Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY REPORT

Aviation Research and Analysis Report - B2006/0171

Final

An Analysis of In-flight Passenger Injuries and Medical Conditions

1 January 1975 to 31 March 2006

Dr David G. Newman

MB, BS, DAvMed, PhD, MRAeS, FAICD, AFAIM

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An Analysis of In-flight Passenger Injuries and Medical Conditions: 1 January 1975 to 31 March 2006

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EXECUTIVE SUMMARY

Approximately 1.5 to 2 billion passengers fly on the world's civil aircraft each year. As the population ages, the number of air travellers increases and longer routes are flown by bigger aircraft, the number of medical events involving passengers is anticipated to increase.

The purpose of this study was to determine the prevalence, nature, type and extent of medical problems and injuries occurring in passengers on board civil registered aircraft. The aim, in particular, was to determine the most common in-flight medical problems in passengers, and what proportion of these events result in an aircraft diversion.

A search of the Australian Transport Safety Bureau's accident and incident database was conducted for medical conditions and injuries in passengers between 1 January 1975 and 31 March 2006. There were 284 passenger medical events and injuries (defined as 15 accidents, one serious incident and 268 incidents). These events accounted for only 0.18 of a percentage point of all the occurrences listed on the Australian Transport Safety Bureau's database. In-flight deaths accounted for only 3 per cent of the total passenger injury events.

The most common cause of in-flight death, at 44 per cent, was heart attack. Serious injuries accounted for slightly more than a third of reported occurrences. Minor injuries accounted for the majority of cases, at 53 per cent. The most common medical event in passengers was minor musculoskeletal injury (26 per cent of cases). Ninety-five flights were diverted (33 per cent). Of the known medical conditions, heart attack was the most common reason for an aircraft diversion (33 cases out of 95), followed by a fitting episode (in six cases).

The results of this study are consistent with other published international experience. There is a low risk of passengers sustaining either an injury or a medical event as a consequence of travel on a civil aircraft.

ABBREVIATIONS

ATSB	Australian Transport Safety Bureau
ICAO	International Civil Aviation Organization

1 INTRODUCTION

Approximately 1.5 to 2 billion passengers fly on the world's civil aircraft each year (see references 13, 14, 22). With an aging population, an increasing number of air travellers, and longer routes being flown by bigger aircraft, the number of medical events occurring in passengers on board aircraft is anticipated to increase (9, 14, 23).

Various estimates have been made of the likelihood of an on-board medical event occurring in a passenger. There is approximately one medical event for every 11,000 to 50,000 passengers, or about 30 such events per day on a global basis (6, 11, 13, 14, 37). On international flights, the incidence of passenger-related medical events is increasing (10, 11, 14, 16, 17).

In-flight medical events are a potentially significant problem. The airliner cabin at 35,000 feet is far from advanced medical care, space is restricted, the appropriate and necessary equipment for handling a given emergency may or may not be present, and qualified medical personnel are not generally available unless they are travelling on board as passengers. The cabin environment is also pressurised to an altitude in the range of 4,000 to 8,000 feet, which may pose its own difficulties for passengers with certain medical emergencies such as respiratory or cardiac arrest (22). Without treatment, a passenger suffering from a heart attack is unlikely to survive (28).

Diverting the aircraft from its planned route and making an unscheduled landing in order to get an ill passenger to definitive medical help is also a complex issue. It takes time for such a diversion to be made. It can take in the order of 30 minutes to land from typical cruising altitudes (24). Diversions are inconvenient for other passengers, and result in significant additional costs being incurred by the airline. A diversion can cost anywhere up to US$100,000, depending on the particular circumstances of the flight (14, 16). Fuel may need to be dumped (to avoid an overweight landing), additional accommodation costs for all affected passengers need to be met, and extra landing charges may be incurred. The delay in reaching the final destination may have significant flow-on effects on the rest of the airline's network and timetable, since the diverting aircraft with the on-board emergency may be unavailable for its planned onward journey. Since the diversion usually occurs in a stressful situation, in which a passenger's life may be compromised, there is always the risk that flight safety may be adversely affected.

Increasingly, on-board medical kits are becoming more sophisticated (4, 7, 9, 10, 15, 29-32, 34, 39). There is also a growing trend among the world's airlines to make use of 24-hour ground-based medical centres that are able to directly communicate with an aircraft wherever it might be in the world, with the added ability to transmit patient medical data to the ground for definitive diagnosis (12). Coupled with greater levels of crew training, it is hoped that this will not only improve the chances of a passenger surviving the emergency, but also reduce the requirement for a diversion.

The purpose of this study was to determine the prevalence, nature, type and extent of medical problems and injuries occurring in passengers on board civil registered aircraft. The aim, in particular, was to determine the most common in-flight medical problems in passengers, and what proportion of these events result in an aircraft diversion.

2 METHODOLOGY

2.1 Data sources

A comprehensive search of the accident and incident database held and managed by the Australian Transport Safety Bureau (ATSB) was conducted. The search period was 1 January 1975 to 31 March 2006. The database was searched for terms such as passenger injury, injury related to turbulence, medical condition, etc. The current ATSB database policy is that passenger injury or illness-related occurrences are only recorded in the database where the injury or illness occurs as the result of an aircraft-related safety deficiency. Occurrences reported to the ATSB include Australian civil registered aircraft operating both within and outside Australian territory or over international waters, and foreign registered aircraft operating within Australian territory.

The ATSB database records events according to occurrence type in accordance with the *Transport Safety Investigation Act 2003* (TSI Act 2003). The occurrence types searched were accidents, serious incidents and incidents. The ATSB definition of an accident is "an investigable matter involving a transport vehicle where: (a) a person dies or suffers serious injury as a result of an occurrence associated with the operation of the vehicle; or (b) the vehicle is destroyed or seriously damaged as a result of an occurrence associated with the operation of the vehicle; or (c) any property is destroyed or seriously damaged as a result of an occurrence associated with the operation of the vehicle."

A serious incident is an occurrence involving circumstances indicating that an accident nearly occurred. According to International Civil Aviation Organization (ICAO), the difference between an accident and a serious incident is essentially in terms of the end result. An incident is defined in the TSI Act 2003 as all other investigable and reportable matters where safety was potentially affected.

For the purposes of this study, serious injury was defined as an injury that required, or would usually require, admission to hospital within 7 days after the day when the injury was suffered. Minor injuries were defined as those not requiring hospital admission, treated by first aid or other simple measures, and did not significantly affect the health status of the individual[1].

2.2 Method of analysis

The data collected was then tabulated in a commercially-available spreadsheet program and analysed. For each event, the following parameters were recorded: occurrence date, occurrence type, aircraft manufacturer, aircraft type, nature of operations, pilot licence held, highest injury level sustained, type of medical condition, cause of incapacitation, and outcome of medical condition or incapacitation.

1 In accordance with ICAO Annex 13, *International Standards and Recommended Practices*, an injury resulting in death within 30 days of an accident is classified as a fatal injury (19).

Injuries resulting from an accident, where the aircraft was substantially damaged or destroyed, were specifically excluded from the database search. Those injuries were a direct result of the aircraft's impact with the ground. The subject matter for this investigation was passenger injuries sustained during routine or regular operations on board serviceable aircraft, which either complete the flight as originally planned or result in a diversion due to the state of the passenger's health. Injuries sustained during the process of boarding the aircraft prior to flight, or exiting the aircraft after flight, were included in the analysis.

Similarly, injuries to parachutists sustained either during boarding the aircraft or during egress from the aircraft were also included. If the parachutist sustained injury as a consequence of being on board the aircraft, then such an event was included, as they were effectively an aircraft passenger at the time of sustaining the injury. However, injuries sustained as part of the post-egress parachuting activity per se (ie parachute landing injuries, non-deployment of the parachute, etc) were not included. Injuries sustained by crew members of the aircraft (ie pilots or cabin crew) were also not included in the analysis.

3 RESULTS

The ATSB database, for the search period 1 January 1975 to 31 March 2006, declared an all-cause and all-classification total of 8,302 accidents, 95 serious incidents, and 151,941 incidents, giving an overall occurrence total for the study period of 160,338 events.

3.1 Passenger medical events by occurrence type

There were 284 occurrences in which passengers either sustained an injury or developed an in-flight medical condition during the study period. Of these 284 events, 15 were classed as accidents, one as a serious incident and 268 as incidents. These figures are shown in table 1.

Table 1: Passenger medical events by occurrence type

Occurrence type	Number
Accident	15
Serious incident	1
Incident	268
Total	***284***

3.2 Passenger medical events by operation type

Table 2 shows the type of air operations being conducted for each event. The vast majority of these events occurred in high capacity air transport/airline operations (75 per cent). However, passenger injuries were reported in most classes of air operations, ranging from airline operations to balloon flights.

Table 2: Passenger medical events by operation type

Operation type	Number	Percentage of total
Airlines	214	75.35%
Ballooning	13	4.58%
Charter	15	5.28%
Commuter	6	2.11%
Military[2]	1	0.35%
Other aerial work	12	4.23%
Private	19	6.69%
Sport aviation	4	1.41%
Total	***284***	***100%***

2 While the ATSB does not investigate military accidents or incidents where there was no civil aircraft or infrastructure involved, this particular incident involved a civil registered aircraft leased to and operated by the Australian Defence Force.

3.3 Passenger medical events by aircraft type

Table 3 shows the aircraft types involved in these events; the vast majority are in the large passenger commercial transport category. This is not surprising, given that these aircraft types are responsible for the bulk of passenger carrying, by design. Sixty-five different aircraft types from 29 different aircraft manufacturers were represented in the study period.

Table 3: Passenger medical events by aircraft type

Manufacturer	Aircraft type	Number
Aero Commander Div	500	1
Aero Commander Div	680	1
Aerospatiale	AS.350	1
Airbus	A310	1
Airbus	A320	9
Airbus	A330	1
American Aircraft Corp	AA-5B	1
Auster Aircraft Ltd	J5G	1
Beech Aircraft Corp[3]	1900	2
Beech Aircraft Corp	65-B80	1
Beech Aircraft Corp	95-B55	1
Beech Aircraft Corp	A56TC/A1	1
Beech Aircraft Corp	B200	1
Beech Aircraft Corp	V35	1
Bell Helicopter Co	206	1
Bell Helicopter Co	47G	1
Boeing Co	707	8
Boeing Co	747	63
Boeing Co	767	36
Boeing Co	717	2
Boeing Co	727	16
Boeing Co	737	18
British Aerospace Plc	BAe 146	8
Britten Norman Ltd	BN-2A	1
Cameron Balloons Ltd	A-140	1
Cameron Balloons Ltd	N-160	1
Cessna Aircraft Company	208	1
Cessna Aircraft Company	340	3
Cessna Aircraft Company	404	1
Cessna Aircraft Company	172	2

3 Beech Aircraft Company became a subsidiary of Raytheon Company in 1980. Hence, Beech Aircraft Corp may also be referred to as Raytheon.

Table 3: Continued

Manufacturer	Aircraft type	Number
Cessna Aircraft Company	182	2
Cessna Aircraft Company	210	6
Cessna Aircraft Company	310	2
Cessna Aircraft Company	402	4
Cessna Aircraft Company	206	2
CLASSIC	YMF	1
De Havilland Aircraft	DH-114	1
de Havilland Canada[4]	DHC-8	5
Douglas Aircraft Co Inc	DC3	1
Douglas Aircraft Co Inc	DC9	3
Embraer-Empresa Brasileira de Aeronautica	EMB-110	2
Embraer-Empresa Brasileira de Aeronautica	EMB-120	2
Fairchild Industries Inc	SA227	1
Fokker B.V.	F27	13
Fokker B.V.	F28	10
Kavanagh Balloons Pty Ltd	B-350	2
Kavanagh Balloons Pty Ltd	B-400	1
Kavanagh Balloons Pty Ltd	C-65	1
Kavanagh Balloons Pty Ltd	D-105	1
Kavanagh Balloons Pty Ltd	E-120	1
Kavanagh Balloons Pty Ltd	E-180	2
Kavanagh Balloons Pty Ltd	E-200	1
Kavanagh Balloons Pty Ltd	E-300	2
Lockheed Aircraft Corp	P2V	1
McDonnell Douglas Corporation	DC-10	5
Piper Aircraft Corp	PA-28	7
Piper Aircraft Corp	PA-31	5
Piper Aircraft Corp	PA-32	1
Robinson Helicopter Co	R22	1
Rockwell International	114	1
Saab Aircraft AB	SF-340	6
Short Bros Pty Ltd	SD360	1
Ted Smith Aerostar Corp.	600	1
Victa Ltd	AIRTOURER 115	2
Unknown	Unknown	1
Total		***284***

4 The de Havilland Canada DHC-8 or Dash 8 is a twin turbo-prop aircraft designed by de Havilland Canada in the 1980s. The Dash 8 aircraft type is now manufactured by Bombardier Aerospace who acquired the company from Boeing in 1992. Hence, the Dash 8 may be referred to as the de Havilland Canada Dash 8, the Boeing Dash 8 or the Bombardier Dash 8.

3.4 Highest injury outcome

Table 4 shows the breakdown of injuries and medical conditions sustained by the passengers in these 284 events. The majority of injuries were classified as minor. Fatal injuries accounted for only 3 per cent of the total passenger injury events. In 9 per cent of cases the nature of the passenger injuries was not specified. It is most likely that the majority of these non-specified injury events were of a minor nature, given the nature of the accident or incident involved, and that if a major injury or fatality had been recorded the event would have been the subject of a wider, more detailed investigation by the ATSB. However, notwithstanding this, minor injuries accounted for the majority of injuries and medical conditions sustained by the passengers, at 53 per cent. Serious injuries accounted for slightly more than a third of reported occurrences.

Table 4: Highest injury outcome

Injury level	Number	Percentage of total
Fatal	9	3%
Serious	100	35%
Minor	150	53%
Not specified	25	9%
Total	***284***	***100%***

3.5 Types of medical event or injury

Table 5 shows the nature of injuries and medical conditions sustained by the passengers, according to injury type. The most common injury type sustained by passengers was minor musculoskeletal injury (26 per cent of cases), which included injuries such as minor joint, skin or limb injury, direct blunt trauma of a relatively trivial nature, etc. In the majority of these cases, the injury was a result of turbulent weather, or a minor fall or slip. In some cases, the injury was a result of being struck by a cabin trolley (usually on the elbow, knee or foot). In one unusual example, a parachutist slipped while attempting to board the aircraft just as it began taxying. The aircraft subsequently ran over one of the parachutist's feet, resulting in a minor sprain.

In 55 events, the nature of the injuries or in-flight medical event were not directly specified, with the database describing the passenger as either sick or ill (categorised here as unspecified illness), or critically, severely or seriously ill (categorised here as unspecified serious illness). More detailed information on these cases was not available.

In 43 events (15 per cent), passengers sustained a heart attack during the flight. With the exception of four passengers, all survived. In a typical example, a passenger on a Boeing 747 bound for Singapore had a heart attack over the West Australian coast. A doctor on board attended the patient, and the aircraft was diverted to Perth, Western Australia.

There were four cases of burns, involving a total of five passengers (two of which were infants). All of these burns were due to hot fluids and drinks served as part of the in-flight meal service being spilt. One of these events was a result of an Airbus A320 encountering unexpected clear air turbulence, which led to hot fluid being spilt. One of the passengers sustained second degree burns to the arm, and an infant sustained minor burns to the face. A doctor on board the aircraft assisted the two injured passengers.

There were nine events in which passengers sustained fractures and/or joint dislocations. The bones affected were generally limbs, such as ankles, arms and legs. Falling or tripping were the most common reason for a fracture or dislocation. Three cases of fracture occurred as a result of a heavy landing in a balloon. There was one case of a fractured hip in an elderly passenger, sustained after a fall while attempting to board the aircraft. Two passengers on a Boeing 747 sustained ankle fractures after the aircraft encountered severe clear air turbulence.

There were 14 cases where passengers became drunk and/or violent, including several cases where a drunk passenger assaulted another passenger. In several cases, these passengers required restraining by the cabin crew. In one case, involving a Boeing 747 en route to Paris, two male passengers had a physical altercation, with one of them receiving minor injuries. The cabin crew were able to calm both individuals, and the aircraft continued on its planned flight.

Table 5: Types of medical event or injury

Condition	Number	Percentage of total
Anxiety/panic attack	2	0.70%
Bruising/lacerations	14	4.93%
Burns	4	1.41%
Drunk and/or violent	14	4.93%
Ear injury	1	0.35%
Eye injury	3	1.06%
Fitting episode	8	2.82%
Food poisoning	3	1.06%
Fractures/dislocations	9	3.17%
Fumes	1	0.35%
Head injury	29	10.21%
Heart attack	43	15.14%
Loss of consciousness	5	1.76%
Motion sickness	4	1.41%
Musculoskeletal injury	74	26.06%
Obstetric emergency	1	0.35%

Table 5: Continued

Condition	Number	Percentage of total
Pain	2	0.70%
Respiratory illness	9	3.17%
Stroke	2	0.70%
Suicide	1	0.35%
Unspecified serious illness	11	3.87%
Unspecified illness	44	15.49%
Total	***284***	***100%***

There was only one obstetric emergency, in which a heavily pregnant female passenger went into imminent labour onboard the flight 7 hours from the destination.

There were 29 cases of head injury. The most common reason for this was loose objects falling out of the overhead locker onto the seated passenger underneath (16 events, or 55 per cent of all head injury cases). The responsible items typically consisted of briefcases, bottles and laptop computers. The next most common head injury was due to the passenger being thrown up and out of their seat during a period of turbulence and colliding with the overhead locker (nine cases). In one such example, a Bombardier Dash 8 aircraft encountered severe turbulence on approach to land. One of the passengers attempted to tighten her seatbelt but inadvertently released it. As a result, the unrestrained passenger was thrown up and struck her head on the overhead cabin fittings. In another case, involving a Boeing 767 aircraft, an overhead light assembly panel fell onto the head of a passenger seated underneath as a result of excessive vibration. The passenger received only minor injuries.

There were nine events where passengers developed respiratory problems during the flight. These incidents ranged from acute asthma attacks, to respiratory arrest and hypoxia. Asphyxiation occurred in one case and resulted in the death of the passenger. This event involved a passenger choking on a small piece of steak which had been served as part of the in-flight meal. Although a doctor was on board the flight and attended to the patient, the passenger could not be revived.

3.6 Causes of passenger deaths

Table 6 lists the details of the nine in-flight deaths.

Table 6: Causes of passenger deaths

Fatality number	Aircraft type	Operation	Cause
1	Boeing 727	Airlines	Heart attack
2	Piper PA-28	Private	Heart attack
3	Douglas DC3	Airlines	Respiratory arrest
4	Boeing 747	Airlines	Heart attack
5	Boeing 747	Airlines	Asphyxiation
6	Cessna 402	Commuter	Heart attack
7	McDonnell Douglas DC-10	Airlines	Suicide
8	Bell 206	Private	Fall from aircraft
9	Cessna 208	Sport aviation	Head injury

Four out of the nine passenger fatalities were due to heart attack. This was the most common cause of in-flight death, at 44 per cent. There was a single case of suicide of a passenger on board the aircraft. The passenger apparently set fire to himself in one of the aircraft toilets. The passenger subsequently died from the extent of the burns. In a somewhat unusual case, the pilot of a Bell 206 helicopter heard a noise from the right-hand side of the rear passenger cabin. He then discovered that the passenger was no longer in the right rear seat where she had been seated, and that the door was open. He landed immediately, and the passenger's body was found about an hour later. The investigation found no mechanical deficiencies with the right rear door. This may well have been a second case of suicide, but the details are insufficient to make that conclusion with any degree of certainty. It is also possible that the fall was accidental. The single case of head injury was sustained by a parachutist on exiting from the aircraft. He hit the tailplane of the aircraft, lost consciousness and subsequently died from his injuries.

3.7 Flight outcome

Table 7 shows the outcome of the flight. In 28 cases, the outcome was not specified, but there was no indication of a diversion having being made. Of the remainder, 95 flights were diverted and 161 continued on to their planned destination.

Table 7: Flight outcome

Operation type	Number	Percentage of total
Diversion	95	33%
Continuation	161	57%
Not specified	28	10%
Total	***284***	***100%***

Table 8 shows the medical conditions that lead to a diversion. It is clear from this table that the more serious the on-board medical emergency, the greater the likelihood of an aircraft diversion. Heart attack was the most common reason for an aircraft diversion (33 cases out of 95). The next most common specified condition was fitting (in six cases).

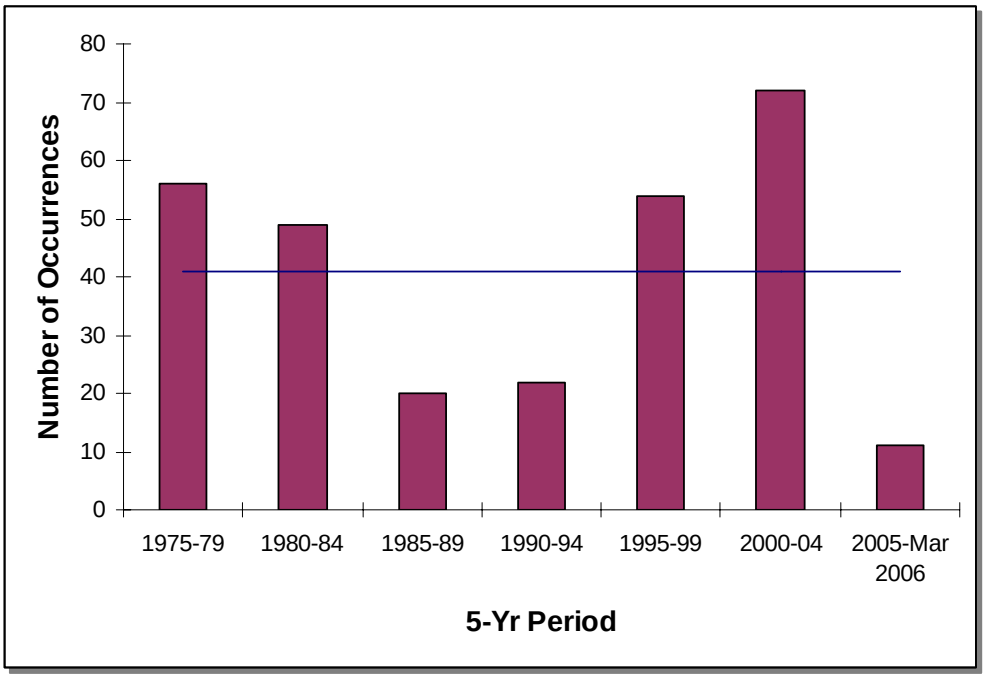
Table 8: Medical conditions leading to aircraft diversion

Condition	Number	Percentage of total
Drunk and/or violent	1	1%
Fall from aircraft	1	1%
Fitting episode	6	6%
Food poisoning	3	3%
Head injury	1	1%
Heart attack	33	35%
Loss of consciousness	2	2%
Motion sickness	1	1%
Obstetric emergency	1	1%
Pain	1	1%
Respiratory illness	4	4%
Stroke	2	2%
Unspecified serious illness	10	11%
Unspecified illness	29	31%
Total	***95***	***100%***

3.8 Passenger medical events by 5-year periods

Figure 1 shows the incidence of these occurrences in 5-year epochs across the study period. The largest number of reported occurrences in the study period was in the 2000 to 2004 period. The average number of medical and incapacitation events per 5-year epoch is 41 (shown on the graph). The 2005 to 31 March 2006 epoch represents an incomplete 5-year period.

Figure 1: Passenger medical events by 5-year periods



4 DISCUSSION

The results of this study show that there is a low risk of passengers sustaining either an injury or a medical event as a consequence of travel on a civil registered aircraft. The database search yielded only 284 cases out of a total occurrence number of 160,338 accidents, serious incidents and incidents (which is a rate of only 0.18 of a percentage point). The results also show that the majority of medical conditions and injuries are minor, with musculoskeletal injuries accounting for 26 per cent of occurrences. The rate of in-flight death during the study period was only 3 per cent of the total medical conditions or injuries sustained by passengers. In-flight death accounted for only 0.006 of a percentage point of all occurrences on the ATSB database for the study period. In general, these results indicate that flying in Australia is generally a safe form of transport for passengers. Despite the potentially difficult environment, the chances are good that an in-flight emergency will be well-handled and have a good outcome.

There have been several studies over the years that have examined the prevalence and nature of passenger medical conditions and injuries sustained in-flight (2-6, 8-11, 13-18, 20-29, 33-38). In general terms, the results of the present Australian study are consistent with international experience.

The majority of studies have shown that most in-flight passenger medical events and injuries are not serious (6, 9, 11, 14, 16-18, 37). This was also shown in the present study.

In a survey of 260 in-flight medical conditions at one major United States airport between October 1985 and March 1986, only 10 per cent of patients ended up in hospital. The majority of the cases seen were trivial, with 137 individuals requiring no more than first aid treatment. The authors of this study considered true emergencies to be rare (37).

In a Korean study, it was found that most events (27 per cent) involved passengers over 60 years of age (17). Approximately half of the in-flight medical events occurred on flights lasting more than 6 hours. The major medical problems seen were gastrointestinal (25 per cent), vascular (17 per cent), and trauma. Cardiac events accounted for only 8 per cent of the occurrences.

A British Airways study found that the most common potentially life-threatening medical condition was asthma, but that most of these events were minor and readily treated (11). Many of these cases resulted from passengers putting their medications in their checked-in luggage, which was therefore not available to them during flight. An important finding of this study was that 70 per cent of the in-flight medical emergencies were handled successfully by the cabin crew.

In another survey, involving the examination of 190 in-flight medical events, injuries related to minor trauma were the most common, at 25 per cent (6). In 84 per cent of cases, appropriately trained emergency medical technicians were able to adequately and effectively deal with the problem.

A French study examined medical assistance provided to commercial airline flights over an 11-year period (38). The results of this study showed that serious emergencies are rare, with cardiopulmonary resuscitation being required very rarely. The authors calculated an incidence rate of one emergency per 20,000 passengers. The most common problem was fainting and/or dizziness. There were

also two in-flight births. In terms of serious events, the two most common types were heart disease and neurological complaints (usually taking the form of fitting episodes). This is consistent with the results of the present study in Australian civil aviation, in which the two most common reasons for aircraft diversion were cardiac disease and fitting. In the French study, there were three cardiac arrests. None of these passengers survived. There were 11 trauma cases, but only one was severe, and this involved multiple passengers on an aircraft that encountered severe turbulence.

In an American report, United States airlines had 1,016 in-flight medical events between 1 August 1986 and 31 July 1987. The most common events were chest pain and fainting/collapse (18). In a study of paediatric consultations for an American airline in the period 1995 to 2002, there were 220 such events, at an approximate rate of one in every 21,000 flights (27). One-hundred and sixty-nine of these consultations were for in-flight medical problems, the most common of which were infectious disease (27 per cent) and neurological problems (15 per cent).

Another study found that the most common events requiring use of the on-board medical kit were fainting (29 per cent), chest pain, asthma and allergic reactions. In 80 per cent of cases the medical kit was found to be useful and in some cases life-saving (4).

Qantas published the results of their in-flight medical events involving international flights for the 1993 calendar year (10). This study found that out of a total of 454 significant medical events, fainting accounted for the majority of events (35 per cent), followed by cardiac emergencies (23 per cent), gastrointestinal problems, respiratory tract infections and asthma, and then anxiety and panic reactions.

It is therefore clear, that from an analysis of these studies the most common serious medical events occurring in passengers in-flight are cardiac (chest pain or heart attack), neurological (usually fainting, fitting or dizziness) and respiratory problems (7, 9, 13, 14). The results of the present study involving Australian civil aviation passengers are certainly consistent with this international experience.

Head injuries as a result of overhead locker involvement are not an uncommon event (11). Fifty-five per cent of the head injuries sustained in the present study were due to objects falling from overhead lockers. In other cases, passengers not wearing their seatbelts were thrown up into the overhead locker during periods of turbulence. For the most part, these injuries are preventable. The safety announcements made by the crew at various stages of the flight about wearing seatbelts when seated and taking care when opening the overhead lockers are designed to minimise the potential for these injuries to occur. Passengers need to act on these announcements if they are to be effective. However, the increasing volume of luggage being taken on board aircraft may also contribute to full overhead lockers, with an attendant increase in potential for injury.

Fortunately, in-flight deaths are rare, although they do occur (5, 7, 9, 17, 18, 20, 37). In-flight deaths have been shown to occur at a rate of between 0.3 and one per million passengers (20). A Korean study reported three in-flight deaths out of 201 medical emergencies between January 1995 and May 1999 (17). Two of these deaths were due to heart attack, and one to the terminal effects of cancer. The in-flight death rate (as a function of total medical emergencies) was 1.5 per cent. Another study found an in-flight death rate of 2.7 per cent of all in-flight medical events (37).

Cummins et al examined 577 in-flight deaths that occurred worldwide between 1977 and 1984 (5). The data was provided to the International Air Transport Association by approximately 120 of its member airlines. Most of the in-flight deaths were in middle-aged men, with 77 per cent apparently not suffering from any health problems prior to travel. The results showed an annual in-flight death rate of 72 deaths per year. The majority (56 per cent) of the in-flight deaths were due to heart disease, which is consistent with the findings of the present study, in which heart disease also accounted for the majority of in-flight deaths.

It is interesting to consider how frequently a medically-qualified passenger responds to a medical event on board an aircraft. It has been shown that a doctor is travelling on board an aircraft as a passenger in 85 per cent of cases (7). In a survey of doctors, 62 per cent reported that they had been called on at least once to assist a sick or injured passenger during a commercial aircraft flight (31). In several studies the rate of on-board doctor participation in in-flight medical events has been variously reported at anywhere from 8 per cent to 63 per cent of cases (5, 9, 11, 17, 18, 37, 38). Significantly, research has shown that there is generally good agreement (79 per cent) between the in-flight emergency diagnosis made by the attending doctor and the subsequent diagnosis made following the flight. In-flight diagnosis is therefore generally accurate, with any treatment given likely to be appropriate (8).

In this study, diversions happened at a rate of 33 per cent of all in-flight medical events reported to the ATSB. How does this compare with other published experience? The diversion rate has been reported by several authors at approximately one diversion per million passengers (17, 26). Other researchers have quoted a diversion rate of 1.5 diversions per billion revenue passenger miles flown (7), or one diversion for every 240,000 flights (27). These statistics are not directly comparable with the present study, as figures for denominators such as passengers flown, revenue passenger miles flown and total flights made were not available. Using total in-flight medical events as the denominator allows a comparison of the present study with others. The reports in the literature cite a diversion rate of anywhere from 4 per cent to 15 per cent for in-flight medical events (6, 13, 17, 18, 27, 36).

Most studies have shown that the most common reasons for a diversion are cardiac, neurologic, and respiratory problems (6, 7, 9, 11, 13, 14, 16-18, 37, 38). The present Australian study found that cardiac causes accounted for the majority (35 per cent) of diversions. This is consistent with most studies, in which the most common medical reason for a diversion is a cardiovascular event (7, 9, 17, 38). A Korean study reported a cardiac-related diversion rate of 36 per cent (17), while a French study also showed that cardiac causes account for most diversions, at 30 per cent (38). However, neurological causes have been shown to account for most diversions in other studies. In a paediatric study, in a population with an average age of almost seven years, the majority of diversions (47 per cent) were due to neurological reasons (27). Sirven et al found that in their sample population neurological events accounted for 34 per cent of diversions. Furthermore, they also estimated that the annual cost of diversions due to neurological events is approximately US$9 million (36).

Several authors have commented on the need for cabin crew to be adequately and appropriately trained in all aspects of first aid and emergency medical treatment, especially in terms of performing cardiopulmonary resuscitation (6, 11, 13, 26, 33). Such training may reduce the need for a costly diversion (26). First aid treatment given by cabin crew has been shown to be effective in most cases (11, 17). The modern on-board medical kit is becoming increasingly sophisticated, and the advent of automatic external defibrillators has increased the crew's ability to handle cardiac arrests (7-9, 10, 15, 29-32, 39). The use of telemedicine for in-flight medical support of commercial air operations is becoming more widespread (12).

Education may also help prevent these events. While not all on-board medical emergencies can be prevented, those that occur as a consequence of deterioration in a pre-existing medical condition can be. Knowledge of the physiological challenges involved in air travel, and the medical contraindications to flight, can help prevent a number of these events (1, 13, 30, 33). Adequate pre-flight medical screening of passengers with medical conditions is an important aspect of reducing the overall incidence of in-flight medical events (1, 17, 30).

5 CONCLUSIONS

The results of this study show that modern air travel is generally a safe environment for the vast majority of passengers. When an in-flight medical event does occur, it is most likely to not be serious. In the majority of these cases, minor musculoskeletal injury is the most likely condition. In most cases the cabin crew will be able to effectively deal with the problem. Serious events are rare, and most commonly these are due to cardiac, neurological and respiratory problems. Diversions occur in the minority of events, but when they do occur they are most likely to be due to cardiac or neurological emergencies. In-flight deaths are rare.

First aid training of cabin crew, sophisticated on-board medical kits and remote telemedicine links all help to reduce the need for diversion and improve the chances of a passenger surviving the medical emergency.

Passengers can also do their part to reduce the risks of injury. Wearing seat belts during all phases of flight, as instructed by the cabin crew, and taking particular care with opening overhead lockers can help to prevent or minimise the possibility of some of the more common injuries suffered on an aircraft. Furthermore, passengers with medication for pre-existing medical conditions need to ensure they have easy access to their medication, particularly as some sectors are now between 14 and 19 hours long.

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