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Turbulence-related Injuries Pose Continued Risk To Passengers and Cabin Crew

Analysis of aircraft accident and incident data indicates that turbulence accounted for nearly twice as many serious injuries in nonfatal accidents as those resulting from emergency evacuations.

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Turbulence-related injuries are the most frequent serious injuries to flight attendants and passengers in scheduled U.S. Federal Aviation Regulations (FARs) Part 121 air carrier nonfatal accidents, according to a U.S. Federal Aviation Administration (FAA) study.

The study, conducted by the FAA's Office of Integrated Safety Analysis, Survivability Division, said that turbulence accounted for nearly twice as many serious injuries in nonfatal accidents as those resulting from emergency evacuation of the aircraft, the second most frequent cause of serious injury.

Additional analysis was conducted to determine whether the extent and nature of these turbulence-related injuries suggested actions that could be taken to reduce them.

U.S. National Transportation Safety Board (NTSB) and FAA accident reports were used as the basis of the analysis, which included accidents reporting an inflight fatality or serious injury as a result of weather, clear-air turbulence, wake turbulence, mechanically induced abrupt pitch-up/ pitch-down movement or collision-avoidance maneuvers.

The analysis was limited to accidents (involving fatalities, serious injuries or significant damage to aircraft) during the period 1982 through 1991 in which turbulence-related serious injuries or fatalities were reported by U.S. air carriers operating under Part 121 and Part 135 (Tables 1–8, pages 2–5). For those accidents, turbulence-related minor injuries were also identified. Turbulence-injury incidents (involving minor injuries or minor damage to aircraft) accounted for an additional 350 to 400 minor injuries during the period studied. Nevertheless, the incident data were not reliable enough to include in the analysis.

Analysis focused on Part 121 operations because serious turbulence- related injuries were reported on only one Part 135 commuter flight during the period studied. Injuries were categorized as flight attendant or passenger, phase of flight (climb, cruise or descent), aircraft type, year and month of occurrence, status of the seat belt sign and type of serious injury.

Fifty-five turbulence-injury accidents were reported during the period 1982–1991, ranging from a maximum of 10 in 1986 to three in 1989. One fatality and 79 serious injuries were reported, ranging from 14 serious injuries in 1986 to four serious injuries in 1983. Serious passenger injuries usually were not reported on aircraft smaller than the McDonnell Douglas DC-9, although four such accidents were reported in which flight attendants were seriously injured.

Part 121.317(f) requires that each passenger fasten his or her seat belt and keep it fastened while the seat belt sign is lighted. There is no regulatory guidance on flight attendant

requirements to be seated with belt fastened except for takeoff and landing.

Although passengers outnumbered flight attendants 20 to one on turbulence-accident flights, flight attendants sustained serious injuries nearly as often as passengers (Tables 5–7, page 4). The majority of these injuries occurred while flight attendants were conducting normal duties or were attempting to secure the cabin and passengers after the seat belt sign had been illuminated.

Fifty-five percent of all reported serious injuries occurred during the cruise phase of flight, and nearly 40 percent occurred during descent (including approach). Most serious injuries (60 percent) occurred after the seat belt sign had been illuminated in adequate time for passengers to comply. In all except one of these cases, passengers who were injured had failed to comply with the seat belt sign and verbal instructions by the crew.

The most common types of serious injuries for both flight attendants and passengers were fractures of the leg/ankle/foot and back/spinal injuries (Table 8, page 5). In some accidents, loose objects in the cabin, such as serving carts, caused serious injuries. Further study is recommended to determine the extent to which loose objects and interior cabin design contribute to serious injuries.

Turbulence-related injuries are preventable. Of the 5,501 passengers, 281 flight attendants and 132 flight crew members on board turbulence-injury flights, only one serious injury was documented in which the injured person was restrained by a seat belt. Passengers who disregard the seat belt sign and verbal crew instructions expose themselves and flight attendants to unnecessary risk.

Flight attendants are at the greatest risk of turbulence-related injuries because they often continue working after the seat belt sign is illuminated unless advised by the flight crew to discontinue cabin service. Even flight attendants so advised are frequently delayed in being seated because they are securing equipment and checking passenger seat belts.

The relative infrequency of turbulence-related injuries on Part 135 commuter flights merits further study. Although some reasons for this appear obvious — shorter flight segments, less room to move about and lower cabin ceilings — some knowledge gained from studying this type of operation might be applied to reduction of turbulence-related injuries in Part 121 operations.

While emerging technology enhancing the pilot's ability to predict and/or avoid turbulence may result in fewer turbulence-related accidents, steps can be taken now to reduce injuries at little or no financial cost to carriers.

These steps include increased flight attendant enforcement of seat belt sign compliance, increased flight crew and flight attendant awareness of turbulence risk to flight attendants, improved cockpit/cabin communications and promotion of increased passenger awareness of the need to use seat belts at all times except when movement about the cabin is necessary and permissible. A joint government/industry effort should be initiated to determine the most effective way of communicating this important message to airline passengers. ♦

TABLE 1 — Total Turbulence-related Injuries 1982–1991

U.S. Federal Aviation Regulations Part 135	Total	Phase of Flight		
		Climb	Cruise	Descent
Flights	1	0	1	0
Serious Injuries	**1**	**0**	**1**	**0**
• flight attendant	[1]	[0]	[1]	[0]
• passenger	[0]	[0]	[0]	[0]
Minor Injuries *	**0**	**0**	**0**	**0**
U.S. Federal Aviation Regulations Part 121	**Total**	**Phase of Flight**		
		Climb	**Cruise**	**Descent**
Flights	54	5	29	20
Fatal Injuries	**1**	**0**	**1**	**0**
Serious Injuries	**78**	**4**	**43**	**31**
• flight attendant	[37]	[2]	[22]	[13]
• passenger	[41]	[2]	[21]	[18]
Minor Injuries	**320**	**1**	**198**	**121**
• flight attendant	[70]	[0]	[38]	[32]
• passenger	[250]	[1]	[160]	[89]

* Minor injuries on flights in which no serious injury occurred are not included in this analysis.

Source: U.S. Federal Aviation Administration, U.S. National Transportation Safety Board

TABLE 2 — Turbulence-related Injuries by Aircraft Type 1982–1991

Aircraft Type	Number of Flights	Flight Attendant Injuries Serious/Minor	Passenger Injuries Serious/Minor	Total Injuries Serious/Minor
B-747	2	1 / 6	2 / 2	3 / 8
L-1011	2	1 / 3	7 / 59	8 / 62
DC-10	4	4 / 13	7 / 54	11 / 67
B-767	4	3 / 10	1 / 14	4 / 24
B-757	1	0 / 0	1 / 0	1 / 0
A-300	6	2 / 16	9 / 73	11 / 89
DC-8	3	2 / 3	1 / 3	3 / 6
B-727	11	7 / 12	7 / 6	14 / 18
B-737	12	11 / 5	2 / 14	13 / 19
DC-9	6	3 / 1	1 F*, 4 / 25	1 F*, 7 / 26
F-28	1	1 / 0	0 / 0	1 / 0
CV-580	1	1 / 0	0 / 0	1 / 0
DHC-7	1	1 / 1	0 / 0	1 / 1
SD3-30	1	1 / 0	0 / 0	1 / 0
TOTAL	**55**	**38 / 70**	**1 F*, 41 / 250**	**1 F*, 79 / 320**

TABLE 3 — Turbulence-related Injuries by Year of Occurrence 1982–1991

Year	Number of Flights	Flight Attendant Injuries Serious/Minor	Passenger Injuries Serious/Minor	Total Injuries Serious/Minor
1982	4	5 / 3	5 / 17	10 / 20
1983	4	2 / 2	2 / 6	4 / 8
1984	5	3 / 6	2 / 3	5 / 9
1985	5	4 / 5	4 / 19	8 / 24
1986	10	8 / 20	6 / 30	14 / 50
1987	8	5 / 9	5 / 68	10 / 77
1988	6	4 / 11	2 / 4	6 / 15
1989	3	1 / 2	8 / 21	9 / 23
1990	5	3 / 8	1 F*, 4 / 61	1 F*, 7 / 69
1991	5	3 / 4	3 / 21	6 / 25
TOTAL	**55**	**38 / 70**	**1 F*, 41 / 250**	**1 F*, 79 / 320**

TABLE 4 — Turbulence-related Injuries by Month of Occurrence 1982–1991

Month	Number of Flights	Flight Attendant Injuries Serious/Minor	Passenger Injuries Serious/Minor	Total Injuries Serious/Minor
January	5	2 / 12	4 / 38	6 / 50
February	0	0 / 0	0 / 0	0 / 0
March	5	4 / 10	2 / 3	6 / 13
April	4	2 / 2	3 / 2	5 / 4
May	8	6 / 2	4 / 29	10 / 31
June	5	3 / 5	9 / 21	12 / 26
July	7	5 / 11	10 / 48	15 / 59
August	4	3 / 6	1 / 3	4 / 9
September	3	2 / 2	1 / 43	3 / 45
October	3	2 / 3	1 F*, 2 / 23	1 F*, 4 / 26
November	5	4 / 9	3 / 27	7 / 36
December	6	5 / 8	2 / 13	7 / 21
TOTAL	**55**	**38 / 70**	**1 F*, 41 / 250**	**1 F*, 79 / 320**

*F = Fatality

Source: U.S. Federal Aviation Administration, U.S. National Transportation Safety Board

TABLE 5 — Turbulence-related Injuries — Seat Belt Sign Not Illuminated 1982–1991
(Unanticipated Turbulence)

U.S. Federal Aviation Regulations Part 121	Total	Phase of Flight		
		Climb	Cruise	Descent
Flights	13	1	9	3
Serious injuries	**17**	**1**	**13**	**3**
• flight attendant	[12]	[1]	[8]	[3]
• passenger	[5]	[0]	[5]	[0]
Minor injuries	**56**	**0**	**55**	**1**
• flight attendant	[23]	[0]	[23]	[0]
• passenger	[33]	[0]	[32]	[1]

TABLE 6 — Turbulence-related Injuries — Seat Belt Sign Illuminated With Insufficient Time to Restrain Occupants* 1982–1991

U.S. Federal Aviation Regulations Part 121	Total	Phase of Flight		
		Climb	Cruise	Descent
Flights	7	0	5	2
Serious injuries	**14**	**0**	**12**	**2**
• flight attendant	[6]	[0]	[5]	[1]
• passenger	[8]	[0]	[7]	[1]
Minor injuries	**24**	**0**	**24**	**0**
• flight attendant	[7]	[0]	[7]	[0]
• passenger	[17]	[0]	[17]	[0]

* Except in one case, turbulence occurred within seconds after the seat belt sign had been illuminated. One passenger was in the lavatory when the sign was illuminated approximately four minutes prior to encountering turbulence.

TABLE 7 — Turbulence-related Injuries — Seat Belt Sign Illuminated In Adequate Time to Restrain Occupants 1982–1991

U.S. Federal Aviation Regulations Part 135

One flight, one serious flight attendant injury; flight attendant was hit by a loose object in the galley.

U.S. Federal Aviation Regulations Part 121	Total	Phase of Flight		
		Climb	Cruise	Descent
Flights	34	4	15	15
Fatal injuries	**1**	**0**	**1**	**0**
Serious injuries	**47**	**4**	**18**	**25**
• flight attendant	[19]	[1]	[9]	[9]
• passenger	[28]	[3]	[9]	[16]
Minor injuries	**240**	**1**	**119**	**120**
• flight attendant	[40]	[0]	[8]	[32]
• passenger	[200]	[1]	[111]	[88]

- A DC-9 flight resulted in one fatality, two serious injuries and 23 minor injuries to passengers. The seat belt sign had been on since departure and passengers had been verbally briefed to remain seated, but flight attendants indicated the seat belt instruction had not been enforced. According to flight attendants, all injured passengers were either standing in the aisle, in lavatories or seated without belts on.
- In accidents in which the seat belt sign was on with sufficient time, all but one injured passenger failed to comply with the seat belt sign and verbal instruction by the crew. The injured passenger who was restrained stated that he was pulled back down into his seat by his seat belt after impacting the ceiling.

Source: U.S. Federal Aviation Administration, U.S. National Transportation Safety Board

TABLE 8

Types of Turbulence-related Serious Injuries 1982–1991

U.S. Air Carriers operating under Part 121 and Part 135*

Types of Injuries	Flight Attendant	Passenger
Head	**2**	**4**
Head injury	[2]	[4]
Neck	**1**	**3**
Neck injury	[1]	[1]
Fractured neck		[2]
Ribs	**2**	**1**
Broken ribs	[2]	[1]
Back/Spine	**15**	**11**
Back injury	[8]	[8]
Fractured vertebrae	[6]	[3]
Compressed spine	[1]	
Pelvis/Hip	**6**	**3**
Fractured pelvis	[4]	[2]
Broken hip	[2]	[1]
Shoulder/Arm/Wrist	**5**	**5**
Fractured wrist	[4]	[0]
Broken arm		[2]
Broken elbow		[2]
Dislocated shoulder	[1]	[1]
Leg/Ankle/Foot	**19**	**12**
Leg fracture	[5]	[5]
Broken ankle	[9]	[4]
Broken knee	[2]	[1]
Broken fibula	[1]	
Foot injury	[2]	[2]
Other		**4**
Unidentified broken bones		[1]
Heart palpitations		[1]
Coronary atherosclerosis		fatality [1]
Contusions/pregnancy complications		[1]
Injuries Not Identified	**0**	**8**

* Only one turbulence-related serious injury reported under U.S. Federal Aviation Regulations Part 135 operations.

Source: U.S. Federal Aviation Administration, U.S. National Transportation Safety Board

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