Safety Science 113 (2019) 171–179

Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/safety

Global incidence of theme park and amusement ride accidents

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ARTICLE INFO

Keywords:
Amusement rides
Safety
Accidents
Theme parks
Carnivals
Water parks

ABSTRACT

This study describes worldwide occurrence of accidents involving amusement rides. The study compiled and classified reports in international media coverage for a one-year period, analysing event type, ride type, operation type, and regional location. Media reports provided limited detail and almost certainly omitted some events but remain the only publicly available data on a global scale.

Over the year, 182 accident events were reported, from 38 countries, of which 51 events involved a fatality. Mechanical rides and roller coasters were involved in 87 events. Fixed-site rides (amusement and theme parks), mobile rides, and waterparks were involved with a similar number of cases. The most common event type with fixed-site and mobile rides was ride malfunction (63 cases). In waterparks, drowning or near-miss of drowning was most common (27 cases). Just 11 reports involved improper rider action, 12 involved failure of reasonable action, and 11 involved medical conditions or reactions.

Occurrence as a proportion of attendance was highest in Latin America, predominantly involving mechanical non-tracked rides; water attractions predominated in North America. Lower prevalence of malfunctions in North America suggests value of professional development for mechanics and inspectors and strong regulation to promote international safety standards.

1. Introduction

Amusement attractions including theme parks, family entertainment centres (FECs), waterparks, and carnivals are a meaningful component of the tourism industry in regions around the world. Attractions offer an escape from the ordinary, into a world of imagination and illusion. Those illusions often contain elements of daring and danger, but a critical quality of attractions is that danger remains in the realm of illusion.

The safety of amusement rides at theme parks and carnivals is a matter of considerable public interest, and guides decisions ranging from public policy about scope of regulatory oversight to choices made by individuals for themselves and their children. Interests include comparison of risk of amusement rides to the risk of other activities, comparison of one jurisdiction (or form of oversight) to others, or comparison between different types of attractions.

Public interest is reasonable, given the numerous hazards in theme parks and carnivals, from sunburns and bee stings to brain injury or ejection from a moving ride (Avery, 1998). Operators manage these hazards in various complementary ways, including pest control and compliance with international standards for ride design and operation (Avery and Dickson, 2010).

Risk management occasionally fails. A 10-year old boy died in 2016 after impact with ride structures when his waterslide raft became airborne over a hill ("Boy who died", 2016). One man died and seven others were injured when an entire seating unit broke off a high energy ride in 2017 due to catastrophic structural failure linked to metal fatigue and interior corrosion ("One dead", 2017). A 14-year old female guest slipped out of her seat on a slow-moving gondola ride in 2017, holding on until a crowd of guests assembled and prepared to catch her from a 25-foot height (Wang, 2017).

While isolated occurrences are not necessarily indicative of high risk, they can be alarming to the public, potentially jeopardizing public trust and confidence in safety of attractions in general. For instance, Alton Towers reported attendance decline in excess of 25% following a tragic roller coaster collision resulting in amputations, with nearly 12% decline also recorded at the same owner's Thorpe Park (Themed Entertainment Association, 2017). Similarly, a river raft ride malfunction in Australia that killed four guests diminished attendance not only at the park, but other venues in Australia (International Association of Amusement Parks and Attractions, 2017). Safety, public confidence, and commercial viability of attractions are closely coupled.

Despite intense competition among operators, the International Association of Amusement Parks and Attractions (IAAPA) facilitates considerable information sharing on safety matters among operators and between operators and their manufacturers and suppliers. While details are not publicly available, IAAPA reassures the public that the

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https://doi.org/10.1016/j.ssci.2018.11.014
Received 13 July 2018; Accepted 20 November 2018
Available online 30 November 2018

chance of being seriously injured on a fixed-site ride at an amusement park in the United States is one in 17 million rides, based on annual surveys of its membership (International Association of Amusement Parks and Attractions, 2018a), in which injury tallies and ridership data are requested from amusement and theme parks, tourist attractions, and family entertainment centers. For reporting year 2016, 218 of 411 eligible IAAPA North American facilities (53%) reported the number of injuries as well as attendance, ridership, or both. Their responses indicated 3.9 injuries per million attendance, or 0.8 injuries per million patron-rides, for injuries of all severity, of which 8.5% were serious injuries (those requiring hospitalization overnight or longer, other than for observation). Among the 2016 reports, 36% involved roller coasters, 58% family and adult rides, and 6% children's rides (National Safety Council, 2017a). The same analysis for the Asia-Pacific region reported a 48% response rate, with 3.0 injuries per million attendance and 0.8 injuries per million patron-rides, with serious injuries comprising 5.7%. Roller coasters were involved in 32%, family and adult rides 66.9% and children's rides 1.1% (National Safety Council, 2017b). Reports from other regions are not publicly available. There is no international counterpart for portable rides, but the U.S.-based Outdoor Amusement Business Association (OABA) estimates eight injuries per million riders, less than 1% being serious injuries (Outdoor Amusement Business Association, 2012). Low rates may reflect strong overall safety. However, modest response rate and unknown number and performance of non-member operators limits global insight, and overall incidence rate does not answer specific questions public individuals may have about the relative safety of different types of attractions, local safety performance, or similar interests.

Regulators may obtain more detailed information through legally mandated reporting. For instance, the public safety regulator in Ontario, Canada, acquires and reports raw counts for several categories of attractions, such as roller coasters, go karts, waterslides, inflatable devices, and ziplines (Technical Standards and Safety Authority, 2017). TSSA (2017) reported no fatalities in the 10-year period 2008–2017, in an operating population of approximately 2 276 individual regulated amusement rides and devices. In the period, they recorded 3 407 occurrences, of which 95.0% involved "non-permanent" injuries. These sources are useful indicators of priority for policy attention since raw counts show the overall injury toll for the population. The number of occurrences may be elevated for devices that are particularly hazardous, or for devices that are not particularly hazardous but that are numerous. The individual patron making choices among options is interested in the former more than the latter. Raw counts cannot answer that interest without information about attendance/ridership exposure. Regulators do have access to device registrations, but there is substantial variation in the operating season and business volume from one device to another, limiting use of registration data as a measure of exposure. Furthermore, data from regulators only exists where amusement devices are regulated, which falls far short of national, let alone global, data coverage.

Rider "behaviour" is commonly cited as a type, cause, or precipitating event for rider injury by both trade organizations and regulators. OABA cites the State of Michigan regulator as the chance of serious injury as attributing "some 60%" of rider injuries as due to misconduct (Outdoor Amusement Business Association, 2012). North Carolina Department of Labor (NCDOL) Elevator and Amusement Device Bureau was cited as asserting that "a majority of amusement ride and device incidents are patron and/or operator driven" (NCDOL cited by Avery & Dickson, 2010). In Ontario, the Technical Standards and Safety Authority (TSSA) (2017) reported 95% of reported events in the 10-year period ending 2017 were classified as "external factors". This category includes both rider characteristics and actions and other human failures including misoperation and deviation from prescribed installation or maintenance procedures. It could be that some events classified as "external" or "human factors" are actually produced by the design or operation of the device and have been mis-classified by investigators. In addition, ascription of causality reflects investigators' interpretation of event evidence, with familiar and accepted explanations such as rider behaviour more readily identified than alternate explanations. For instance, authoritative reports that "rider error" was involved with 75% of accidents over the past five years may influence investigator's beliefs about typical causation patterns, and thereby affect the causal inference for a new event and creating a self-perpetuating causal explanation (Woodcock, 2008).

Another commonly used data source is the U.S. Consumer Product Safety Commission (CPSC) National Electronic Injury Surveillance System (Consumer Product Safety Commission, 2018), which collects data from a sample of Emergency Departments, statistically extrapolating to national incidence of injury involving consumer products. Often used to analyse and report on public safety of consumer products, NEISS data overstate the incidence of injury involving amusement rides: examination of records showed the inclusion of unrelated devices subsumed under the same product code (Woodcock, 2014). The CPSC has also acknowledged the potential effect of oversampling the vicinity of fixed-site amusement parks due to the location of participating Emergency Departments (Arndt and Al-Tarawneh, 2003; Levenson, 2003). In addition, while thoroughly recording injury detail and gender, age, and race of the injured person, the records capture little or no information about the type of ride or device involved (Woodcock, 2014). The CPSC NEISS system recorded no fatal injuries in either code 1293, Amusement Attractions (including Rides), or code 3295, Water Slides, Public (stationary Amusement Rides) in the 10-year period 2008–2017 (Consumer Product Safety Commission, 2018). The CPSC has stated it is "aware of" 22 fatalities involving amusement rides, excluding waterparks or waterslides, since 2010 (Karimi, 2018), comparable to an average of 2 to 3 per year.

Major Florida theme parks report serious injuries to state authorities on a quarterly basis, and these occurrences are summarized in local news media and widely recirculated. These records identify the specific attraction involved and report the age, gender, and type of injury or illness for events requiring overnight hospital care in the previous quarter. Juxtaposition of these reports to industry attendance estimates and attractions descriptions can provide interesting insight. For example, in 2017, the world's most-visited theme park, the Magic Kingdom at Walt Disney World Resort, reported eight guest injury or illness cases that met the level requiring disclosure to the state of Florida and the news media (hospitalization overnight or longer, other than for observation) (Russon, 2018; Russon, 2017a, 2017b; Pedicini, 2017). In the same period, 20,450,000 people visited the Magic Kingdom (Themed Entertainment Association, 2018). (Attendance is estimated by industry analysts. Walt Disney Parks and Resorts does not publicly disclose business volumes.) Seven of the cases ranged in age from 41 to 70, with the 8th case aged 17. Most were described as feeling ill or dizzy; two had pre-existing conditions. None of the cases involved malfunction of the attraction and there is no evidence from the injury descriptions that the attractions presented hazards in their design. The most "intense" attraction involved is described as having a maximum speed of 27 mph ($12\,m{\cdot}s^{-1}$) (Roller Coaster Database, n.d.) and an estimated maximum acceleration of 2G mid-cycle (Gulf Coast Data Concepts, n.d.). One of the injuries occurred during load-unload and another occurred in the use of a transportation train rather than a ride. The low rate of occurrence, and the nature of even these serious reports, suggest that risk management of this park is highly effective and rides are very safe for people in good condition, and also that people in less robust condition still want to experience park attractions. The obvious concern is that every attraction may not have access to the sophisticated design and risk management resources of Walt Disney Parks & Resorts, and there remains an interest in the relative injury experience of attractions of different types and different locations.

Faced with barriers to accessing primary source reports, and limitations of sources such as regulators and NEISS to single jurisdictions, some researchers have used cumulative media reports (Stenzler, 2016;

Woodcock, 2008). While media reports are selective and almost certainly exclude many occurrences, particularly less severe events, the emergence of social media has made it easy for reporters to discover events and even acquire video media to enhance their coverage, and conversely less feasible for operators to conceal serious events from the media. News can travel instantly around the world, unrestricted by borders and jurisdictional authorities, enabling a global view. Media coverage of an event is an indication that the event is serious enough that an editor believes it will be of interest to the news audience. As such, media reports are a practical and informative data source, if not perfectly complete.

This study describes worldwide occurrence of accidents involving amusement attractions, as documented in international media coverage, for the one-year period 1 June 2017 to 31 May 2018 and compares total reports and event types among device types and continental regions.

2. Method

Reports of amusement ride injury were sourced from major attractions-industry news aggregators IAAPA News Flash (International Association of Amusement Parks and Attractions, 2018b) and International Theme Park Services Leisure News (International Theme Park Services, 2018). Each broadcasts a summary of media reports by email to subscribers each weekday. As these news aggregators compile a variety of news related to theme parks and attractions, media reports were extracted for items described as accidents or injuries in the headline or brief summary of the article. Additional cases referred by various means such as Twitter, personal communication, and news article sidebars were included if reported in the media and the reported "accident" occurred in the one-year period 1 June 2017 to 31 May 2018, was broadcast by 7 June 2018, and the type of event was not excluded (exclusion criteria in Table 1). Google Translate was used to acquire information from non-English language media. A single record was created for each event, but subsequent articles were used to clarify the record if necessary.

For each accident reported in one or more media articles, a record was created of the ride type, event type, the number of fatalities if any, the date of the event, the specific name of the ride, and the venue and locale, including whether it was a fixed site or mobile ride. The ride type was classified by type of ride action and control, and not by market (e.g., thrill, family, children's). Event type was also recorded using a list of categories. Ride type and event type categories are listed in Table 1. Fatalities were recorded if they were reported as immediate, or if a related non-immediate fatality was reported in a news update broadcast in the period.

The quality of news reports limited and complicated data acquisition. For instance, the age of injured person(s), severity of non-fatal outcomes, and whether the ride was a fixed-site installation or travelling operation would be of interest. Unfortunately, this information was omitted from many news reports, thus could not be analysed. Although specific accident event description was often missing, many reports provided human-interest content such as bystander reaction, operator holding statements, description of next steps such as seizure of the device or arrest of operator, and recapped previous occurrences in earlier periods. However, original articles, particularly local media, frequently failed to report even the date of the event or specific city, region, or even country.

Photos in the article were examined or further search was used to complete records, particularly where automated translation of non-English reports was unclear about the ride type and event. Where ambiguity remained about the event type, logical inference was used to eliminate interpretations that would be improbable based on the characteristics of the amusement device involved. Logical inference uses a lower standard of evidence than official investigation but avoided loss of data points.

Table 1
Categories of ride and event types, and exclusion criteria.

Ride types	Event types	Exclusions
Mechanical ride, not roller coaster • Revolving, translating, multiaxial • Wheel • Slow, flat train/car/boat rides • Motion theatre **Roller coaster type (tracked ride, with speed, elevation or both)** • Gondola • Roller coaster • River rapids • Flume ride **Patron-directed ride action** • Go kart • Mountain coaster • Scooter (bumper car) • Inflatable • Trampoline park and play structures • Walkthrough and scenery **Water attractions** • Water slide • Water park, pool **Adventure** • Bungee • Zipline	**Rider** • Failure of an intended action, e.g., jump during ride cycle or evacuation, slip or trip while walking, standing, loading, unloading • Rider experienced a medical condition, potentially aggravated by ride experience • Self-extraction or standing, e.g., unintentional ejection after standing or rising, or intentional self-extraction and consequential fall or impact **Hazard exposure** • Chemical release or unintended concentration • Electricity – fatal or nonfatal electric shock • Surface contact produces laceration, burn, abrasion • Foreign object – injury inflicted by foreign object on ride **Clearance failure** • Rider's body impacted against stationary or moving object that is or should be outside clearance envelope • Free-moving riders/vehicles collided with other riders/vehicles • Rider's hair, clothing, or body part became entangled or pinched in machinery **Other event types** • **Ejection** – unintended separation from ride or ride vehicle due to ride forces and inadequate containment of body size or shape • **Submersion** – rider was submerged in water and drowned or rescued from drowning • **Malfunction** of ride – loss of integrity of ride structure or mechanical components including restraint devices • **Misoperation** – operator incorrectly started or stopped the ride • **Unintended reaction** – includes bodily motion due to ride forces within the restraint and containment system, with or without impact	• Occurrence outside eligible period • 1 June 2017 to 31 May 2018 • Excluded venues (e.g., aquarium, zoo, museum, golf, arcade, hot air balloon and areas of theme parks or carnivals not involving rides such as hotel, retail, dining, parking) • Criminal activity of patrons, fighting, trespassing, indecent exposure, attempted abduction • Public health issues, e.g., food poisoning, infectious diseases, water quality • Weather and climatic events and recovery; • fire other than on ride • Employee safety hazard or injury • Reports on safety programs, regulatory changes, overview of multiple past events • Ride openings and closings • Alleged safety deficiency or protective measure without reporting specific event • Unclear what type of ride or attraction

Table 2
Event types by ride type and operation type.

Attraction type/Event type	Fixed-site rides (59, 32% of all events)	Mobile rides (58, 32% of all events)	Both operation types, subtotal	% of all 182 events	% events fatal
Mechanical not roller coaster					
Malfunction	12 (50%)	26 (60%)	38 (57%)		
Rider	5 (21%)	7 (16%)	12 (18%)		
Clearance failure	2 (8%)		2 (3%)		
Hazard		4 (9%)	4 (6%)		
Ejection	5 (21%)	3 (7%)	8 (12%)		
Misoperation		3 (7%)	3 (4%)		
Subtotal (column %)	**24 (41%)**	**43 (74%)**	**67 (57%)**	**37%**	**18%**
Roller coaster type					
Malfunction	7 (58%)	8 (100%)	15 (75%)		
Rider	2 (17%)		2 (10%)		
Clearance failure	2 (17%)		2 (10%)		
Ejection	1 (8%)		1 (5%)		
Subtotal (column %)	**12 (20%)**	**8 (14%)**	**20 (17%)**	**11%**	**20%**
Patron-directed device					
Malfunction	1 (6%)	3 (60%)	4 (19%)		
Rider	7 (44%)	1 (20%)	8 (38%)		
Clearance failure	6 (38%)		6 (29%)		
Hazard	1 (6%)	1 (20%)	2 (10%)		
Misoperation	1 (6%)		1 (5%)		
Subtotal (column %)	**16 (27%)**	**5 (14%)**	**21 (17%)**	**12%**	**24%**
Adventure attraction					
Malfunction	5 (71%)	1 (50%)	6 (67%)		
Rider	1 (14%)		1 (11%)		
Clearance failure	1 (14%)		1 (11%)		
Misoperation		1 (50%)	1 (11%)		
Subtotal (column %)	**7 (12%)**	**2 (3%)**	**9 (8%)**	**5%**	**67%**
% of events fatal (column)	**34%**	**12%**			
Waterparks	Pools	Slides	Both waterpark attraction types, subtotal	% of all 182 events	% of events fatal
Submersion	26 (60%)	1 (5%)	27 (42%)		
Malfunction	1 (2%)	2 (9%)	3 (5%)		
Rider	7 (16%)	4 (18%)	11 (17%)		
Hazard	8 (19%)	5 (23%)	13 (20%)		
Clearance failure		3 (14%)	3 (5%)		
Ejection		7 (32%)	7 (11%)		
Misoperation	1 (2%)		1 (2%)		
Subtotal (% of waterpark)	**43 (66%)**	**22 (34%)**	**65**	**36%**	**37%**

Note. Percentages in table cells represent event type as proportion of ride type within operation type. Percentages in subtotals represent proportion of column. Percentages "of all 182 events" indicates proportion of all reports. "Percentage of events fatal" reports number of occurrences for the ride type that involved one or more fatal injuries as a proportion of that ride type and operation type. "Pools" includes events on decks and stairs, as well as pools, wave pools, and lazy rivers.

Other analyses were limited due to lack of industry data. Lack of data on the regulatory status of rides in general and specific types of rides across the multiplicity of jurisdictions precluded analysis of differences associated with code adoption of international standards.

3. Results

3.1. Global overview

International media reported 182 accident events in the reporting period. Among these, there were 65 fatalities in 51 events, or 28% of events overall. While excluded from the analysis, there were also 14 additional events referring to worker accidents (six fatal) not in the context of riding the attraction, and there were 63 reports of ride stoppages. Table 2 tabulates the 182 occurrences, broken down by operation type (fixed-site, mobile, or waterpark) and within operation, by ride type, and event type within ride type.

3.1.1. Ride types

Mechanical rides were involved in 87 events, including 67 events involving flat or non-tracked rides and 20 involving roller coasters, river rapids rides, and gondolas. Patron-directed devices such as go-karts, inflatable bounces, and trampoline parks were involved in 21 events. New types of attractions in the Adventure attraction category (ziplines, bungees) were involved in nine events, of which two-thirds involved a fatality. Only one-third of waterpark occurrences involved waterslides. The majority of waterpark reports involved a pool, wave pool, lazy river, or beach and surrounding deck areas.

3.1.2. Operation type

A similar fraction of events occurred in fixed-site, mobile rides, and waterpark operations. However, 37% of waterpark reports and 34% of fixed-site reports involved one or more fatalities, in comparison to 12% of mobile ride reports.

3.1.3. Event type

Examining the type of accident event is important to understand and manage the safety of amusement rides. Safety interventions for malfunctions are completely different from those to prevent accidents related to hazards in ride design, or rider actions or conditions. Table 3

Table 3
Event type number, proportion, and percent fatal.

Event type	N	% of 182 cases	% fatal
Malfunction	66	36	23
Rider	34	19	41
Rider: Failed action	*12*		*33*
Rider: Medical condition	*11*		*82*
Rider: Self-extraction	*11*		*9*
Hazard exposure	19	10	11
Hazard: Electrical	*8*		*25*
Hazard: Surface hazard	*6*		*0*
Hazard: Chemical	*4*		*0*
Hazard: Foreign object	*1*		*0*
Clearance failure	14	8	21
Clearance: Collision of people or vehicles	*6*		*17*
Clearance: Impact against surface	*4*		*25*
Clearance: Entanglement	*4*		*25*
Ejection	16	9	25
Misoperation	6	3	0
Submersion	27	15	48
All events	**182**	**100%**	**29%**

tabulates the number of reports of each event type and sub-type, and the proportion of each type involving one or more fatal injuries.

The most common event type overall was some form of loss of structural or mechanical integrity of the ride ("malfunction") of which 23% of reports involved one or more fatal injuries. Riders' characteristics, actions or reactions contributed to 34 cases, but not all can be characterized as "misbehaviour": 12 events (7%) were failures of a reasonable action (such as tripping while boarding or unloading, or an unintended landing position while jumping in a trampoline foam pit), and 11 (6%) medical reactions or conditions. Just 11 (6%) involved self-extraction or standing on the moving ride, and only one of the latter resulted in fatal injury. No cases in the period reported unintended motion such as strains due to ride forces.

There were 27 cases of drowning or near-miss of drowning ("submersion"), comprising more than half of pool occurrences. Unfortunately, media coverage rarely reported whether submersions occurred due to the attraction, such as wave height, or operational oversight, such as lifeguard staffing or performance, or patron characteristics, such as lack of swimming skill. Media reports were also indiscriminate in the use of "waterpark" terminology to refer to a range of facilities from international vacation destination waterparks to what seemed to be municipal recreation facilities with a waterslide.

Some fatal events affected multiple riders, particularly for device-related failures. Mechanical and structural malfunctions produced 22 fatalities in 15 events, while one obstruction across the path of a roller coaster fatally injured three people. There were 14 fatalities in 13 drowning events. Electrical exposures accounted for 6 fatalities in two events.

3.1.4. Event and ride type

Ride type would be expected to influence the type of injury events that can occur. Mechanical rides constrain autonomous actions by the rider, while patron-directed rides require them. Due to the small number of reports and number of diverse categories, statistical test of the association is infeasible, but Table 2 shows that rider-related events were the largest type among patron-directed ride reports, while mechanical rides and roller coasters had a smaller proportion of that type and a larger share of malfunctions.

3.1.5. Event and operation type

Event type also appears to vary with operation type. A chi-squared test of association was possible by collapsing event types other than malfunction and rider-related events into "other". (To avoid exaggerated association, this test excluded submersion events, which are inherently exclusive to waterparks.) A significant association was seen between event type and operation type ($\chi^2_{4\ \text{d.f.}} = 32.79346$, $p < 0.00001$.) Malfunctions were involved in 42% of reports at fixed-site operations, 66% of reports involving mobile rides, and less than 5% of reports from waterparks. Rider actions and conditions were involved with 25% of reports involving fixed-site rides, 14% of reports involving mobile rides, and 17% of reports from waterparks. Other event types (hazard exposure, clearance failure, ejection, and misoperation) comprised 37% of waterpark reports, 32% of fixed-site reports and 20% of mobile ride reports.

3.2. Regional variation

The 182 events occurred in 38 countries. U.S. reports occurred in 30 different states, while reports from Canada originated from five different provinces. Among the 66 fatalities, 14 (21%) occurred in the United States, 13 (20%) occurred in India, 6 (9%) in Turkey, 5 (7%) in China and Hong Kong, and 4 (6%) in Mexico. Sixteen other countries had one or two fatalities. There is a significant association between severity (fatal or non-fatal) and region ($\chi^2_{3\ \text{d.f.}} = 8.57$, $p = 0.0356$) with 52% of events in Asia Pacific involving a fatality compared with 24–25% elsewhere. This may be due to underreporting of nonfatal events in Asia Pacific rather than a different hazard level.

Rides in fixed-site operations predominated in Asia Pacific and Europe, Middle East, and Africa (EMEA), while mobile rides were involved in the majority of cases in Latin America. Waterparks were most commonly involved in reports from North America (Fig. 1).

3.2.1. Occurrence in proportion to exposure, by region

Occurrences must be interpreted in relation to business activity. For instance, the U.S. has more than 400 amusement parks and attractions (IAAPA, 2018c), whereas there are an estimated 155 parks of various sizes operating in India (Menon, 2018), putting the two countries' similar fatality occurrence into perspective.

To approximate comparative occurrence in proportion to attendance (Table 4), incidence was normalized to industry-projected amusement park and theme park attendance by region (IAAPA, 2017), prorated to correspond to the media coverage (i.e., 7 months of 2017, 5 months of 2018). As attendance estimates include only theme parks and amusement parks, the proportion should include only accidents from these operations. It was possible to filter out events from waterpark rides, adventure attractions (bungee, zipline, trampoline park), inflatables, and go-karts, and reports that appeared to refer to mobile rides, but it was not possible to determine whether other events occurred in FECs or parks. Thus, the calculated proportion is not a representation of risk of riding, but rather a metric of comparison across regions, presuming a similar proportion of FEC to amusement parks across regions.

3.2.2. Ride type and operation type, by region

Mechanical rides (excluding roller coasters and other elevated tracked rides) predominated among events involving mobile operations in all regions and were also most prevalent in fixed-site operations except in North America, where patron-directed rides were involved in more reports (Fig. 2). Mechanical rides (excluding roller coasters) were involved in 68% of Latin America reports, and 50–53% of reports from other regions. Roller coasters were involved in 31% of reports from EMEA, 16% from Asia Pacific and North America, and just 10% from Latin America. Patron-directed and adventure rides combined were involved in 32% of Asia Pacific and North American reports, and 19–22% of reports from EMEA and Latin America. Differences in proportions may reflect regional differences in the inventory of attractions.

3.2.3. Event type and operation type, by region

Ride malfunctions were the predominant event type in all regions and operation types except North American fixed-site operations, where 25% of reports involved malfunctions and 31% involved riders' actions and conditions (Table 5). Elsewhere, events involving rider actions and conditions were the second most common event type in all regions

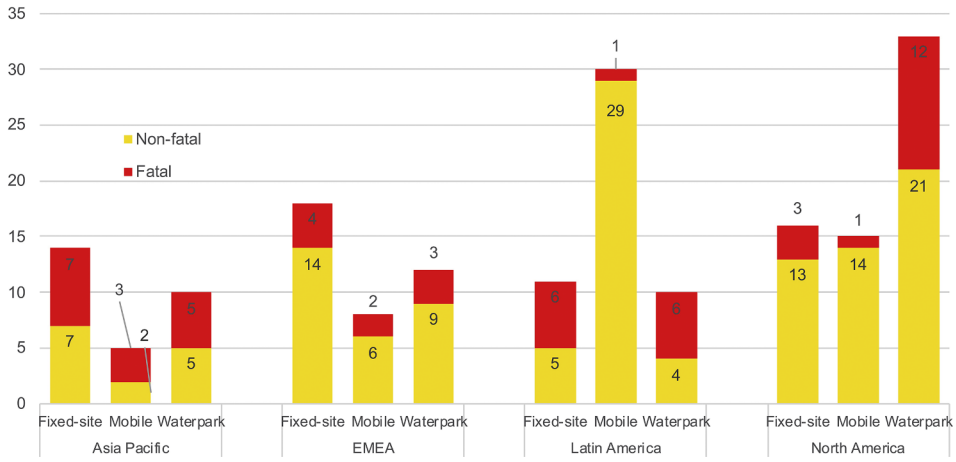

Fig. 1. Occurrences by operation type by region.

Table 4
Attendance, accidents, and accident proportion of attendance.

	Attendance[1]	% Attendance	All accidents[2]	% Accidents	Subset of accidents[3]	Fixed-site accidents per 10 million visits
Asia Pacific	476,758,333	43.7%	29	15.9%	10	0.21
Europe, Middle East, Africa	173,816,667	15.9%	38	20.9%	13	0.57
Latin America	31,391,667	2.9%	51	28.0%	6	3.2
North America	409,991,667	37.5%	64	35.2%	9	0.24
Total	1,091,958,333	100%	182	100%	38	0.35

Notes.
[1] Pro-rated from 2017 and 2018 IAAPA projections of theme park attendance (IAAPA, 2017) on a 7:5 proportion, corresponding to media coverage period.
[2] Excluding media reports about ride stoppages and worker accidents.
[3] Excluding ride stoppages, worker accidents, water ride accidents, adventure attractions, go-karts, and inflatables.

except in Asia Pacific, where only one such event was reported. Combining all regions, 66% of reports involving mobile rides entailed malfunctions, in comparison with 42% of reports involving fixed-site rides. Association cannot be tested statistically due to small expected numbers.

3.3. Stoppages

Reported ride stoppages were excluded from the above analysis. However, because they were frequently mentioned in media reports and influence public perception of amusement ride safety, they are

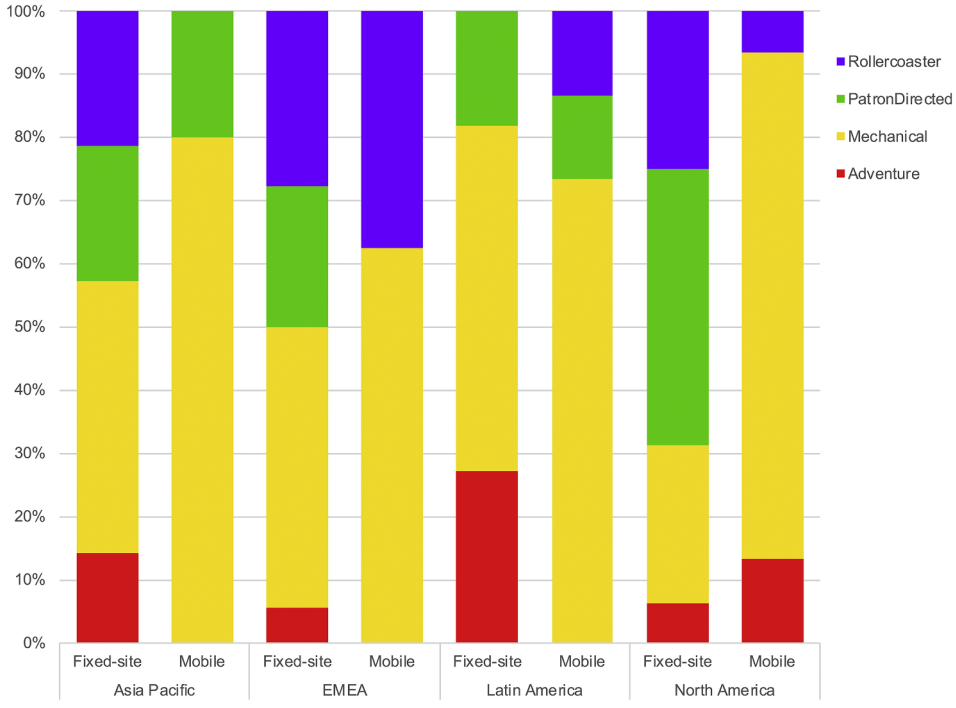

Fig. 2. Proportion by type of ride, type of operation, and region (excluding waterparks).

Table 5
Number and proportion of event type within operation type, by region and globally (excluding waterparks).

	Fixed-site	Mobile
Asia Pacific		
Malfunction	9 (64%)	4 (80%)
Rider	1 (7%)	
Clearance	2 (14%)	
Ejection	2 (14%)	
Misoperation		1 (20%)
EMEA		
Malfunction	7 (39%)	6 (75%)
Rider	5 (28%)	2 (25%)
Clearance	6 (33%)	
Latin America		
Malfunction	5 (45%)	19 (63%)
Rider	4 (36%)	3 (10%)
Clearance	1 (9%)	
Ejection	1 (9%)	2 (7%)
Hazard		5 (17%)
Misoperation		1 (3%)
North America		
Malfunction	4 (25%)	9 (60%)
Rider	5 (31%)	3 (20%)
Clearance	2 1(3%)	
Ejection	3 (19%)	1 (7%)
Hazard	1 (6%)	
Misoperation	1 (6%)	2 (13%)
Global Total		
Malfunction	25 (42%)	38 (66%)
Rider	15 (25%)	8 (14%)
Clearance	11 (19%)	
Ejection	6 (10%)	3 (5%)
Hazard	1 (2%)	5 (9%)
Misoperation	1 (2%)	4 (7%)

Note. Percentage in table cell represents proportion of event type within operation type and region.

briefly summarized here. Stoppages involve riders contained in ride vehicles in potentially uncomfortable positions until it is possible to restart the ride or evacuate riders along an alternate exit path, with or without assistance. While stoppages may be uncomfortable and experienced as poor customer service, these interruptions are often a correct function of safety related control systems. Many faults cannot be prevented by adequate maintenance. Some stoppages occur due to loss of power but many occur when sensors or trained ride operators detect abnormalities and interrupt the ride cycle before a malfunction or collision can occur. For instance, sensors may detect high winds, or debris may blow onto sensors, which may then be unable to confirm adequate separation between vehicles, or vehicles may not pass through a segment of track as quickly as intended, due to low total passenger weight, requiring the following vehicle to be stopped. The majority of stoppages involved roller coasters (37, 59% of stoppages), with 19 mechanical non-tracked rides (30%), four gondola/cable car rides (6%), two bungee jump attractions (3%), and one zipline (1.5%).

Many stoppage reports failed to indicate the number of people affected. Where stated, the mean was 21 people, median 12, ranging from 1 (bungee jumper) to 100 (cable cars). Only three injuries were reported among these cases: chest pain, back pain, and hypothermia, due to the posture or delay pending evacuation or restart or both. The majority of articles describe dissatisfaction and discomfort rather than injury, and some articles also commend customer service to keep riders comfortable and informed during the delay.

Some coverage of stoppages failed to report the duration of the stoppage, but among those that did, the maximum duration was five hours, and the minimum under three minutes, with a mean delay to the final rider unload of 63 min, median 30 min. Four of the accounts using non-quantitative descriptions of duration referred to “brief”, “timely” or “a few” minutes, while one mentioned a stoppage of “quite a while”. Among the reports that provided quantitative descriptions, the average delay on roller coasters was 48 min, median 32.5 min. Extended delays were reported for cable cars, a motion theatre, and a large observation wheel, where the attraction has a large capacity and the configuration permits only unloading a few riders at a time.

4. Discussion

The observed proportion of 28% fatal events contrasts strongly with zero fatalities in CPSC and TSSA data sources (Consumer Product Safety Commission, 2018; Technical Standards and Safety Authority, 2017) and is even higher than the 2 to 3 per year rate known to CPSC. However, a previous analysis of a media-based dataset found a 19% fatality proportion for rider accidents, 24% overall when worker accidents were included (Woodcock, 2008). It appears that non-fatal events are relatively under-reported in the media, either not drawn to the attention of reporters, or deemed not newsworthy. News coverage favours dramatic and unusual accident situations (Woodcock, 2014). Newsworthiness may also reflect factors such as prevalence of amusement attractions in the region and readership interest in previous reports and availability of previously researched background information to include in a report. This is a limitation of using news media to accommodate the general absence of publicly available data. The unrepresentative severity level of media reports versus all injuries does not necessarily undermine the value of the analysis for public insight. On the contrary, most people are likely to be very concerned about the risk of fatal injury. They may be less likely to decline to ride on the basis of a chance of bruise, abrasion, strain, or motion sickness. Media reports may reflect outcomes of types that concern the general public more than the comprehensive all-severity injury tallies of regulators. The possibility of regional difference in media attention must be considered. It was notable that many media reports were found in media outlets other than those in the country of occurrence. Whether due to tourism or general human interest, media attention crossed borders.

Malfunctions were the predominant event type in the global media reports, except that malfunctions constituted a much lower proportion of reports from North American fixed-site operations. Robust maintenance programs and regular, competent inspections are key approaches to prevent malfunctions. Access to professional development for owner/operator personnel may have been a factor in the lower proportion of reports involving malfunctions and mechanical rides in North American reports, compared with the rest of the world. Industry organizations provide annual professional development in maintenance, inspection, and operation of mechanical rides, attended by hundreds of participants annually, primarily from North American operators (AIMS: aimsintl.org; NAARSO: naarso.com). Where owner/operator commitment or expertise are insufficient to maintain high reliability, a third-party inspectorate can be a key element of protection of public safety. Many regions with a developing attractions industry lack a regulatory framework or use of international standards. Unfortunately, the media dataset lacks information on the existence and scope of authority of amusement device safety regulation and inspection. Also lacking in the media dataset is further detail on the nature and source of malfunctions, information that would add valuable insight into preventable defects contributing to reportable events.

Waterparks predominated among North American reports, primarily reports of drowning and near-drowning. Waterparks have seen considerable growth and escalating sophistication of slides and water rides appealing to all thrill levels, with indoor complexes becoming enticing destinations across North America even in winter climates. As such, the prevalence of these reports may reflect increasing participation. As well, swimming skills may be proliferating at an inadequate rate to keep pace with the burgeoning appeal of waterparks, and the presence of numerous lifeguards may promote a false sense of security among patrons and parents of children with weak swimming skills.

Further interpretation about injury proportion in this sector would require the ability to extract only waterpark reports and exclude public swimming facilities, and offset occurrences against attendance data from waterparks.

Reported accident occurrence compared to attendance in Latin America is markedly higher relative to other regions. However, the proportion was calculated using a ratio of accidents to theme park attendance, while the included accidents occurred in both amusement parks and FECs. It is possible that the ratio of theme park and FEC attendance is similar across other regions while Latin American market has a larger fraction of FECs. If so, this may account for some or all of the difference in proportion. However, reports from Latin America also reflected a larger proportion of mechanical malfunctions. This may reflect greater usage of older or previously owned equipment, and potentially compounded by less access to professional development in maintenance, inspection, and operation. To clarify this question, it would be necessary to acquire or estimate attendance data aligned with the operations included in the accident data. Further study of Latin American ride safety is necessary.

Mechanical rides and waterparks predominated in this study; patron-directed rides including inflatable bounces comprised only 12% of reported events. A previous analysis of 2010 CPSC data noted prevalence of inflatable bounces (Woodcock, 2014). However, up to 55% of 2010 reports may have originated from the use of mechanical rides if unspecified ride types were mechanical rides, versus the 42% of cases that mentioned inflatable bounces (Woodcock, 2014). In addition, media reports may not treat inflatable device injuries as newsworthy when settled with local treatment. The 11% proportion of media reports involving roller coasters is considerably lower than the 36% reported by IAAPA members in 2016 (or 2003–2016 average 32%). If stoppages are included, however, 25% of the media reports involved roller coasters.

Previously cited sources have asserted that rider characteristics and actions precipitate the majority of injuries, whereas this dataset included a far lower proportion of rider-centred events, and higher proportion of malfunction and misoperation and hazard exposure. The media data predominance of malfunction rather than rider action is consistent with a previous media analysis that found just 7% of reported events explained as due to the rider's action, while 39% had mentioned the ride as a pre-failure factor and 87% of reports referred to the ride as a factor at any stage (Woodcock, 2008). As noted earlier, rider-centred causal attribution could be influenced by conscious or unconscious and self-perpetuating bias by investigators. Alternatively, or in addition, it could be that rider-centred events do predominate overall but are more likely to be low or moderate severity, whereas higher severity events that attract media coverage are more likely to involve a failure of the ride or hazards in its design or operation. It may also be that rider-centred events are assessed as less newsworthy. "Innocents harmed by businesses operating ill-maintained equipment" provides a convenient and compelling narrative, whereas other narratives may be harder to report and reporters may be reluctant to be seen as victim-blaming.

Although they are not accidents, stoppages must be discussed here because of the potential for perception of amusement ride safety to be skewed by the prevalence of dramatic reports from stoppages. Stoppages are clearly an alluring topic for reporters. Interview subjects are readily available, including affected patrons, rarely seriously injured but often uncomfortable and vocally displeased with the experience. They may even be streaming their experience on social media (Pevos, 2018). Media reports would ideally note that stopping the ride is a planned alternate mode of operation, and considerably preferable to the casualties that would occur had a stoppage not been effected.

Ultimately, media reports have provided a limited insight into the types of amusement ride accidents that occurred around the world in this one-year period but alternate publicly available data sources are unavailable or more limited.

From this study, we can conclude that the global occurrence of amusement ride accidents attracting media attention supports industry characterizations that serious injuries are few compared with the extensive public participation. However, the occurrence of any fatal injuries indicates that continued attention is warranted, particularly to measures that could prevent ride malfunctions, and a need to consider swimming skill as a public health priority. The lower rate of malfunction among North American reports, particularly in fixed-site operations, suggests a benefit to professional development and engagement in industry associations that promote safety education and safe practices, strong regulation, and use of international standards. However, this conclusion is limited by the lack of confirmation in media reports of the membership status of individual accident sites in industry associations and the regulatory status of the jurisdictions in relation to adoption and manner of enforcement of international standards. Conclusions drawn from inferences from proportions reported here should be cautious due to the relatively small number of these events in the context of a large global industry.

Acknowledgements

The author appreciated the valued epidemiological counsel by Dr. M. Anne Harris.

This work was supported by a Discovery Grant from the Natural Sciences and Engineering Research Council of Canada to the author.

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