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In-Flight Injuries Involving Children on Commercial Airline Flights

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Background: More than 3 billion passengers are transported every year on commercial airline flights worldwide, many of whom are children. The incidence of in-flight medical events (IFMEs) affecting children is largely unknown. This study seeks to characterize pediatric IFMEs, with particular focus on in-flight injuries (IFIs).

Methods: We reviewed the records of all IFMEs from January 2009 to January 2014 involving children treated in consultation with a ground-based medical support center providing medical support to commercial airlines.

Results: Among 114 222 IFMEs, we identified 12 226 (10.7%) cases involving children. In-flight medical events commonly involved gastrointestinal (35.4%), infectious (20.3%), neurological (12.2%), allergic (8.6%), and respiratory (6.3%) conditions. In addition, 400 cases (3.3%) of IFMEs involved IFIs. Subjects who sustained IFIs were younger than those involved in other medical events (3 [1–8] vs 7 [3–14] y, respectively), and lap infants were overrepresented (35.8% of IFIs vs 15.9% of other medical events). Examples of IFIs included burns, contusions, and lacerations from falls in unrestrained lap infants; fallen objects from the overhead bin; and trauma to extremities by the service cart or aisle traffic.

Conclusions: Pediatric IFIs are relatively infrequent given the total passenger traffic but are not negligible. Unrestrained lap children are prone to IFIs, particularly during meal service or turbulence, but not only then. Children occupying aisle seats are vulnerable to injury from fallen objects, aisle traffic, and burns from mishandled hot items. The possible protection from using in-flight child restraints might extend beyond takeoff and landing operations or during turbulence.

Key Words: in-flight injuries, aeromedical diversions, in-flight medical events, trauma, burn

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More people are spending more time in the air than ever before in the history of commercial aviation. In fact, more than 3.2 billion passengers were transported on commercial airline flights worldwide in 2014,[1] many of whom are children. Considering that more than 8.8 million passengers fly on any given day, the commercial airspace can be viewed as a suspended metropolis where medical events can and do occur. While onboard, passengers might experience exacerbation of a preexisting illness due to natural disease progression or cabin environment (eg, hypoxia, trapped gas expansion, reduced mobility), manifest a newly acquired health condition, or even experience an injury related to the inherent risk of traveling inside a crowded compartment subject to unexpected turbulence, among many other potential hazards.[2]

When a medical emergency arises during flight, access to care is limited, and resources are finite. First aid and basic life support are generally provided by trained crew members, whereas more complex situations require the engagement of a passenger volunteer with a medical background. In addition, specialized ground-based medical support (GBMS) centers have increasingly been used to remotely assist crew members in dealing with these events.[3,4] Although in-flight medical events have been well characterized for adults,[3,5–13] data on pediatric travelers are much more limited and restricted to a relatively small study that compiled cases from a single US-based commercial airline.[14] Published data regarding injuries (ie, trauma and burns) sustained by children during commercial flights are nonexistent.

The objective of this exploratory study was to characterize in-flight medical events experienced by children worldwide, with particular focus on in-flight injuries. We also sought to identify patterns that could lead to the development of injury prevention strategies to protect the health of pediatric travelers and inform further research.

METHODS

To identify pediatric in-flight medical events, we reviewed the electronic records of all in-flight medical events between January 1, 2009, and January 1, 2014, reported to the world's busiest GBMS center. This GBMS center provides remote medical support to approximately 35% of the commercial airline passenger traffic worldwide. The GBMS center is located at a US-based level 1 trauma center staffed continuously by dedicated on-site emergency physicians trained in telemedicine, flight physiology, airline protocols, and in-flight medical resources.

Satellite telephone or radio relay communication was used between crew members and the GBMS center in the event of an in-flight medical event. A detailed account of the event, medical recommendations, disposition, and immediate outcomes were entered into a structured electronic record in real time by trained operators listening to the exchange and saved to a protected proprietary electronic database. In addition, all voice communications were recorded for further review, if necessary. Available data fields included event date, patient age and sex, diagnostic category, diagnostic impression, flight origin and destination, aircraft type, flight duration, unscheduled landing (flight diversion), professional background of the passenger health care volunteer, patient disposition, and whether medications or medical equipment were used. The record also included a free form narrative summary of the medical concern, available relevant medical history, and any recommendations given by the GBMS center physician. When more than 1 volunteer provider assisted with the emergency, the one with the highest perceived level of training was noted.

By searching the GBMS center's database for all in-flight medical events that occurred during the study period, we identified those that involved children, arbitrarily defined here as passengers between 0 and 18 years old. These de-identified data were then abstracted into an electronic database (Excel 2013;

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Microsoft Corporation, Redmond, WA) and analyzed with dedicated software (SigmaPlot for Windows version 13.0; Systat Software, Inc, San Jose, CA). Data are presented as counts and percentages for categorical variables and medians and interquartile ranges for continuous variables, unless otherwise specified. Associations involving categorical variables were analyzed using the χ^2 test with Yates correction, and those involving continuous variables were analyzed using the Mann-Whitney rank sum test. All reported P values are 2-tailed, and a value of less than 0.05 was considered statistically significant.

For the purpose of this study, the term *in-flight injury* was used to denote medical events caused by injuries (ie, trauma or burns) that occurred or manifested themselves during flight. Lap infants were defined as passengers younger than 24 months, the age until which a child is allowed to travel while sharing a seat with an adult passenger. The term *wide-body* was used to denote aircraft with a 2-aisle configuration. Flight duration was calculated using the great circle distance between origin and destination airports and the average speed for each specific aircraft. This study was approved by the University Hospitals of Cleveland Medical Center Institutional Review Board.

RESULTS

The GBMS center received a total of 114 222 in-flight medical event calls during the study period. Among these, we identified 12 226 (10.7%) unique records involving pediatric-aged passengers. These cases originated from a pool of 77 airlines operating in 6 continents and representing approximately 35% of the commercial aviation passenger traffic worldwide. The median age of patients involved in these pediatric in-flight medical events was 7 years (25th-75th percentiles, 3–13), 7068 (57.8%) were female, and 2017 (16.5%) were lap infants. The most common pediatric in-flight medical events involved gastrointestinal (35.4%), infectious (20.3%), neurological (12.2%), allergic (8.6%), and respiratory (6.3%) conditions (Table 1). In-flight injuries accounted for 400 (3.3%) of all pediatric in-flight medical events, including 243 (2%) cases classified as trauma and 157 (1.3%) cases involving burns.

Patients who sustained in-flight injuries were younger than those involved in other in-flight medical events, and lap infants were overrepresented among the former (Table 2). Most in-flight injuries occurred on international flights (83.5%), serviced by wide-body aircraft (72%), covering distances of more than 3500 miles, and lasting longer than 6 hours. Crew members interfacing with the GBMS center provided first aid and onboard assistance to most in-flight injuries (69.8%), whereas a health care professional passenger volunteer also provided care in certain cases (30.3%), and these involved mostly physicians and nurses (20.3% and 7.8%, respectively). Children sustaining in-flight injuries were less likely to require administration of drugs from the onboard medicine kit but more likely to require items from the medical equipment kit. The vast majority of flights with a pediatric in-flight injury continued to the intended destination, whereas 7 cases resulted in aircraft diversion. A greater number of children who sustained in-flight injuries required additional medical care at the destination (52.8%) compared with those involved in other medical events (23%).

The most common types of in-flight injuries involved burns (39.3%), contusions (29.5%), lacerations (20.5%), and closed head injuries (8%) (Table 3). Among the children who sustained lacerations, 46 (56%) had a wound deemed to require suture repair. Scalding burns from hot beverages or soups spilled over a child during hot meal service were the most commonly identified mechanism of injury (36%) (Table 3). Other prevalent mechanisms included falls from the seat involving unrestrained children and lap infants (25.3%); injuries occurring before boarding that manifested themselves during flight (7.8%); children colliding with the aircraft interior due to tripping, turbulence, or both (6.3%); contusions to an extremity caught between the armrest and passenger aisle traffic (4.3%) or the service cart (1%); falls from infant bassinettes (3.8%); trauma from heavy objects (eg, bags, computers, bottles) falling from the overhead compartment (3.8%); and cuts from sharp glass or metal (3.3%). Expectedly, all cases of fall from a bassinette involved lap infants because these devices only accommodate children with a body weight of up to 10 kg.

TABLE 1. Pediatric In-Flight Medical Events According to Type and Clinical Category

Type	Category	n (%)
In-flight injuries		400 (3.3)
	Trauma	243 (2)
	Burn	157 (1.3)
Other in-flight medical events		11 826 (96.7)
	Gastrointestinal	4332 (35.4)
	Infectious/communicable	2480 (20.3)
	Neurological	1497 (12.2)
	Allergic/immunological	1052 (8.6)
	Respiratory	775 (6.3)
	Ear, nose, and throat	602 (4.9)
	Dermatological	220 (1.8)
	Psychiatric	190 (1.6)
	Orthopedic/musculoskeletal	140 (1.2)
	Cardiac	107 (0.9)
	Dental	72 (0.6)
	Pharmacological	64 (0.5)
	Endocrine	53 (0.4)
	Ophthalmological	45 (0.4)
	Envenomation/environmental	44 (0.4)
	Urological/renal	41 (0.3)
	Obstetric/gynecological	29 (0.2)
	Vascular	29 (0.2)
	Substance abuse	20 (0.2)
	Medical equipment	18 (0.2)
	Hematologic/oncological	6 (0.05)
	Other	11 (0.09)

DISCUSSION

Our study is the first to characterize pediatric in-flight medical events using a representative worldwide sample large enough to allow for a meaningful examination of pediatric in-flight injuries. The only other published study characterizing pediatric in-flight medical events restricted its observations to cases from a single US-based airline and included a total of 222 events, of which only 169 involved actual pediatric in-flight events, as opposed to preflight consultations.[14] In that study, only 9 children (5%) sustained an in-flight injury,[14] thus making it impossible to properly characterize this important subgroup. In-flight injuries are of particular relevance because, unlike other in-flight medical events, injuries are potentially preventable should specific patterns and mechanisms be identified. Using a considerably larger sample

TABLE 2. Pediatric In-Flight Injuries and Other Medical Events

	All In-Flight Medical Events (N = 12 226)	In-Flight Injuries (N = 400)	Other Medical Events (N = 11 826)	*P*
Age [IQR], y	7 [3–13]	3 [1–8]	7 [3–14]	0.001
Lap infant, n (%)	2017 (16.5)	143 (35.75)	1874 (15.85)	0.001
Route, n (%)				0.24
International	9918 (81.1)	334 (83.5)	9584 (81)	
Domestic	2308 (18.9)	66 (16.5)	2242 (19)	
Flight distance [IQR], mi	3468 [2189–5321]	3549 [2033–5382]	3461 [2190–5321]	0.69
Flight duration [IQR], min	377.9 [253.2–585]	393.3 [231.2–602.4]	377.6 [253.2–585]	0.69
Aircraft type, n (%)				0.87
Wide-body	8736 (71.45)	288 (72)	8448 (71.44)	
Single aisle	3478 (28.45)	112 (28)	3366 (28.46)	
Volunteer provider, n (%)				
Crew	8987 (73.51)	279 (69.75)	8708 (73.63)	0.09
Heath care volunteer	3239 (26.49)	121 (30.25)	3188 (26.37)	
Physician	2275 (18.61)	81 (20.25)	2194 (18.55)	
Nurse	684 (5.59)	31 (7.75)	653 (5.52)	
Other	280 (2.29)	9 (2.25)	271 (2.29)	
Medicine kit used, n (%)	6925 (56.65)	196 (49)	6730 (56.91)	0.002
Equipment kit used, n (%)	466 (3.81)	55 (13.75)	411 (3.48)	0.001
Aircraft diversion, n (%)	115 (0.94)	7 (1.75)	110 (0.93)	0.16
Disposition, n (%)				
No additional care needed	8429 (68.94)	121 (20.25)	8308 (70.25)	<0.001
Additional care at the destination	2928 (23.95)	211 (52.75)	2717 (22.97)	
Refused additional care	343 (2.81)	25 (6.25)	318 (2.69)	
Death	11 (0.09)	0 (0)	11 (0.09)	
No data	515 (4.21)	43 (10.75)	472 (3.99)	

size, we encountered 400 (3.3%) cases of in-flight injuries among 12 226 pediatric in-flight medical events. A recent study estimated that approximately 44 000 in-flight medical events involving adults and children occur worldwide each year.[3] However, we believe this to be an underestimation, considering that we screened 114 222 such cases during a 5-year period for a projected annual occurrence of approximately 65 000 in-flight medical events cases worldwide. By extrapolating our data, we estimate that approximately 7000 pediatric in-flight medical events and nearly 250 pediatric in-flight injuries occur every year.

The finding that most in-flight injuries occurred during international flights or those covering distances greater than 3500 miles and with flight duration greater than 6.5 hours is not surprising because the longer a child passenger is onboard an aircraft, the greater the chance that an opportunity for injury will present itself. Lap infants were more than twice as likely to sustain an in-flight injury compared with other in-flight medical events. This could be the result of multiple factors, including seating position within the aircraft, challenges in controlling an unrestrained child during long flights, or the inability to hold on to an infant during sudden or heavy turbulence, to name a few.

In our study, a greater percentage of children who sustained in-flight injuries required additional medical care upon arrival at the destination (52.8%) compared with those who experienced other medical events (23%) that might have been more effectively treated while in flight. This newly reported finding differs from that of another large study on a predominantly adult sample, where 18.5% of in-flight trauma resulted in transport to a hospital, compared with 25.5% for all in-flight medical events.[3] Our finding could suggest that these pediatric in-flight injuries had a higher degree of complexity than other in-flight medical events or could simply represent a bias on the part of the airline or caregiver to recommend additional care after a pediatric injury due to fear of potential litigation. A greater percentage of in-flight injuries were cared for by a health care professional, compared with other in-flight medical events, although that difference was not statistically significant. It is impossible to know whether a health care professional was not traveling on those flights where a crew member solely provided first aid or one simply elected not to volunteer. However, we speculate that injuries, especially those involving the head or burns, lacerations, or serious contusions, would have prompted crew members or the GBMS center physician to recommend the engagement of an onboard volunteer medical professional so as to better evaluate and address the problem.

Our analysis of in-flight injury types and mechanisms relative to passenger age might aid in the development of injury preventive strategies. Considering that children younger than 2 years comprise approximately 1% of enplanements,[15] these lap infants seem to be particularly vulnerable because we found them to be involved in more than 35% of pediatric in-flight injuries. Education, regulation, and dissemination of high-quality information by consumer-oriented publications and medical organizations have resulted in increased safety of children being transported on land, and yet, many of these important safety mechanisms are completely abandoned once a child boards an aircraft. For instance, we have previously identified a group of healthy lap infants who died during long-haul flights while co-sleeping with an adult.[4] Co-sleeping is a well-known risk factor for sudden

TABLE 3. In-Flight Injury Type and Mechanism According to Age Category

	All Ages	Lap Infants	Older Children
Injury type			
All injuries	400/400 (100)	143/400 (35.75)	257/400 (64.25)
Burn	157/400 (39.25)	38/157 (24.2)	119/157 (75.8)
Contusion	118/400 (29.5)	58/118 (49.15)	60/118 (50.85)
Laceration	82/400 (20.5)	33/82 (40.24)	49/82 (59.76)
Closed head injury	32/400 (8)	11/32 (34.38)	21/32 (65.63)
Crush injury (digit)	4/400 (1)	1/4 (25)	3/4 (75)
Abrasion	3/400 (0.75)	1/3 (33.33)	2/3 (66.67)
Amputation (digit)	1/400 (0.25)	1/1 (100)	0/1 (0)
Other	3/400 (0.75)	0/3 (0)	3/3 (100)
Injury mechanism			
All mechanisms	400/400 (100)	143/400 (35.75)	257/400 (64.25)
Scalding burn	144/400 (36)	37/144 (26.69)	107/144 (74.31)
Fall	101/400 (25.25)	43/101 (41.58)	58/101 (58.42)
Before flight	31/400 (7.75)	2/31 (6.54)	29/31 (93.55)
Hit aircraft	25/400 (6.25)	11/25 (44)	14/25 (56)
Armrest	17/400 (4.25)	9/17 (52.94)	8/17 (47.06)
Bassinette	15/400 (3.75)	15/15 (100)	0/15 (0)
Object overhead	15/400 (3.75)	3/15 (20)	12/15 (80)
Sharp glass or metal	13/400 (3.25)	10/13 (76.92)	3/13 (23.08)
Service cart	4/400 (1)	1/4 (25)	3/4 (75)
Contact burn	4/400 (1)	0/4 (0)	4/4 (100)
Lavatory door	3/400 (0.75)	0/3 (0)	3/3 (100)
Tray table	3/400 (0.75)	2/3 (66.67)	1/3 (33.33)
Unknown/other	25/400 (6.25)	10/25 (40)	15/25 (60)

unexplained infant death.[16] In fact, the American Academy of Pediatrics (AAP) does not recommend any type of bed-sharing arrangement as safe, noting that this practice carries a risk of sudden unexplained infant death, suffocation, strangulation, or entrapment for the infant.[17] Although this issue is widely considered on land, little thought is given to the increased risk of co-sleeping with a lap infant during a long flight, particularly when the adult is fatigued or might have consumed alcohol.

Child safety seats and the use of restraints are other examples of discrepancy between what occurs on land and onboard an aircraft. The AAP strongly supports optimal safety for children and adolescents of all ages during all forms of travel,[18] including those involving an aircraft.[19,20] By law, in the Unites States, an infant must be secured to a properly positioned safety seat with a 5-point restraint to ride in an automobile at 50 mph but is free to ride unrestrained on the lap of an adult inside an aircraft moving at speeds greater than 500 mph on a tridimensional trajectory and subjected to unexpected turbulence. The AAP has recommended that regulations be enacted to ensure optimal protection to all pediatric patients, including those younger than 2 years, during all phases of commercial flights.[19,20] This would entail discontinuing the policy of allowing children younger than 2 years to be held on the lap of an adult during air travel, instituting the mandatory use of aircraft-approved child restraint systems, and enforcing the correct use of these restraints during taxiing, takeoff, landing, turbulence, and as much as feasible, all other phases of flight, as is already the case for other passengers. The AAP's position is echoed by other entities such as the Association of Flight Attendants and the National Transportation Safety Board, and both have called for regulation requiring the appropriate use of restraints by children during flight.[21,22] Detractors from that position[15] contend that a requirement for children to have a dedicated seat fitted with a child restraint system would invariably increase the cost of air travel and would have the unintended consequence of increasing mortality because the resultant higher cost of travel could cause families to divert to a less safe mode of transportation, namely, automobiles. We believe this to be a weak argument on many levels and akin to projecting that the higher cost of acquiring an automobile outfitted with airbags would inadvertently increase the risk of injury because families could shift to using cheaper and riskier vehicles (eg, motorcycles) as a mode of transportation. Furthermore, these assumptions were modeled using only estimates of pediatric deaths in survivable airline crashes, which are admittedly very rare. Considering the number of pediatric injuries caused by falls from the seat or collision against the aircraft interior in our sample, either spontaneously occurring or related to turbulence, we believe that the use of restraints could have, at least in part, prevented harm.

We also uncovered a previously unrecognized actionable factor associated with pediatric in-flight injuries: the child's seat location relative to the aisle. Scalding burns from mishandled hot liquids spilled onto a child are more likely to occur when the hot item is passed over a child seating on an aisle seat in an attempt to reach the intended adult recipient occupying an adjacent middle or window seat. Children occupying the aisle seat were also more likely to sustain injury from heavy objects falling from the overhead compartment or trauma to an extremity by having that appendage crushed between the arm rest or seat frame and the service cart or aisle passenger traffic. It should be noted that these in-flight injuries occurred more frequently on wide-body aircraft where the twin aisle configuration doubles the potential exposure to injuries attributed to this type of seat location. Alternatively, the

higher incidence of in-flight injuries involving wide-body aircraft could be related to the fact that these type of planes often carry a greater number of passengers for longer routes, thus possibly increasing the opportunity for an injury to occur, if simply a function of passenger count and flight time. The role of boredom experienced by restless children during a long flight must also not be overlooked. Placing children away from the aisle on a safer (and arguably more entertaining) window seat might help address many of these aforementioned issues.

Because thermal injury severity is a function of contact time and temperature,[23] another potentially useful injury prevention strategy would involve lowering the temperature of hot beverages served onboard. Coffee and tea are usually served at 160°F to 185°F (71°C to 85°C),[24] and at these temperatures, a full-thickness burn occurs almost instantaneously (<1-second exposure) once the spilled beverage contacts the human skin.[23] Lowering the beverage temperature to 140°F (60°C) would afford at least 5 seconds of contact before a serious thermal injury ensues,[23,25] which could have a major impact on decreasing the number and severity of these scald burns. This is a reasonable temperature target, considering that 140° F (60°C) was the mean preferred temperature for consumption of coffee in a study evaluating drinking preferences in a large cohort,[24] considerably lower than the industry standard. In addition, we submit that a passenger's expectation relative to the in-flight hot beverage experience is likely lower than that of customers purchasing beverages from a purveyor of fine tea and coffee on land.

Our study has several limitations, including its retrospective design and the possibility that not all in-flight medical events were called into the GBMS center. However, we believe that, although a crew member might elect not to contact the GBMS center for a minor in-flight medical event, we consider that to be less likely when a child sustains an injury during flight. Therefore, we are confident that our sample captured most in-flight injuries or at least those of consequence. Another limitation of our study is the lack of granularity regarding certain relevant details, such as the role of undisclosed preexisting medical conditions, comorbidities, or detailed descriptions of selected incidents beyond diagnostic and mechanistic categories. Nevertheless, we believe that these limitations are offset, at least in part, by our large sample size and a robust searchable data set created by experienced personnel.

In conclusion, pediatric in-flight injuries are relatively infrequent given the total passenger traffic, but not negligible. Unrestrained children, especially lap infants, are prone to injuries during flight. This is particularly true during hot meal service or turbulence, but not only then. The possible protection from using in-flight child restraints might extend beyond takeoff and landing operations or during turbulence. Children seating in aisle seats are exposed to the risk of injury from fallen objects, aisle traffic, and burns from mishandled hot meals and beverages. These findings could be useful for those crafting policies aiming to reduce risk exposure to pediatric travelers or at least inform the general public on simple steps that could make traveling with a child safer.

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