fixed or variable	•			
Variable		•	•	•
Type of latching/locking				
Rider or operator may latch	•	•		
Automatic lock			•	•
Type of unlatching/unlocking				
Rider or operator may unlatch	•	•		
Automatic or manual unlock by operator only			•	•
Type of external correct/incorrect indication				
None required	•			
Visual check by operator		•	•	
Primary system failure detectable within one ride cycle		•		
External indication required				•
Failure causes cycle stop or inhibits cycle start				•
Means of activation				
Manually or automatically opened and closed	•	•	•	•
Redundancy or latching/locking device				
Redundancy not required	•	•		
Redundant locking device function			•	•
Restraint configuration				
Two restraints or one fail-safe restraint				•

To provide some perspective, the sustained acceleration levels of a person sitting upright and motionless in a chair would correspond to a Class-2 restraint.[9]

[8] Based on Table X1.1 in ASTM F 2291 – 04. Kiddie rides may have additional requirements beyond those identified in this chart. The characteristics identified for Class-5 restraints are for primary restraints only. Secondary restraints have less stringent requirements.
[9] This would correspond to 0.0g horizontally and 1.0g vertically. As confirmed in correspondence with an industry representative, accelerations of this type would require a Class-2 restraint unless riders are provided sufficient support and a way to react to the forces.

Hazard Patterns

The most recent and readily available analysis of hazard patterns associated with mobile amusement rides appears in the 2001 CPSC staff report, *Amusement Ride-Related Injuries and Deaths in the United States: 1987–2000* (Morris, 2001). These hazard patterns were derived from a review of 90 CPSC in-depth investigation reports on amusement ride-related incidents. Morris (2001) identified three general hazard patterns: Mechanical failures, operator error, and consumer behaviors. Morris also identified "other" incidents, and incidents involving combinations of the above hazard patterns. The three general hazard patterns are consistent with the classification scheme typically used by the amusement ride industry and state regulatory agencies for amusement ride incidents, but "rider error" or "rider misconduct" is commonly used in place of Morris' "consumer behaviors" hazard pattern.

Among the three general hazard patterns, most incidents associated with amusement rides and devices are reportedly attributable to rider error or misconduct. For example, the amusement ride industry claims that about 80 percent of accidents are the result of rider error or misconduct (OABA, 2004a; OABA, 2004b; Halper, 2001; Eggen, 1999). The findings of state regulatory agencies are generally consistent with this figure:

- The Florida Department of Agriculture and Consumer Services claims that rider error accounted for about 76 percent of all amusement park rides reported over a recent three-year period (Orlando Business Journal, 2002).

- A fact sheet published by the Ohio Department of Agriculture (2004) reports that more than 80 percent of amusement ride injuries in Ohio during the last 4 years have been caused by human error or horseplay unrelated to the condition or operation of the ride.

- According to statistics kept by the Michigan Department of Consumer Industry Services, rider behavior was at fault in all but one of the 47 rider injuries reported to them in 2000 (Durbin, 2001).

- Kingsley (2003) states that all 25 amusement ride incidents reported to the Oklahoma Department of Labor, Safety Standards Division, were attributed to rider error. One of these incidents was also attributed to operator error, and mechanical malfunction was reported in four incidents (Oklahoma Department of Labor, 2001).

Similarly, Canada's Technical Standards and Safety Authority (2002, 2003) found that rider-related causes factored into almost three-quarters of all reported amusement device incidents in 2002, and into more than half of all amusement device incidents in 2001.

Whether these general findings can be applied to incidents involving restraint failures is unclear, especially since terms such as “rider error” and “rider misconduct” are often not well defined. Detailed data on the circumstances and potential causes of incidents involving restraint failures are sparse, but the staff was able to locate relevant data from two sources: CPSC in-depth investigation reports and State investigation reports. Although these data are not necessarily representative of all incidents involving a restraint failure, they are useful for identifying how restraint failures have occurred with amusement rides.

Restraint Failure Data Sources

The CPSC staff has completed 92 in-depth investigations of incidents that involved an amusement ride and occurred during the 10-year period from 1993 through 2002.[10] All incidents occurred on either a mobile ride or a fixed-site ride that is also used in mobile settings (Levenson, 2003); therefore, all incidents are thought to be relevant to mobile amusement rides. Of these, 28 involved a restraint failure as defined by this project. Appendix B summarizes these in-depth investigations (INDP reports).

Saferparks, a non-profit corporation dedicated to preventing amusement ride-related accidents, has compiled a Ride Incident Database of accident records provided to them by several U.S. states that have regulatory laws governing amusement rides (Saferparks, 2002). Access to this database is available through their website.[11] Most of the data consist of very brief incident summaries, but a query of the database on June 23, 2004 identified detailed investigation reports for 112 amusement ride-related incidents that occurred between February 22, 1997 and May 1, 2004. Of these, 17 appear to be restraint failures on mobile amusement rides. Another case[12] appears to be a restraint failure, but does not specify whether the ride was a fixed or mobile ride. Appendix C summarizes the investigation reports.

The 46 apparently relevant investigation reports described in the two paragraphs above reflect 43 unique incidents since three are in both CPSC and Saferparks databases. These 43 incidents are known to have involved at least 53 riders or victims, consisting of at least 26 males and 25 females.[13] More riders may have been involved, but the riders cited above are the only ones specifically identified in the reports and for which some details, such as age and sex, were available. Of these 53 victims, six died and 47 were injured. Impact between the victim and the ride, ground, or some other object was the immediate cause of all injuries and deaths, and most impacts were immediately preceded by the victim falling or being thrown from the intended riding position or the ride itself. Victim age ranged from 1 to 57 years, but most victims and fatalities were to riders under 20 years old.

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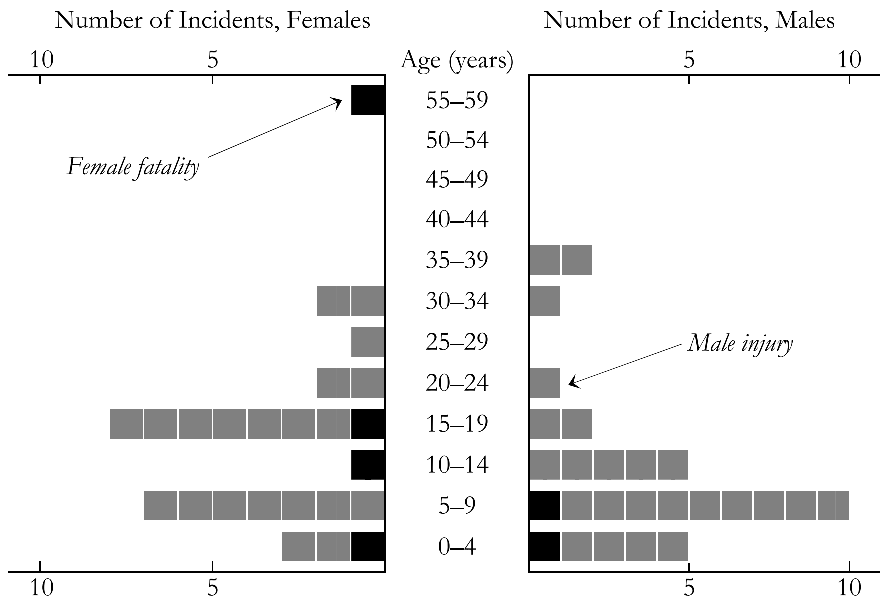
10 Based on Levenson (2002, 2003) and Morris (2001).
11 http://www.saferparks.org
12 Saferparks ID 898124
13 One incident did not report the sexes of the two injured victims. These numbers include only those riders who left the intended riding position, and do not include others who may have been injured by being struck by a rider who left this position.

Age, sex, and disposition data for all 51 victims for which this information was available is shown graphically below. Black segments represent fatalities and gray segments represent injuries.



Restraint Failure Hazard Patterns

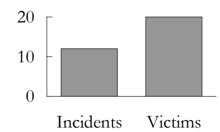
To identify hazard patterns associated with restraint failures, the staff identified and analyzed the sequence of events from the time the incident initiated to the time injury first occurred for each of the 43 unique and relevant incidents. An incident is assumed to have initiated the moment something "out of the ordinary" occurred during the ride cycle; for example, the moment a rider unlatches his restraint mid-cycle or the moment the ride gets stuck in an unusual position. The most common initiating event among these 43 incidents was the restraint opening during the ride cycle. The following were common to three or more incidents:

- The restraint opens (not rider-initiated)
- The rider falls or is thrown from the intended riding position (unintentional)
- Part of the ride fails (component failure)
- The rider squirms from the restraint
- The rider stands or slides from the intended riding position (deliberate)
- The rider opens the restraint

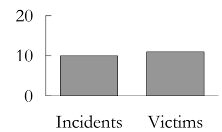
Within the sequence of events comprising the incident is the moment the rider leaves the intended riding position. The staff has identified the associated event as the *failure event* since this is the moment the ride restraint system has officially failed, as defined by this project. By focusing on the failure events for each incident, the staff was able to divide most incidents into the following two groups: Those in which the rider falls from, is thrown from, or otherwise unintentionally leaves the intended riding position during the ride cycle, and those in which the rider squirms from, stands from, or otherwise deliberately leaves the intended riding position during the ride cycle.

Based on its analysis of the available incident data, while focusing on the factors described above, the staff identified five general hazard patterns or scenarios associated with restraint failures on mobile amusement rides:

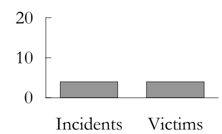
1. *Restraint unexpectedly opens*: The existing restraint unexpectedly opens, loosens, or separates from the ride during the ride cycle, and the rider falls or is thrown from the intended riding position.



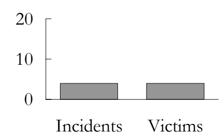
2. *Rider defeats restraint*: The rider deliberately squirms from or opens the existing restraint and leaves the intended riding position during the ride cycle.



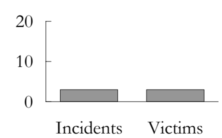
3. *Unrestrained rider leaves*: The rider stands or otherwise deliberately leaves the intended riding position during the ride cycle on a ride lacking a restraint.



4. *Unrestrained rider falls or is thrown*: The rider falls or is thrown from the intended riding position during the ride cycle on a ride lacking a restraint.



5. *Rider thrown from closed restraint*: The rider falls, slips, or is thrown from the intended riding position during the ride cycle despite the restraint system remaining closed and intact.



These five scenarios, combined, account for at least 33 of the 43 available incidents[14] and at least 42 of the associated 53 victims for which disposition information is available. The remaining 10 incidents either lacked details that would enable classification into a scenario, included conflicting details that prevented classification into a single scenario, or differed from the scenarios specified above.

As the listing above shows, the first two scenarios—*Restraint unexpectedly opens* and *Rider defeats restraint*—are the most common in the available incident data. Each is associated with at least 10 incidents, which is more than twice the number of

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[14] See Appendixes B and C.

incidents associated with each of the other three scenarios and nearly as many as all three of these other scenarios combined. Combined, these two scenarios account for more than half (22) of the 43 available incidents. Moreover, the incidents associated with these two involve 31 of the 53 victims for which disposition information is available. Of the six available deaths associated with restraint failures on a mobile amusement ride, four involve incidents encompassed by these two scenarios. For these reasons, the staff focused the remainder of its analysis on these scenarios.

The staff analyzed these two scenarios and their corresponding incidents to identify common characteristics of the user, product, and user-product interface or interaction that probably contributed to the restraint-system failure. The *user* may be the rider or the ride operator. Since the available incidents associated with each scenario are only a sample of all incidents that are potentially relevant to that scenario, the intent was to identify factors that are common to several incidents. The staff presumes that, for a given hazard pattern or scenario, addressing factors that are associated with only one or two incidents is unlikely to have a substantial impact on injury reduction. Conversely, addressing more common factors is presumed to be more effective.

Restraint Unexpectedly Opens

Of the 43 unique and relevant incidents from CPSC and State investigations, at least 12 involved the existing restraint system opening, loosening, or separating from the ride.[15] These 12 incidents involved 20 victims for whom the disposition is reported. One victim died and 19 were injured. Two additional incidents,[16] involving two injured victims, may be relevant to this scenario, but conflicting details in the reports do not enable the staff to draw a firm conclusion.

Component Failures

Five incidents[17] associated with this scenario involved restraint-system component failures that left the restraint system non-functional. These incidents include failures of the restraint itself (a center weld on the lap bar), the restraint latch, or the junction between the restraint and the floor or seat of the ride. Another incident[18] involved worn pawls in the ratcheting system of the restraint; this case did not involve a sudden component failure, but is similar because the restraint was no longer functional following the incident. In some cases, the staff cannot tell whether the component failure preceded, coincided with, or followed the restraint opening. Two cases in particular suggest that the component failure may have been preceded by a restraint latch opening, but the sequence of events is unclear.[19] Incidents associated with this scenario and involving component failures, therefore, tended to follow one of the following two patterns:

Component failure(s)	→	Ride restraint opens	→	Rider(s) falls or is thrown from riding position	→	Rider(s) strikes the ground or some other object
Ride restraint opens	→	Component failure(s)	→	Rider(s) falls or is thrown from riding position	→	Rider(s) strikes the ground or some other object

Little else is common among these six incidents. For example, some cases[20] reported that the components showed obvious and excessive wear before failure. In other cases,[21] the components did not. The lack of consistency among these incidents suggests that the failures are probably situation-specific, and might not necessarily be addressed effectively by revisions to the applicable voluntary standards.

15 Eight CPSC and four State investigations; see Appendixes B and C.
16 CPSC INDP report numbers 010122CNE6084 and 940830CWE5024. The former may have involved the ride (car) tipping over, and the investigator found that the restraint release may contact the ground when this happens; however, there are conflicting reports about the events of the incident. The latter appears to involve the restraint unexpectedly opening during the ride cycle; however, some witness reports suggest that the rider might have squirmed from the restraint instead.
17 990524HCN0210, 980708CNE5183, 980320CWE7133, 970304CNE5090, and Saferparks ID 909312.
18 898059.
19 980320CWE7133 and 970304CNE5090.
20 For example, 909312 and 898059.
21 For example, 990524HCN0210 and 980708CNE5183.

Non-component Failures

Five incidents[22] of the restraint unexpectedly opening did not report a component failure and are generally consistent with the following pattern:

Ride restraint opens or loosens	→	Rider(s) falls or is thrown from riding position	→	Rider(s) strikes the ground or some other object

Two additional cases[16] may involve the pattern above, but the available incident details are inconsistent.

In some of these cases, later inspection or testing found the restraint latching or locking system to be working as intended.[23] The staff is also aware of one "out-of-scope" case[24] in which a ride restraint opened during the ride cycle but later appeared to be fully functional. These incidents suggest that the restraint was either physically opened during the ride cycle or was not properly closed before the ride cycle, causing it to open when a force was applied to it during the cycle. The details surrounding some incidents suggest the latter.

For example, in three cases,[25] the incident investigator or the operator himself stated that the restraint may not have fully locked or latched. Also, in three cases,[26] force was likely being applied to the restraint when it opened because the seat of the ride was tilting forward or the ride motion forced the riders toward the restraint. Lastly, in one case[27] the restraint did not properly latch the first time it was closed, causing the operator to re-open and close the restraint; a witness on the ride claims that the restraint still was not properly closed. Based on these incidents, the design of the restraint latch may be relevant.

Potential Preventive Measures

Latch designs that improve the likelihood of operators closing the restraint properly may address some incidents associated with restraints unexpectedly opening. For example, all restraint latches should allow operators to readily identify the status of the restraint (open or closed) upon closure. The incident data supporting this as a requirement is not conclusive, however, and details about the specific restraint systems and latching mechanisms in use are not readily available. A special study or investigation into restraint latch mechanisms would probably be necessary before the staff could make specific recommendations.

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[22] 020716HCN0633, 940817CCN2199, 930809CBB2486, 909411, and 909314.

[23] 020716HCN0633, 940817CCN2199, and 930809CBB2486, among those known to be relevant. Both incidents that may be relevant also involved a restraint operating as intended.

[24] 991021CNE5318; this case was only considered to be outside the scope of this project because the riders were held by a secondary restraint, and therefore, did not leave the intended riding position.

[25] 020716HCN0633, 940830CWE5024, and 940817CCN2199

[26] 940830CWE5024, 940817CCN2199, and 930809CBB2486

[27] 940830CWE5024

The staff believes that the most effective method of preventing injuries associated with restraints unexpectedly opening would be to require redundant or secondary restraints on all rides that lack these restraints and from which a rider could be thrown due to the motion of the ride. Most incidents associated with this scenario, whether due to a component failure, the operator failing to latch the restraint, or some other cause, are unlikely to have resulted in injury if a secondary restraint, such as a seatbelt, had been in use.[28]

[28] The "out-of-scope" incident referred to earlier, 991021CNE5318, is consistent with this, in that a restraint unexpectedly opened but the riders were uninjured because they were held by a secondary restraint.

Rider Defeats Restraint

Of the 43 unique and relevant incidents from CPSC and State investigations, at least 10 involved the rider deliberately squirming from or opening the existing restraint and leaving the intended riding position during the ride cycle.[29] These 10 incidents involved 11 victims for whom the disposition was reported. Three victims died and eight were injured. Three additional incidents, involving three injured victims, may have involved this scenario, but conflicting details and reports surrounding the incidents do not enable the staff to draw a firm conclusion.[30]

This scenario differs substantially from the unexpected-opening scenario because the rider takes an active role in the restraint-system failure. Hence, most investigators are likely to attribute incidents associated with this scenario to rider error or misconduct. As described in *Hazard Patterns*, the amusement ride industry and state regulatory agencies tend to attribute most amusement ride incidents—perhaps 75 percent or more—to rider error or misconduct. If one presumes that this percentage also holds for restraint failures on amusement rides, finding ways of addressing incidents associated with the rider defeating the restraint system might have a substantial impact on the number of amusement ride incidents associated with restraint failures.

Restraint Design

Incidents associated with this scenario require that the rider be physically capable of defeating the restraint system. Hence, the design or defeatability of the ride restraint is relevant to this scenario. The available incident data show that riders generally defeat amusement ride restraints by either squirming from or manually opening the restraint system.

For example, at least six incidents[31] relevant to this scenario involved the rider squirming or sliding out from under a closed restraint, and were generally consistent with the following pattern:

Rider squirms from ride restraint	→	Rider falls or is thrown from ride	→	Rider strikes the ground or some other object

As described earlier, the staff has very little information on the general types of restraints available on mobile amusement rides, and the incident data do not provide much more detail. The ability to squirm from a restraint, however, does require enough space between the restraint and the rider to allow escape, suggesting a possible anthropometric mismatch between the restraint design and rider

29 Eight CPSC and five State investigations; see Appendixes B and C.
30 940830CWE5024 (see footnote 16), 909402, and 909395. The latter two incidents do not specify whether a restraint was in place at the time of the incident.
31 020827CWE5027/909382, 990917CWE6003, 980609CWE7164, 970409HCC3090/898124, 970220CHE5083, and 960819CCN1702.

dimensions. Two incidents of this type involved children who were smaller than the ride manufacturer's recommended size for riding without an adult.[32] Some rides use a single lap bar to restrain multiple riders at once.[33] Anthropometric differences among riders in this situation effectively guarantees unequal restraint, and would typically enable the smallest riders to escape more easily.

At least three other incidents involved the rider manually opening or unlatching the restraint.[34] These incidents were generally consistent with the following pattern:

Rider opens ride restraint	→	Rider stands, climbs, falls, or otherwise leaves riding position	→	Rider strikes the ground or some other object

For the rider to open the restraint, he or she must have access to the restraint-opening mechanism and be capable of operating that mechanism. All three rides reportedly used a seatbelt as the restraint, which probably provides the rider with easy access to the restraint-opening mechanism. These mechanisms also appear easy to open since, for example, one was opened by a 2-year-old child.

Cognitive Development

The rider's level of mental or cognitive development appears particularly relevant to this scenario. For example, in four of the 10 incidents known to be associated with this scenario, the rider was no more than 3 years of age.[35] Two additional incidents involved mentally disabled riders, one of whom was reported to have been mentally equivalent to a 5-year-old.[36] All three of the incidents that are possibly, but not definitely relevant to this scenario involved 3- or 4-year-old riders.[37]

Children's knowledge of safety precautions and ability to assess risk are much better at 8 years of age than for younger children (Cushman & Rosenberg, 1991). Yet, of the 13 incidents that potentially involved a rider defeating the restraint system in some way, nine involved riders whose cognitive development levels were probably less than that of a typical 8-year-old, and one involved an 8-year-old child. Many of the children involved in these incidents, therefore, were probably unable to fully appreciate the dangers associated with defeating the restraint.

Furthermore, most children from the age of 2 years to about 6 or 7 years have a limited ability to think logically about situations and events, and are unable to concentrate on multiple aspects of a problem or situation at once (Goswami, 1998; Shaffer, 1999; Vasta et al., 1999). These children tend to center their attention on one salient aspect of a problem, and to make a decision based on that aspect. This

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[32] 020827CWE5027/909382 and 970409HCC3090/898124.
[33] For example, those involved in 970409HCC3090/898124 and 970220CHE5083.
[34] 010515CNE6365, 909315, and 898055.
[35] 020827CWE5027, 010515CNE6365, 980902CWE5016, and 970409HCC3090
[36] 990917CWE6003 and 960819CCN1702
[37] 940830CWE5024, 909402, and 909395

tendency suggests that a preschool-age child who wanted to achieve a certain goal would likely focus on the actions necessary to achieve that goal, without simultaneously considering the potentially negative consequences of those actions.

The available incident data associated with this scenario and involving the nine victims within this age range are consistent with this conclusion. For example, an analysis of the incident data associated with these victims reveals the following:

- Three cases involved the rider becoming frightened and wanting to escape the ride.[38]
- One case involved a young child who opened his restraint and stepped from the ride to visit his sister.[39]
- One case involved a rider leaning up and out of the car while reaching toward a surrounding fence, seemingly in an attempt to slap the hands of others on the opposite side of the fence.[40]

Thrill-Seeking Behavior

Some incidents associated with this scenario do not appear to have involved immature cognitive development. For example, two incidents involved adult males deliberately pulling their legs out from under a restraint, placing them on the seat beside them, and riding while turned sideways in the seat.[41] It is doubtful that these riders failed to recognize the potential risks associated with defeating a restraint, and most adolescents are likely to be as capable of recognizing the consequences of risky behaviors as adults (Beyth-Marom et al., 1993). However, the riders involved in these incidents still chose to defeat the restraint and to ride incorrectly rather than to ride in the manufacturer's intended riding position.

A decision to defeat the restraint implies that the riders may have perceived the benefits of doing so as outweighing the associated costs. This cost-benefit evaluation is considered by many researchers to be the most significant factor affecting risk-based decisions (Ropeik & Slovik, 2003; Wickens, 1992). The perceived costs of defeating the restraint may include the perceived increase in injury risk and the required effort to defeat the restraint. The perceived benefits are less obvious. Amusement rides provide "controlled exposure to fear, thrills, and excitement" and the illusion of danger (Brain Injury Association of America, 2004; Avery, 2001), and this characteristic suggests the most likely perceived benefit of defeating the restraint: The increased thrill associated with riding unrestrained.

Sensation-, stimulation-, or thrill-seekers—whom Farley (1986) labels as *Type T personalities*—are willing to accept and to even seek out a greater level of risk than

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[38] 020827CWE5027/909382, 990917CWE6003, and 960819CCN1702.
[39] 010515CNE6365
[40] 909395
[41] 980609CWE7164 and 970220CNE5083. *Adult* refers to someone 18 years of age or older.

most consumers. These people are not only less likely to obey a warning about a hazardous situation, but may intentionally ignore the warning just to experience the increased risk (DeJoy, 1999). Repeated exposures to potentially dangerous situations without injury tends to lower the perceived risks associated with those situations, and increases the chances that the person who is performing risky behaviors will do so again or will perform even more daring actions. Hence, thrill-seeking riders will probably continue to defeat restraint systems on amusement rides as long as they are physically capable of doing so, making prevention very difficult.

Other Possible Factors

Several incidents suggest that operator attention and vigilance are relevant. Five incidents associated with this scenario reported that the operator of the ride was looking away from or not paying attention to the ride when the rider left the intended riding position.[42] In two of these cases, the operator was pressing the start button while his back was to the riders. Had the rider's attempts to defeat the restraint been detected earlier, the operator would have been able to respond earlier and may have prevented the resulting rider injury. Ride-stop or emergency-stop time may also be relevant to this scenario. In at least six incidents, the ride operator saw the rider defeat the restraint and began the stop sequence, hit the emergency stop button, or took some other action to stop the ride.[43] In each case, however, the rider left the intended riding position and was injured before the ride could stop.

Potential Preventive Measures

Existing restraint systems appear to be designed with the goal of limiting unintentional, not deliberate, escape from the restraint system. Although this goal might be reasonable in the context of thrill-seeking riders, the available data show that many incidents involved very young riders, and that these riders are not likely to be defeating restraints for increased thrill. The most effective way to reduce deaths and injuries associated with this scenario would likely be to design the system so that riders are unable to squirm from the restraint while it is closed and are unable to open the restraint during the ride cycle. Specific recommendations are difficult to make given the limited data available on ride and restraint designs.

Additional preventive measures that may be somewhat effective in addressing incidents associated with this scenario could include the following:

- *Secondary restraints*: Although riders may be capable of defeating a secondary restraint, the restraint's presence provides an extra safeguard that the rider must circumvent, and would provide the ride operator with extra time to detect the rider's attempts to defeat the restraints and to respond appropriately. Secondary restraints would likely be more effective for young

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[42] 020827CWE5027/909382, 010515CNE6365, 980902CWE5016/909377, 970409HCC3090, and 898055.
[43] 020827CWE5027/909382 (E-stop), 990917CWE6003 (E-stop), 980902CWE5016/909377 (pressed stop), 970220CNE5083 ("off"), 960819CCN1702 (started stop sequence), 909315 (slowed ride)

riders than for adolescents and adults since (1) young children have less advanced motor skills and would probably require more time to defeat any given restraint, and (2) young children are likely to defeat restraints due to limited cognitive development rather than thrill-seeking behavior and would, therefore, be less likely to hide that they are trying to defeat the restraints.

- *Reduced ride-stop times*. The typical operator response to detecting that a rider is trying to defeat or has defeated a restraint is to stop the ride. However, amusement rides do not stop immediately. Although sudden stops would be counterproductive, minimizing the time for the ride to stop safely would reduce the time available to the rider to defeat the restraint or to be thrown due to the ride's motion. Alternatively, more rides could be designed to automatically begin emergency-stop procedures if the restraint opens during the ride cycle or the rider leaves the intended riding position with the restraint still intact.[44]

- *Improved operator-rider visibility*: The ability of the ride operator to see the riders during the ride cycle is crucial for the ride operator to detect rider attempts to defeat the restraints. Improved visibility, however, is only likely to be effective if operators are vigilant in watching riders, and the incident data suggests that problems with the latter are more relevant to this scenario.

Warnings to consumers about the hazards associated with defeating the restraints are unlikely to substantially reduce the frequency of injuries associated with this scenario. As described earlier, riders who engage in this behavior appear to be those with limited cognitive development or those who engage in thrill-seeking behaviors. Instructing the former on proper riding behavior is important, but may not be effective if the rider panics during the ride cycle and wants to escape. Thrill seekers are likely to either ignore warnings about the potential dangers, or perform the very actions warned about to increase the thrill experience of the ride, making the warning counterproductive. Still, providing parents and other caregivers with adequate warning information about the potential risks might have some impact in that it would allow these consumers to make more educated decisions about whether their children should be placed on a ride.

[44] For example, the latter might be done through the use of sensors.

Conclusions

The incident data relevant to restraint failures on mobile amusement rides suggest that most incidents involve either the restraint system unexpectedly opening during the ride cycle or the rider deliberately defeating the restraint system. However, the factors relevant to, and possibly contributing to, a particular scenario do not necessarily apply to all incidents associated with that scenario.

Some unexpected-opening incidents appear to have involved the operator not closing the restraint properly. More detailed investigations or analyses of the restraint designs associated with incidents involving this scenario would be necessary before specific recommendations could be made. Restraint or latch designs that allow operators to readily identify the status of the restraint as either open or closed may address some of these incidents. The most effective preventive measure, however, would be to require redundant or secondary restraints on all rides from which a rider could be thrown if the primary restraint unexpectedly opened. This would likely be effective at preventing all incidents associated with this scenario, whether due to a component failure or not.

Preventing incidents associated with riders defeating restraint systems would be considerably more difficult, and would require making the rides essentially rider-proof. That is, to design the system so that riders are unable to squirm from the restraint while it is closed and are unable to open the restraint during the ride cycle. Specific recommendations would require more detailed analyses of rides, restraints, and the particular methods employed by riders to escape. Secondary restraints may slow riders' escape and provide the operator with more time to stop the ride, and reducing the time for a ride to stop would limit the time available to a rider to escape after being detected. It is unclear, however, how effective these measures would have been at preventing the incidents on record.

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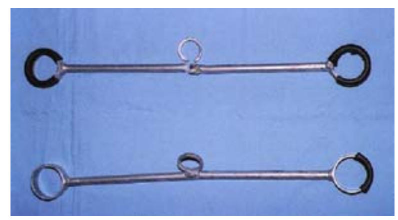
Appendix A: Sample Restraint Images

INDP Report No.	Ride	Reported Restraint	Image(s)
020827CWE5027	(RESTRICTED)	Security bar/cage	
020416CCN0406	(RESTRICTED)	Lap bars	
010122CNE6084	(RESTRICTED)	Lap bar	
990524HCN0210	(RESTRICTED)	Padded lap bar	

INDP Report No.	Ride	Reported Restraint	Image(s)
981022CCC3028	(RESTRICTED)	Lap chain and crotch chain	
980902CWE5016	(RESTRICTED)	Rope with cam locks	
980708CNE5183	(RESTRICTED)	Sliding aluminum lap bar with crotch chain	
980609CWE7164	(RESTRICTED)	Lap bar	

Appendix B: Relevant CPSC Investigations

INDP Report No.	Brief Description	Hazard Pattern[45]
021016HNE7523	An 8-year-old male sustained facial fractures and lacerations when he was pulled from a moving car on an amusement ride after reaching out and touching or grabbing a steel upright on the ride.	Unrestrained rider leaves
020827CWE5027[46]	A 2-year-old male squirmed from his restraint and fell from the back of a ride.	Rider defeats restraint
020716HCN0633	Two victims, a 15-year-old female and 6-year-old female, fell out of a car on an amusement ride when the car door of the ride suddenly opened.	Restraint unexpectedly opens
020416CCN0406	A 30-year-old female was thrown to the ground while riding an amusement ride with her friend.	Unrestrained rider falls or is thrown
011001HEP8213	An 8-year-old female, riding a carousel, let go of the support pole and fell to the floor.	Unrestrained rider falls or is thrown
010917HNE6705	A 7-year-old victim was riding a roller coaster when the ride stopped suddenly, throwing the victim forward and causing him to strike his abdominal region on the front of the car. The victim died.	Unrestrained rider falls or is thrown
010515CNE6365	A 2-year-old male was injured when he got out of his seat on a rotary kiddie-ride and the succeeding car ran him over.	Rider defeats restraint
010122CNE6084	A 39-year-old male fell about 12 feet when the riding tub he was seated in tipped over.	Other/Unknown
000327HCC0512	A 19-year-old female and her friend were tossed around in the car of the ride in which they were seated.	Restraint unexpectedly opens (likely)
990917CWE6003	A 22-year-old (or 35-year-old) mentally disabled male squirmed from his ride restraint, climbed onto the car in which he was seated, and fell or was thrown from the ride.	Rider defeats restraint
990524HCN0210	Three victims—a 16-year-old female, a 20-year-old female, and a 17-year-old male—were thrown from a ride when the restraint latching mechanism sheared off the side of the car in which they were seated. Another rider was in the car, but not thrown from the ride.	Restraint unexpectedly opens

[45] See *Hazard Patterns: Restraint Failure Hazard Patterns* for details.
[46] CPSC INDP 020827CWE5027 and Saferparks record ID 909382 report on the same incident.

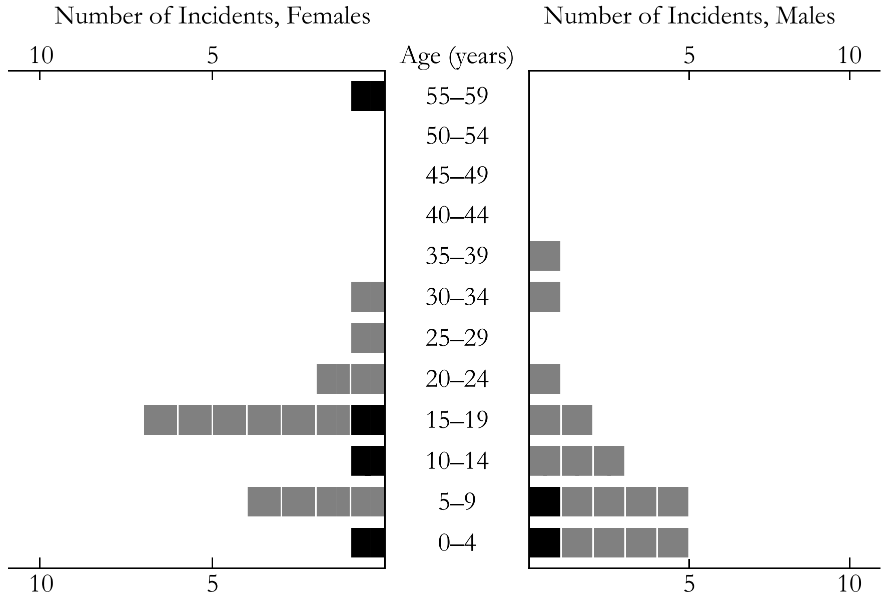
INDP Report No.	Brief Description	Hazard Pattern[45]
990205CEP9003	A 21-year-old female was thrown and "rattled" between two seats. According to the victim, the rope restraint that was present at the other seats was missing on hers.	Unrestrained rider falls or is thrown
981022CCC3028	A 28-year-old female was thrown from her seat when one of the S hooks that connects one of the seat's support chains pulled out of the I bolt to which it was attached.	Other/Unknown
980902CWE5016[47]	A 13-month-old male stood on his seat as the ride cycle began, fell over the back of his seat and onto the ride tracks, and was struck by the car behind his.	Rider defeats restraint
980708CNE5183	A 15-year-old female was thrown from the ride when her lap bar broke.	Restraint unexpectedly opens
980609CWE7164	An 18-year-old male was thrown from his seat after he had raised his leg onto his seat and sat sideways during the ride cycle.	Rider defeats restraint
980601CAA0468	As the ride was slowing, the restraint bar opened and a 10-year-old male stood from his seat. The victim was either thrown to the ground, or stepped from the ride, lost his footing, and fell to the ground.	Unrestrained rider leaves
980320CWE7133	A 15-year-old female, 16-year-old female, and 9-year-old male were thrown from the car in which they were seated when the lap bar broke loose from the car.	Restraint unexpectedly opens
970409HCC3090[48]	A 3-year-old female, during her birthday party, squirmed from her restraint, stood at her seat, and fell from the ride and onto the floor. She was then struck by the ride. The victim died.	Rider defeats restraint
970304CNE5090	Two victims, an 8-year-old male and 10-year-old male, were thrown from their car when the lap bar broke loose from the car.	Restraint unexpectedly opens
970220CNE5083	An adult male (30- or 34-year-old) was thrown from a ride after he pulled his legs up and onto the seat, sitting sideways in his seat.	Rider defeats restraint
960819CCN1702	A mentally disabled teenage female (13- or 14-year-old) wriggled from her restraint, fell or climbed through an opening at the top of the ride, and fell from the ride. She was then struck by the ride, and died.	Rider defeats restraint

[47] CPSC INDP 980902CWE5016 and Saferparks record ID 909377 report on the same incident.
[48] CPSC INDP 970409HCC3090 and Saferparks record ID 898124 report on the same incident.

INDP Report No.	Brief Description	Hazard Pattern[45]
960819HCC5534	At least two victims, a 57-year-old female and 4-year-old female, fell or were thrown from a train ride when two of its cars overturned.	Other/Unknown
940830CWE5024	A 4-year-old male fell from a ferris wheel when the lap bar on his car opened during the ride cycle.	Other/Unknown
940818CCN2210	A 10-year-old male stood during the ride cycle and was thrown from the ride.	Unrestrained rider leaves
940817CCN2199	During its ride cycle, a car with two riders, 8-year-old female and a 9-year-old female, became stuck leaning forward. The riders pushed and pulled on the lap bar to straighten the car, when the bar suddenly opened and the riders fell from the ride.	Restraint unexpectedly opens
930809CBB2486	A 9-year-old male was thrown from a ride when the lap bar disengaged during the ride cycle.	Restraint unexpectedly opens
930519CNE5140	As the ride was slowing, a 15-year-old female slid from her seat toward the exit. The ride speed suddenly increased, causing the rider to be thrown. The rider may have stood and may have had a seizure.	Unrestrained rider leaves

These 28 potentially relevant incidents involved at least 36 riders or victims, consisting of 18 males and 18 females. Six victims died and 30 were injured.[49] Impact between the victim and the ride, ground, or some other object was the immediate cause of all injuries and deaths, and most impacts were immediately preceded by the victim(s) falling or being thrown from the ride or the intended riding position on the ride.[50] Victim age ranged from 1 to 57 years; however, all but one victim were younger than 40. The distribution of ages, sexes, and dispositions for all known victims is shown graphically below.[51] Black segments represent fatalities and gray segments represent injuries.

[49] Of the 30 injured, 18 were reportedly hospitalized, 10 were reported as injured without hospitalization, and the disposition of the remaining 2 is unknown.
[50] Only two of the 28 incidents resulting in injury(ies) were not preceded by falling or being thrown from the ride or intended riding position. 021016HNE7523 involved the rider being pulled from the ride, and 010515CNE6365 involved a rider stepping in front of a moving car/tub on the ride.
[51] One case (990917CWE6003) reports two different ages for the victim: 22 years and 35 years. The staff assumed an age of 22 years for the referenced graph.


Number of Incidents, Females
Number of Incidents, Males
Age (years)
10
5
5
10
55–59
50–54
45–49
40–44
35–39
30–34
25–29
20–24
15–19
10–14
5–9
0–4
10
5
5
10

Appendix C: Relevant State Investigations

Saferparks ID	Brief Description[52]	Hazard Pattern[45]
909412	9-year-old boy came out from underneath the belt while the ride was upside down and fell onto the platform.	Other/Unknown
909411	9-year-old boy was ejected from the ride when the restraining belt came loose.	Restraint unexpectedly opens
909409	8-year-old girl was ejected from the ride, landing on her face and shoulder.	Rider thrown from closed restraint
909402	3-year-old girl fell out of kiddie ride and was run over by following car.	Other/Unknown
909398	5-year-old girl forcefully ejected from a kiddie coaster as her car rounded last curve on the 1st trip of the cycle, landing on her head. The girl was sitting in the 3rd car, left-hand side.	Rider thrown from closed restraint
909395	4-year-old child was thrown from a kiddie coaster when the ride went into the corner. Her foot caught inside the car and she was dragged for a bit, finally falling on her face/head.	Other/Unknown
909382[46]	2-year-old child came out of the ride while it was in motion and fell to the ground.	Rider defeats restraint
909377[47]	Child stood up in seat and fell out during start-up onto the track causing the next car to run over the child.	Rider defeats restraint
909361	Child was ejected from moving ride.	Rider thrown from closed restraint
909315	Victim unbuckled chain restraint and seat belt, then slid or jumped from seat, falling to ground	Rider defeats restraint
909314	Victim came out of waist and ankle restraints, was struck by spinning bar, and ejected from the ride, striking the ground.	Restraint unexpectedly opens
909312	Tub chain broke resulting in patron ejection	Restraint unexpectedly opens
909310	Victim's harness was not properly secured to the ride, allowing the victim to be thrown from the ride to the pavement.	Other/Unknown
898180	Child and a few friends were spinning the wheel of a teacup ride when the child fell out.	Other/Unknown

[52] Copied verbatim from the Saferparks Ride Incident Database.

Saferparks ID	Brief Description[52]	Hazard Pattern[45]
898178	Child fell out of seat and was banging around in car.	Other/Unknown
898124[48]	Child managed to exit a spinning ride while the ride was spinning and was dragged under the ride for 3/4 of a revolution before the ride could be stopped. The rigid lap bar engaged the larger rider seated next to the victim, but left sufficient room for smaller victim to slip out of the vehicle and be run over by the trailing vehicle.	Rider defeats restraint
898059	Worn pawl caused safety restraint to release when child was upside down.	Restraint unexpectedly opens
898055	Ferris wheel stopped abruptly. Two patrons fell from seat and landed on another child who was getting off the ride.	Rider defeats restraint

Rider information was not available for one of the 18 potentially relevant incidents.[53] The remaining 17 incidents involved 18 riders, consisting of 10 males and 8 females. Two riders died and 16 were injured. Impact between the rider and the ride, ground, or some other object was the immediate cause of all injuries and deaths. Among those riders for which it was reported, rider age ranged from 1 to 35 years. The distribution of ages, sexes, and dispositions for these victims is shown graphically below. Black segments represent fatalities and gray segments represent injuries.

[53] Record no. 898055. This incident appears to involve two riders who fell onto another rider departing the ride. Information was available on a rider who was departing, but not on those who fell.