

Children and Infants in Aviation Accidents

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- BACKGROUND:** This study examines the relationship between seat restraints and injuries of children and infants who were passengers on an aircraft and gives a detailed analysis of children whose behavior contributed to an accident.
- METHODS:** A total of 58 accident reports from 1980 until 2015 were extracted from the NTSB online database in which children were mentioned. In at least 10 cases the child's behavior contributed to the accident.
- RESULTS:** Violations of regulations by the Federal Aviation Authority (FAA) as well as the age and number of children and infants on board were each reported inconsistently. Violations of regulations were significantly more common when accidents occurred during the takeoff phase. Child behaviors that caused accidents included distraction of crew, not wearing a seatbelt, and running into dangerous areas.
- CONCLUSIONS:** Pilots and crew, especially in General Aviation, need to be made aware of the need to enforce FAA regulations concerning child restraint systems. It is recommended that children both on the ground and inside an aircraft have adult supervision in addition to supervising aircraft crew to prevent distractions that harm the safe operation of an aircraft.
- KEYWORDS:** safety, general aviation, child, infant, child behavior.

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The protection of children and infants in motor vehicle accidents was pioneered by Susan Baker whose work would lay the groundwork for today's child passenger protection laws in the United States.^{1,6} These laws vary per state but nowadays commonly require a federally-approved child booster seat secured by a seatbelt system for children under a certain age as well as requirements of wearing a seatbelt above a certain age.

In 1990, the National Transportation Safety Board (NTSB) investigated seven aviation accidents with commercial airliners to determine the safety of infants and children. On the basis of their finding that lap-held children could not be held securely during severe turbulence or a crash landing, they issued a recommendation to the Federal Aviation Administration (FAA) in 1990 that read "that all occupants be restrained during takeoff, landing, and turbulent conditions, and that all infants and small children below the weight of 40 pounds and under the height of 40 inches be restrained in an approved child restraint system appropriate to their height and weight."⁸

Today, the FAA recommends a child restraint system (CRS), which is designed to be used in conjunction with the seatbelt system in the aircraft and is similar but not always identical to the ones used in cars.⁴ However, the FAA does not require their use because "a mandate would require parents to purchase an

extra airline ticket for their child, forcing some families who can't afford the extra ticket to drive, a statistically more dangerous way to travel." The FAA acknowledges that airlines commonly allow children under the age of 22 yr to fly free of charge on someone's lap, even though that is not the safest way to travel.³ In the absence of a CRS, infants, i.e., children under the age of 2 yr, are allowed to be on a passenger's lap but all other children are required to use the existing seatbelt system in the aircraft and should not share the seatbelt system with another individual unless it is specifically designed for such a purpose.

A study of GA aviation accidents involving children in 2011 focused on restraint systems and the safety of child passengers.⁹ They identified at least one child in the 2011 dataset who could have been saved if such a system had been used. As a result of this study, the NTSB made improvements to its data management system so that future studies regarding child passengers would be better facilitated.

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Absent from previous studies, and the regulations of the FAA, is a consideration of child behavior and aviation accidents. Children who resist being in a seatbelt, distract crew or pilots, or otherwise affect the safety of themselves or the aircraft are mostly left out of the analyses. They may include children who are on the ground and who were not passengers on an aircraft. The presence of accidents where the agency of children contributed to the accident adds a separate concern in aviation accident analysis that requires additional mitigating measures.

We examined aviation accidents in the United States investigated by the National Transportation Safety Board to understand to what extent children are part of aviation accidents and, in addition, to what extent they contributed to an accident through their actions.⁷ The limitations of the current dataset also made us explore ways in which further changes in current investigation practices on the part of the NTSB may enhance our understanding of child aviation safety in the future other than the recommendations already presented in previous studies.

METHODS

We extracted from the NTSB Aviation Accident Online Database all accidents between 1980 and 2015 that mentioned “child”, “children”, “infant”, “toddler”, and “baby”.⁷ Subsequently all overlap was removed. We included only those accidents in which children or infants appeared as passengers. In addition, if a child was not a passenger but was on the ground, the report was included if the child somehow affected the course of events, such as distracting the crew or running in unexpected directions.

The dataset shows that it is unlikely that all accidents with children on board an aircraft consistently reported the presence of children, and since there are no denominator data concerning children aboard aircraft, we cannot ascertain the overall risk for children and infants to be part of an accident, nor can we determine the relative risk of a fatality or serious injury when they are part of an accident. In a previous study, it was estimated that each year 1 in 30,000 infant passengers 2 yr of age or younger sustains a fatal injury in a GA accident. In a study of child passengers in 2011, it was concluded that “the fatality rate for the accidents involving children was much higher than the rate for all GA travel.”⁹

In addition to the factors and circumstances listed by the NTSB investigators, we retrieved from the narrative statement and the passenger data the following aspects that concern children and infants: their possible role in the accident, the presence and seriousness of their injuries, their use of a seatbelt or other restraint, FAA violations concerning child restraints reported by the investigator, their number on board the aircraft, and their individual age.

We separated the dataset into two parts. One concentrates on child passengers in fixed-wing and helicopter aircraft that have seat belts and includes a discussion of the role and presence of a restraint system. In the second part we analyze child

agency in aviation accidents and include all accidents where a child somehow contributed to the accident on the ground or as a passenger. This latter dataset explores their role in multiple different aircraft.

The significance of correlations within the dataset of categorical data was determined using Pearson’s Chi-Square analysis.

RESULTS

Between 1 January 1980 and 1 January 2015, 58 accidents were reported in which a child was injured as a passenger or contributed to the accident. A significantly higher number of infants (defined as younger than 2 yr of age) were reported for non-GA (7 out of 11) than in GA (6 out of 48) [χ^2 (1, $N = 59$) = 13.62, $P < 0.01$]. Type of aircraft included a balloon, glider, helicopter, float-plane, small fixed-wing aircraft, and a large air carrier.

There were 56 accidents in which at least one child was injured who was a passenger in a fixed-wing aircraft or helicopter. The majority of the accidents involved a fixed-wing aircraft (91%). In seven of the accidents, more than one child was injured. These accidents resulted in at least 26 child fatalities. **Fig. 1** displays the number of accidents that occurred from 1980 through 2014. Zero accidents were reported in 1980, 1981, 1985, 1986, 1993, 1998, 1999, 2000, 2001, and 2002. The accidents occurred in 33 states in the United States, most frequently in Alaska ($N = 6$), California ($N = 5$), and Texas ($N = 5$). **Fig. 2** displays the number of accidents that occurred during each of the broad phases of flight. There was a significantly higher proportion of FAA violations for seat restraint in accidents that occurred during takeoff (7 out of 12) compared to all of the other broad phases of flight combined (11 out of 42), χ^2 (1, $N = 54$) = 4.33, $P < 0.05$. However, the proportion of accidents in which a child died during takeoff (7 out of 18) was not significantly greater than the proportion of accidents in which a child did not die (16 out of 27), χ^2 (1, $N = 55$) = 1.55, $P > 0.05$.

Of the 56 reports, 31 were missing information regarding the kind of safety restraint the child was using. We examined the relationship between FAA-approved restraints and child injury using the remaining 25 reports (see **Table I**). Without the use of an FAA-approved restraint, the proportion of accidents that resulted in at least one child’s death (9 out of 12) was not significantly more than the proportion of accidents that resulted

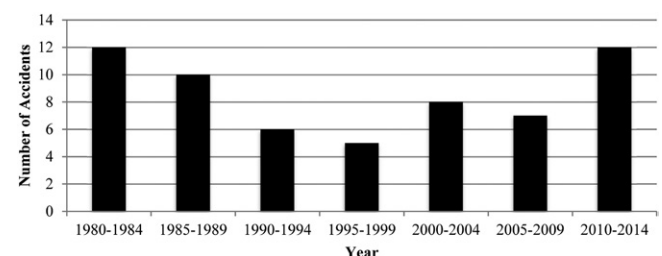


Fig. 1. Number of accidents that involved injured child passengers between 1980 and 2014.

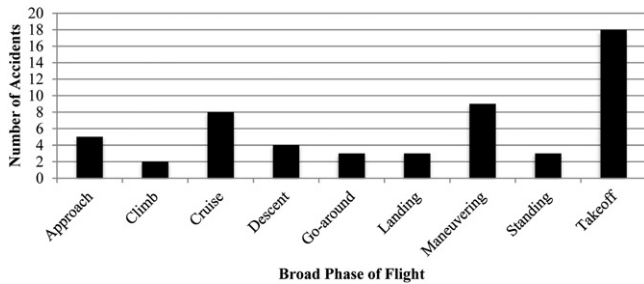


Fig. 2. Number of accidents by broad phase of flight.

in a minor or serious injury (8 out of 15), $\chi^2(1, N = 27) = 2.22, P > 0.05$.

Infants are allowed to be lap-held and all infants were reported to be either in a car seat ($N = 2$), lap-held ($N = 7$), or their restraint was not reported ($N = 9$). There were 12 reported FAA violations concerning the presence or use of seat restraints. FAA violations regarding seat restraints were not more common in accidents that resulted in a death of a child (7 out of 25) compared to nonfatal accidents (6 out of 32), $\chi^2(1, N = 58) = 0.55, P > 0.05$.

Experienced pilots (those who logged more than 500 h of flight time) were not more likely to be involved in an accident that resulted in a child's death (17 out of 26) compared to an accident that resulted in a child sustaining a minor or serious injury (19 out of 32), $\chi^2(1, N = 58) = 0.22, P > 0.05$. Less experienced pilots were also not more likely to receive an FAA violation for seat restraint (3 out of 21) compared to their more experienced peers (9 out of 35), $\chi^2(1, N = 56) = 0.69, P > 0.05$.

In another six cases, the weight and balance was not in order and, according to the NTSB inspector, was caused by taking too many people on board by adding children on someone's lap or putting multiple children in one seat. In three cases, alcohol or drugs impaired the judgment of the pilot. In two additional cases, self-induced pressure was indicated as a likely contributing factor. In one case, the NTSB investigator indicated that the EMS pilot was likely under pressure due to the presence of an 11-d-old infant who needed medical attention and this likely contributed to the outcome of the flight. In a second case, the pilot's wife (a passenger on the flight) indicated in a phone call prior to the accident that they were maintaining the original flight plan, despite inclement weather, to ensure that their five children (all passengers on the flight) would make it home for school the following day. This accident resulted in the death of the pilot and three passengers, while the remaining three passengers were seriously injured.

Table I. Severity of the Injury Sustained by the Child Passengers and FAA-Approved Restraint Status.

FAA-APPROVED	INJURY SEVERITY*		
	MINOR	SERIOUS	FATAL
Yes	6	1	9
No	5	3	3
Unknown	11	11	14

*Seven accidents are counted twice because more than one kind of injury was sustained by the children in the accident.

Out of the 58 accidents that mentioned children, 11 accident reports suggest that the behavior of a child played a role in the outcome of the flight accident. In nine of those cases, the cause of the accident related to the child's behavior, in one other case it was a factor. It was not mentioned as a cause or a factor in one case where an adult passenger unbuckled his seatbelt just before landing to intervene with two children who seemed to interfere with the flight controls, possibly as only minor injuries were sustained and the main cause of accident was maintenance related. The majority of the accidents involved fixed-winged aircraft ($N = 9$) with one occurring in a helicopter and another in a balloon. These accidents occurred most frequently in the 1990s ($N = 7$), with two occurring in the 1980s as well as the 2010s (see **Table II**). The accidents mostly occurred during the landing ($N = 3$) or standing ($N = 3$) phase of flight, while the others occurred during descent ($N = 2$), takeoff ($N = 1$), taxi ($N = 1$), and approach ($N = 1$).

Four of the accidents resulted in the child's death, three resulted in serious injury to the child, one resulted in a minor injury to the child, and in three accidents the child was uninjured. Three accidents reported multiple children injured and more than one kind of injury. In total, the 11 accidents resulted in 8 fatalities, 5 serious injuries, and 3 minor injuries. Five of the aircraft were not damaged as a result of the accident, four sustained substantial damage, and two sustained minor damage.

In 10 cases, the behavior of a child was directly or indirectly a factor or cause of the aviation accident according to the NTSB investigator. In three of those cases the cause of the accident was attributed to the pilot and in two the cause was attributed to the (ground) crew and once to the aviation company. In these cases, the cause was a lack of supervision ($N = 3$), diverted attention ($N = 2$), or not maintaining a visual lookout ($N = 1$). Visual lookout pertained to a crewmember who was warding off a child and failed to see a landing balloon. The balloon basket subsequently seriously injured the crewmember. In one of the lack of supervision cases, the cause was also placed with the child for not wearing a seatbelt. In another instance, diverted attention was only a factor while fuel management was considered the primary cause. When the cause was not attributed to pilot or crew, one report attributed the cause to the "passenger" for not wearing a seatbelt, which included both a child and an adult but the specific passenger was not specified. Finally, in two cases the cause of the accident was attributed to the child alone. In one case for not following instructions and in one other case for the "improper use of a mini-bike". In both those cases, the child was not a passenger but was on the ground when the accident occurred.

DISCUSSION

Children and infants have been part of aviation accidents in all types of aircraft, including balloons, gliders, helicopters, float-planes, and large air carriers. Their presence is attested in multiple different states across the United States. Even though this variety may call for separate investigations of each category of

Table II. Descriptions and Cause Attributions of Accidents in which a Child Played a Role in the Outcome of the Flight.

YEAR	SHORT DESCRIPTION	CAUSE* ATTRIBUTION	INJURIES
1982	Boy occupies baggage compartment and falls out of aircraft during takeoff	Inadequate supervision – Pilot in Command (PIC) seat belt not used – Child [†]	Fatal (child)
1983	Child retrieves doll on airstairs and is hit by propeller	Supervision inadequate – company/operator	Serious (child)
1988	Girl goes to bathroom with mother; on their return turbulence hits aircraft	Instructions not followed – passenger seat belt not used – passenger	Serious (passenger)
1994	Child runs into propeller	Disregarded instructions – child [‡]	Serious (child)
1995	Adult passenger in rear seat unfastened his seat belt because two children in his lap were interfering with “control stick travel”	Maintenance – maintenance personnel	Minor (1 crew, 2 unspecified passengers)
1995	Boy exits through galley servicing door and falls through gap	Supervision not maintained – flight attendant	Serious (child)
1996	Boy collides on his mini-bike with a taxiing aircraft at night	Improper use of equipment – child [§]	Fatal (child)
1997	Balloon lands but ground crewmember distracted by child and gets hit by basket	Visual lookout not maintained – ground personnel	Serious (ground personnel)
1998	Pilot distracted by donning oxygen to himself and his children; forgets to switch fuel tanks	Fuel management – PIC	None
2010	Passenger with 5-yr-old on his lap; child likely to have kicked helicopter controls	Incorrect action sequence – unknown incorrect action selection – flight crew aircraft control – PIC	Fatal (crew and passengers, including child)
2011	Distracted by son sitting next to him, pilot forgets to retract landing gear for water landing	Attention – PIC	Fatal (child – drowned) No injuries (pilot)

* Child is referred to as: [†]passenger; [‡]other person; [§]driver of vehicle.

aircraft or geographic region, particularly in General Aviation (GA),² they confirm the general relevance of regulations addressing the safety of children and infants.

Almost half of the accidents in our dataset report a fatality, with more than one-third reporting the death of child or infant. This high fatality ratio needs to be explained by the underreporting of children in aviation accidents rather than by the proportion of fatal accidents in the dataset.⁵ Firstly, the presence of children and infants is not consistently reported. Infants do not take a separate seat, so they are often not counted and are mostly irrelevant for the weight and balance calculations. Our dataset includes 10 air carriers. While these reports mention the presence of children or infants, it is unlikely that all other air carrier accidents reported by the NTSB had no minors on board at all. Also, three reports mention “several” children on board while neither providing the total number nor their specific age(s). The accidents that the NTSB used to investigate child aviation safety in 1990 did not appear in our database search, which indicates that documenting the presence and age of passengers is not part of standard accident report. Second, the age and injuries of children and infants on board are not consistently reported. Accident reports may mention the presence of child passengers, but the investigator did not specify their age in 95% of the cases. As was confirmed in a previous study, the NTSB investigators do not consistently report the age of injured or uninjured passengers of aircraft involved in an accident, a practice that severely hinders our understanding of child safety in aviation and GA, in particular where additional information beyond the database is commonly not available.⁹

Violations of FAA rules concerning seat restraints for infants and children are not consistently reported for GA accidents, an issue not addressed in previous studies. Children over the age of

2 yr who are lap-held are also not always reported as violating FAA rules. It is, therefore, not just the absence of data but also the inconsistency of reported data, including possible violations, which have room for improvement.

In the case of air carriers, no violations were reported, suggesting that proper protocols were being followed. Of the two fatalities in this category, one was on the ground and one was a lap-held infant. Serious injuries were only reported on the ground and other minor injuries only involved lap-held infants. Although few in number, the injuries sustained by children on board an air carrier concern and further illustrate the known problem of lap-held infants.^{4,7}

The data show that FAA violations concerning seat restraints were significantly more often found when accidents occurred during the takeoff phase. Since prior to takeoff the pilot and crew have every opportunity to enforce regulations, this finding suggests that it should be worthwhile to make flight crew better aware of the necessity to enforce regulations regarding child seat restraints prior to commencing the flight.

Our data suggest that infants are more common on non-GA flights accidents compared to GA flights, suggesting that specific recommendations may need to be made for non-GA flights. From a developmental point of view, infants require a unique set of considerations to ensure safety.¹¹ Because only older infants have the motor skills necessary to walk, although not in an advanced way, crewmembers and caregivers accompanying infants on the flight should be less worried about the infant's behavior directly affecting the flight, and more concerned with potential distraction or diverted attention. It is also not appropriate to expect the infant to be able to control his or her behavior and vocalizations, both of which could potentially be distracting.

While the behavior of child passengers has been part of several accidents, the cause of the accident was sought either with the passenger (often a parent or grandparent), crew or pilot for a lack of supervision of the child or lack of attention to the safe operation of the aircraft. It is the factors that allow the child's behavior to lead to an accident that need addressing rather than blaming the child him or herself.¹⁰ For instance, in one case a child refused to be restrained by a seatbelt and was allowed by his grandfather to sit in the baggage area. During takeoff the baggage latch was dislodged as it was not designed to withstand sudden inputs from inside and the child fell to his death. The cause was attributed to the pilot for a lack of supervision and not to the grandfather or the child.

In light of the above, attributing the cause or “blaming” a child even though the child was on the ground should be considered inappropriate.¹⁰ In one case, “insufficient standards/requirements” by “other institution”, in this case the airfield, was only a factor while the only cause that was mentioned stated the child's “improper use of equipment”. In a second case, a child was running toward the aircraft and nobody but the child was deemed part of the cause while an adult was helping with the deplaning of another child and, apparently, no other supervision was present at the airfield.

When considering the extent to which it is appropriate to attribute the cause of an aviation accident to a child, it is necessary to evaluate the developmentally appropriate expectations of the child.¹¹ As children age, the cognitive, perceptual, motor, and social skills that play a role in risk-taking and risky behavior change dramatically. A system in place to protect 8-yr-olds would not be appropriate for 4-yr-olds. However, when the age of the children involved is not consistently reported, it is impossible to ascertain which age groups are most at risk. If age is regularly reported, it will become possible to not only assess the age group most at risk, but also allow experts in developmental psychology to guide aviation experts in implementing developmentally appropriate systems that ensure the safety of children near aircraft or as passengers on an aircraft. The cases discussed above suggest that mitigating strategies for aviation accidents involving risks posed by children's behavior should always include improved supervision by an adult, preferably in addition to a person who is part of or familiar with aviation operations.

This study confirms previous findings that criticize the current FAA regulations for lap-held infants, as well as the lack of detail concerning children in NTSB reports. This includes missing information about the presence of minors, the ages of children, and the inconsistent reporting of violations of FAA regulations.

We also reported on accidents in which child behavior was directly or indirectly the cause of an aviation accident. Although

these accidents were few, the behavior itself seems common as it includes children refusing to be restrained, running away from supervision, or distracting aircraft crew. Even the seemingly innocuous behavior of a child insisting to go to the bathroom with her mother while the seatbelt sign was on eventually caused the mother to break a leg when turbulence hit the aircraft.

In most, if not all, accidents involving child passengers or any child behavior that may contribute to the cause of the accident, the responsibilities of the pilot and (ground) crew should be central and considered necessary in addition to general adult supervision by noncrew. Crewmembers may enforce FAA regulations, may insist on adequate adult supervision and should be made aware, especially in GA, that distractions by children may have serious or even fatal consequences.

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