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Evaluation of In-flight Medical Care Aboard Selected U.S. Air Carriers: 1996 to 1997

In-flight medical care, patient response in flight and postflight follow-up care for 1,132 in-flight medical incidents in the United States were studied to evaluate in-flight medical care delivery on U.S. airlines and to reevaluate the in-flight medical kit required on air transport aircraft. Cardiac events were the most common serious in-flight medical occurrences and accounted for the greatest percentage of aircraft diversions for medical reasons.

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Medical care in flight and the U.S. Federal Aviation Administration (FAA)-mandated in-flight medical kit (IMK) have been studied for many years. This study includes a detailed correlation between in-flight medical care, patient response in flight and postflight follow-up in an effort to evaluate in-flight medical care delivery on U.S. airlines and reevaluate the FAA-mandated IMK. A survey of five U.S. domestic air carriers that contracted with MedAire and operated under U.S. Federal Aviation Regulations (FARs) Part 121 from Oct. 1, 1996, to Sept. 30, 1997, showed 1,132 in-flight medical incidents. MedAire is a private medical service company that provides in-flight assistance to airlines during medical incidents. These airlines accounted for approximately 22 percent of scheduled U.S. domestic enplanements during the period.[1]

On March 3, 1981, the Public Citizen Health Research Group of the Aviation Consumer Action Project petitioned to amend the FARs to require the carriage of emergency medical equipment on commercial flights in addition to the FAA-required first aid kit. The petition urged that U.S. air carriers be required to have on-board emergency equipment and medication that would enable crewmembers and/or medically qualified passengers to respond to an in-flight emergency. On March 14, 1985, the FAA published Notice of Proposed Rulemaking No. 85-9 on emergency medical equipment and on Jan. 6, 1986, published a final rule requiring IMKs on commercial aircraft, although airlines have never been specifically mandated to provide medical attention to passengers.[2]

The FAA-mandated IMK has been the topic of study for many years.[3] A primary question of interest is whether additional items should be included by regulation in the FAA-required IMK. The current IMK, as mandated under Title 14 of the U.S. Code of Federal Regulations Part 67.121.309(d) and shown in Appendix A (page 17), has a limited number of items. Additional drugs, or drugs with different routes of administration, might be useful in specific incidents. Attitudes toward the IMK have varied widely and several recent studies have asserted that the FAA-mandated IMK is inadequate. Speizer, Rennie and Breton found that none of the 260 passengers arriving at the Los Angeles International Airport (Los Angeles, California) during a one-year period from 1985 to 1986, who developed medical complaints in flight, benefited from the equipment or drugs available, no deaths were prevented, and the absence of qualified personnel on board may have rendered any IMK useless.[4] In contrast, Cottrell et al. reported that 26 percent of 157 health care providers who used the IMK in flight thought that it was very useful, 55 percent felt that it was somewhat useful, and 18 percent felt that it was not of any benefit, and Cummins and Schubach suggested that though the IMK contained useful items, it was inadequate to deal with several problems that may occur in flight and suggested several medications be added to the IMK to improve it.[5,6] In addition, Rosenberg and Pak listed what they broadly classified as mechanical and logistical limitations that made IMKs inadequate for dealing with emergencies.[7] In their review, they made the observation that in-flight medical problems often require the administration of medications not found in the IMK, which frequently may be obtained from other passengers. Also, Prew went as far as to state that some medical experts believe that without special care, including drugs and an automated external defibrillator (AED), there is not much chance of long-term survival for an in-flight cardiac patient.[8] These studies and significant technical shifts in the last few years suggest that the contents of the IMK might be reevaluated and changes considered.

While there have been several studies that have evaluated in-flight medical care aboard commercial airlines, they generally did not include a detailed correlation between medical care and patient response in flight, and postflight follow-up.[9] This study attempts to compare patient response to in-flight medical treatment with follow-up information to evaluate in-flight medical treatment on domestic U.S. air carriers, and the appropriateness of flight diversions for medical reasons.

Data Show Medical Incidents Involving Air-ground Radio Patch

A survey was undertaken of in-flight medical care aboard domestic U.S. air carriers that contract with MedAire for in-flight medical support. Normally this assistance takes the form of a radio patch between the aircraft and a ground-based emergency-room physician who advises the in-flight medical provider on medical treatment decisions, and the aircrew on diversion decisions. Only those incidents that involved an air-to-ground radio patch with MedAire were included in the survey.

Internal data collection forms were used by MedAire staff to collect the data at the time of each in-flight event. After the event, a record was completed by the staff, based on their own experience and the advice of any medical personnel on board at the time of the incident. The staff then entered the information from each record into a database designed by the FAA Civil Aeromedical Institute (CAMI).

Information provided by MedAire included patient demographics, flight information, flight diversion status, details of the in-flight medical event, outcome and postflight discharge diagnosis (Appendix C, page 18). Most of the information supplied by MedAire was closed-formatted, allowing a specific list of responses; however, some information was open-ended, permitting a wide variation of the entered data. Six areas of primary interest included patient presentation, in-flight diagnosis, treatment, IMK items used, outcome and postflight discharge diagnosis. All open-ended items were later coded by the CAMI medical staff into fixed categories more suitable to data analysis, including patient demographics, flight information, diversion status, in-flight treatment category, CAMI diagnostic category, outcome category and postflight discharge diagnostic category (Appendix G, page 19). Patient demographics included age, gender and medical history. Flight information included the origin, destination and type of aircraft. Treatment data, provided in text format, were coded into several categories, including specific medications, patient monitoring and supportive therapy (Appendix F, page 19). Similarly, outcome data were coded to reflect what type of postflight medical treatment facility the patient was transferred to, or whether follow-up treatment was refused or canceled (Appendix H, page 19). Also, the discharge diagnostic category was coded using the postflight discharge diagnosis data (Appendix G, page 19). In addition, the patient's demographics, presenting symptoms, in-flight diagnosis, in-flight treatment, response to in-flight treatment, IMK items used, diversion status of the flight, outcome and postflight discharge diagnosis (when available) were all considered in coding the CAMI diagnostic category (Appendix E, page 18).

Data collection was unique in that it involved radio communication between an aircraft in flight with a physician on the ground. This environment often limits the ability of the ground-based physician to accurately assess and diagnose the airborne emergency situation. The patient can be interviewed and observed with the most rudimentary medical equipment, essentially a stethoscope and sphygmomanometer, an instrument to measure arterial blood pressure using an inflatable cuff and gauge. Additionally, only a limited choice of treatments are normally available in flight. Although items used from the IMK may be supplemented by medications obtained from other passengers, signs and symptoms are likely to be the only reliable information available. As a result, on-board medical conclusions are frequently tentative, and often an accurate diagnosis will not be possible. Consequently, both the in-flight diagnosis and treatment must be viewed with caution and accepted as the best possible conclusions and actions that could be made during an in-flight medical incident. However, the additional quality assurance provided by CAMI physician review allowed for accurate postflight categorization of cases, which reflected detailed postflight verification data, including patient outcome, and postflight discharge diagnosis.

Passenger's Condition Improved in 60 percent of In-flight Cases

Of the 1,125 cases that reported gender, 596 were females and 529 were males. The mean age of the 1,057 individuals for whom age was known was 49 years, and the range was 7 weeks to 106 years. Each case was assigned a category (Appendix E, page 18) based on the patient's presenting symptoms, in-flight diagnosis, in-flight treatment, response to in-flight treatment, IMK items used, the diversion status of the flight, outcome, postflight discharge diagnosis and medical history (Table 1). Although vasovagal cases occurred with the greatest frequency, the most common serious categories of in-flight medical events were cardiac (20 percent), neurological (12 percent) and respiratory (8 percent). (Vasovagal symptoms involve action of the vagus nerve on the blood vessels; vasovagal syncope [fainting], for example, is a loss of consciousness and postural tone caused by reduced blood flow to the brain.)

Table 1
Categories of In-flight Medical Incidents

Category	Frequency	Percent
Vasovagal	254	22.4
Cardiac	221	19.5
Neurological	134	11.8
Respiratory	92	8.1
Gastrointestinal	90	7.7
Trauma	60	5.3
Endocrine	53	4.7
Miscellaneous	52	4.6
Psychological	38	3.4
Vascular	35	3.1
Obstetrical/gynecological	33	2.9
Allergic reaction	27	2.4
Ear-nose-throat	20	1.8
Urological	18	1.6
Not reported	3	0.3
Unknown	2	0.2
Total	**1,132**	**100**

Note: Vasovagal symptoms involve action of the vagus nerve on the blood vessels; vasovagal syncope (fainting), for example, is a loss of consciousness and postural tone caused by reduced blood flow to the brain.

Source: U.S. Federal Aviation Administration

The medical condition of passengers improved in 60 percent of cases, remained the same in 12 percent of cases, worsened in 2 percent of cases, and was not reported by MedAire in 26 percent of cases, as indicated in Table 2.

Table 2
Overall Patient Response in Flight

Response	Frequency	Percent
Improved	675	60
Unchanged	136	12
Worsened	27	2
Not reported	294	26
Total	**1,132**	**100**

Source: U.S. Federal Aviation Administration

Of the 348 cases (Table 3) where physicians were on board and overall patient response was reported, patient condition improved 291 times (84 percent). By comparison, of the 491 cases where there was no physician on board and patient response was reported, patient condition improved 385 times (78 percent). A chi-square test performed on the data, which is summarized in Table 3, showed that the presence or absence of a physician on board was unrelated to the number of patients who improved in flight.[10]

Table 3
Patient Improvement Associated With Physician Presence

	Patient Improved		
Physician On Board	Yes	No	Total
Yes	291	57	**348**
No	385	106	**491**
Total	**676**	**163**	**839**

Source: U.S. Federal Aviation Administration

It is encouraging to note that in over half of the cases in this study, passenger condition improved, whereas passenger condition worsened in only a few cases. Although patient condition improved most of the time when there was a physician on board, it was not significantly different from when a physician was not present. It is also possible that the 26 percent of unreported cases were of a less serious nature, whereas the more serious cases were followed up and reported on. This would imply that more patients might have improved than are indicated by the data. These data suggest that even under the difficult conditions encountered in flight, diagnoses and treatment of passengers appear to be appropriate most of the time, whether or not a physician is aboard. These data are more encouraging than the 32 percent improvement rate reported by Cottrell et al.[11]

The study results showed that IMK use appeared to have an inverse relationship on patient response; that is, IMK use was associated with worsening patient condition. While these results appear to be illogical, they are not, because the data are not the result of a repeated-measures experiment. The patients in the three categories (worsened, unchanged and improved) were different; therefore, the severity of each case was a confounding variable. It is possible that those patients whose conditions improved had less severe medical conditions that improved without IMK use, while patients whose conditions worsened may have had more severe medical conditions that would have become worse with or without IMK use. It is also interesting to note that, while 60 percent of patients improved overall in flight, as shown in Table 2 (page 3), only 31 percent of patients improved when the IMK was used, as shown in Table 4. This is probably because the IMK was used for more serious cases and was not required for less severe cases. Stated differently, those cases that involved IMK use also involved the more seriously ill passengers who were less likely to improve in flight.

Table 4
Patient Response Associated with In-flight Medical Kit Use

Patient Response	IMK Used: Yes	IMK Used: No	Total
Improved	349	314	663
Unchanged	73	60	133
Worsened	22	5	27
Total	**444**	**379**	**823**

IMK = In-flight medical kit

Source: U.S. Federal Aviation Administration

While physicians identified themselves in flight approximately 40 percent of the time, they were the medical provider over half the time when the IMK was used. In other studies, the availability of physicians during in-flight medical events has been shown to vary widely, from about 8 percent to approximately 85 percent.[12] It is not clear, however, whether physicians were actually on board more often but simply did not identify themselves. For example, one study reported that at least one-half of physicians surveyed stated they were reluctant to respond, usually because the problem would be outside their field of practice, or because they believed they would be greatly hampered in conducting treatment on an aircraft.[13]

Study Tracked Passengers In Health Care System

Of the 179 patients transported to the hospital, 173 were admitted with an average stay of 2.8 days compared with the national average of 5.2 days for the same period, although the type of hospital floor or hospital service was known in only 10 cases, therefore, meaningful conclusions could not be drawn.[14] Of those 10 cases, three were admitted to the medical floor, two to the neurological service, two to the obstetrical/gynecological floor, and one to orthopedics.

Of the 173 patients admitted to the hospital, 40 were admitted to an intensive-care unit/critical-care unit (ICU/CCU) with an average length of stay of 3.1 days, while 30 patients were admitted to a telemetry unit for an average of 2.7 days, and five patients were sent to an intermediate-care unit staying an average of 2.2 days (Table 5).

Table 5
Distribution of Patients in Specialty Care Units

Specialty Care Unit	Number of Patients	Average Length of Stay (Days)
ICU/CCU	40	3.1
Telemetry	30	2.7
Intermediate	5	2.2
Total	**75**	**2.7**

ICU = Intensive-care unit
CCU = Critical-care unit

Source: U.S. Federal Aviation Administration

Of the 40 patients admitted to an ICU/CCU, 38 were admitted to a medical unit with an average length of stay of three days; one patient was admitted to a cardiac unit for a day, and another was admitted to a surgical unit for a day. Although only one patient was sent to a cardiac ICU, this does not imply that there was only one cardiac-intensive-care case. Many hospitals do not have separate cardiac ICUs or surgical ICUs; therefore, all serious cases go to a general medical CCU or ICU. When the categories of the 38 patients who were admitted to general ICUs/CCUs were checked, it was discovered that 27 of the patients were diagnosed as cardiac cases in flight. In addition, the one case admitted to the surgical ICU was also diagnosed as a cardiac patient. Consequently, 27 of the 40 patients who were admitted to CCUs were cardiac cases.

Five of the 173 patients admitted to the hospital were sent to intermediate-care units with an average length of stay of 2.2 days. Two patients were sent to a general-medical intermediate-care unit, one patient was sent to a cardiac unit, another to a surgical unit, and one patient was sent to an intermediate-care unit where the type of unit was not specified. The average length of stay for the two medical patients was 2.5 days, while the length of stay for the cardiac, surgical and unknown patients was four days, one day and one day, respectively. While this implies that only one cardiac patient was sent to an intermediate-care unit, many hospitals do not have separate cardiac-intermediate-care units and patients are simply sent to a medical-intermediate-care unit. When the categories of the two patients admitted to general-intermediate-care units were checked, it was discovered that one of them was a cardiac case while one was a neurological case; consequently, two of the five patients who were admitted to intermediate-care units were actually cardiac cases.

Data Show Most Diagnoses Agree During, After Flight

Postflight diagnostic categories were obtained from patients who were seen in the ER, airport clinic or hospital. Postflight diagnostic categories were known in 239 of 1,132 cases, or approximately 21 percent of the time. Those cases where in-flight diagnostic category and postflight discharge diagnostic category were known are compared in Table 6. Cases classified as "unknown" were not included in the comparison. In-flight diagnostic categories are shown as columns, while postflight diagnostic categories are shown as rows. The figure in parentheses next to each category indicates the number of cases in that category. All cases where in-flight diagnostic category agrees with postflight diagnostic category appear on the diagonal row in the table. In-flight and postflight diagnostic categories agreed in 188 of 239 cases (79 percent). Accepting postflight diagnoses as accurate, further comparisons are possible. For example, while 70 patients were assigned a cardiac diagnostic category in flight, only 62 were similarly classified on discharge from the hospital, with agreement in 57 cases. There are two ways that the in-flight category can disagree with the postflight category: (1) a cardiac category could be assigned in flight and a noncardiac category can be assigned postflight (i.e., overdiagnosis in flight), or (2) a noncardiac category could be assigned in flight where a cardiac category is assigned postflight (i.e., underdiagnosis in flight). Examination of the cardiac column (in-flight diagnostic category) in Table 6 reveals that 16 patients were assigned a cardiac diagnosis in flight, and were later assigned a noncardiac diagnosis at hospital discharge, implying that these patients might have been overdiagnosed as cardiac patients in flight. Looking at the cardiac row (postflight diagnostic category) in

Table 6
Comparison of In-flight and Postflight Diagnostic Categories

Postflight Diagnostic Category	In-flight Diagnostic Category: Cardiac (70)	Trauma (22)	Vasovagal (32)	Respiratory (20)	Miscellaneous (15)	Gastrointestinal (15)	Neurological (22)	Vascular (12)	Obstetrical/ gynecological (8)	Endocrine (8)	Ear-nose-throat (5)	Allergic reaction (4)	Psychological (3)	Urological (3)
Cardiac (62)	**57**	0	4	0	0	0	0	0	0	1	0	0	0	0
Trauma (22)	0	**22**	0	0	0	0	0	0	0	0	0	0	0	0
Vasovagal (29)	5	0	**22**	1	0	0	1	0	0	0	0	0	0	0
Respiratory (20)	0	0	1	**18**	1	0	0	0	0	0	0	0	0	0
Miscellaneous (22)	2	0	1	1	**12**	3	3	0	0	0	0	0	0	0
Gastrointestinal (14)	1	0	0	0	0	**11**	1	0	1	0	0	0	0	0
Neurological (10)	0	0	0	0	0	0	**9**	1	0	0	0	0	0	0
Vascular (23)	3	0	3	0	1	1	5	**9**	0	1	0	0	0	0
Obstretrical/ gynecological (8)	0	0	0	0	1	0	0	0	**7**	0	0	0	0	0
Endocrine (10)	0	0	1	0	0	0	2	1	0	**6**	0	0	0	0
Ear-nose-throat (5)	0	0	0	0	0	0	0	0	0	0	**5**	0	0	0
Allergic reaction (4)	0	0	0	0	0	0	0	0	0	0	0	**4**	0	0
Psychological (6)	2	0	0	0	0	0	1	0	0	0	0	0	**3**	0
Urological (4)	0	0	0	0	0	0	0	1	0	0	0	0	0	**3**

Note: Vasovagal symptoms involve action of the vagus nerve on the blood vessels; vasovagal syncope (fainting), for example, is a loss of consciousness and postural tone caused by reduced blood flow to the brain.

Source: U.S. Federal Aviation Administration

Table 6 (page 5) shows that five patients who were diagnosed as noncardiac cases in flight, were eventually classified as cardiac cases postflight, suggesting that these patients might have been underdiagnosed as cardiac patients in flight.

A comparison of in-flight diagnoses and postflight diagnoses for cardiac cases is shown in Table 7. A chi-square analysis of these data shows that there was general agreement between in-flight diagnostic categories and postflight discharge diagnostic categories ($\chi^2 = 154.6$, n = 1, p < .001).

Next, a post-hoc analysis was performed using a McNemar test on the data to determine if cardiac patients were overdiagnosed or underdiagnosed in flight. The results suggest that cardiac patients were neither underidentified nor overidentified in flight.[15]

Similarly, it can be demonstrated that non-neurological cases were overidentified as neurological cases in flight ($\chi^2 = 8.6$, n = 1, p < .003) while vascular incidents were underdiagnosed in flight and attributed to other causes ($\chi^2 = 5.9$, n = 1, p < .01). Of the 14 vascular cases, five were diagnosed in flight as neurological cases, three as cardiac, three as vasovagal, one as gastrointestinal, one as endocrine and one as miscellaneous. Of the 13 non-neurological cases that were diagnosed as neurological cases in flight, two were later determined to be endocrine, one was later diagnosed as gastrointestinal, one as psychological, five as vascular, one as vasovagal and three as miscellaneous.

An agreement rate of 92.2 percent was calculated for cardiac cases by summing the total cases where in-flight and postflight diagnoses agreed (57 cardiac plus 157 noncardiac) and dividing by the total number of cases (232). Agreement rates for the other categories are summarized in Table 8.

There was good overall agreement between in-flight diagnostic categories and postflight diagnostic categories. This agreement suggests that in-flight diagnoses were generally accurate, even under the difficult conditions encountered on board aircraft. However, the data suggest that non-neurological cases were overdiagnosed as neurological cases in flight, and vascular cases appeared to have been underdiagnosed and attributed to other causes in flight.

Table 7
Comparison of In-flight and Postflight Diagnoses for Cardiac Cases

	Postflight Discharge Category		
In-flight Category	**Cardiac**	**Noncardiac**	**Total**
Cardiac	57	13	70
Noncardiac	5	157	162
Total	**62**	**170**	**232**

Source: U.S. Federal Aviation Administration

Table 8
Comparison of In-flight and Hospital Diagnoses for All Categories

Category	Agreement Rate (%)
Cardiac	92.2
Trauma	100.0
Vasovagal	92.9
Respiratory	98.3
Miscellaneous	94.6
Gastrointestinal	97.1
Neurological	94.1
Vascular	92.9
Obstetrical/gynecological	99.2
Endocrine	97.5
Ear-nose-throat	100.0
Allergic reaction	100.0
Psychological	98.7
Urological	99.6

Note: Vasovagal symptoms involve action of the vagus nerve on the blood vessels; vasovagal syncope (fainting), for example, is a loss of consciousness and postural tone caused by reduced blood flow to the brain.

Source: U.S. Federal Aviation Administration

As was previously discussed, there was no independent means of determining the severity of cases. Unless patients can successfully be grouped by severity, it may not be possible to completely evaluate in-flight medical care delivery, or understand the role of IMK use, patient response, diversions or other important questions. At this point, it can only be said that in-flight medical care and IMK use have a significant relationship to patient response that appears to be confounded by the severity of the event.

In-flight diagnoses were in close agreement with hospital discharge diagnoses, and patients' conditions generally improved, implying that in-flight medical care delivery aboard U.S. domestic air carriers is generally well managed. However, there did not appear to be a significant difference between patient improvement and the presence or absence of a physician on board.

Medical Diversion Occurred for One Passenger in a Million

A diversion was defined as a flight that landed at an airport other than the scheduled destination because of an in-flight medical event involving a passenger. Of the 1,132 in-flight medical incidents, 145 (13 percent) resulted in an emergency diversion. This represents a diversion rate of about one passenger per 1 million enplanements.

Of the 449 cases where physicians were on board, 70 (16 percent) flights were diverted for medical reasons. In contrast, of the 683 cases where there was no physician on board, 75 (11 percent) flights were diverted. A chi-square test performed on the data, which is summarized in Table 9, shows that the presence of a physician was associated with an increase in the percentage of diversions ($\chi^2 = 4.75$, $p < 0.03$).

Table 10 summarizes flight diversions by category. There were no diversions reported for the "ear-nose-throat," "urological," "not reported," and "unknown" categories. Cardiac incidents had the greatest percentage of diversions (30 percent), followed by obstetrical-gynecological incidents (21.2 percent) and neurological incidents (19.4 percent).

Table 9
Flight Diversions and Physician Presence

Physician Onboard	Diversion: Yes	Diversion: No	Diversion: Total
Yes	70	379	**449**
No	75	608	**683**
Total	**145**	**987**	**1,132**

Source: U.S. Federal Aviation Administration

Table 11 (page 8) shows the relationship between the number of times the IMK was used and whether the flight was diverted. Unreported cases are not included in the table; therefore, the total of diversions and nondiversions is not equal to 1,132. The IMK was used in 82 of 127 cases (65 percent) when the flight diverted, and in 451 of 949 flights (48 percent) that did not divert. The data, therefore, indicate that there is a greater likelihood that the IMK was used when there was a diversion ($\chi^2 = 12.34$, n = 1, $p < .001$).

Physicians used the IMK most often during flights that were diverted (30 percent), followed by nurses and EMTs (Table 12, page 8). For this analysis, two paramedics were recategorized and included in the "other" category, resulting in a total of eight flight diversions for that category.

Diversions for medical reasons occurred for only one in 1 million passengers. The same rate has been found in earlier studies indicating that despite advances in medicine over the years, the introduction of the IMK in 1986, and the more recent incorporation of in-flight telemedicine, the diversion rate for medical reasons has remained small but constant.[16,17]

Although most occurrences on a "once-in-a-million" basis can generally be considered an acceptable risk, there are two reasons that medical diversions are important: (1) they are time-consuming and expensive events, and (2) many of them can be avoided. Diversions can affect the schedules of large numbers of passengers who require accommodation and possible financial compensation for their inconvenience. As

Table 10
Flight Diversion Frequency by Category

Category	Category Total	Category Percent	Diversions in Category	Category Diversion Rate (%)	Percent of All Diversions
Cardiac	221	19.5	66	30.0	45.5
Obstetrical/gynecological	33	2.9	7	21.2	4.8
Neurological	134	11.8	26	19.4	18.0
Vascular	35	3.1	5	14.3	3.4
Endocrine	53	4.7	6	11.3	4.1
Respiratory	92	8.1	9	9.8	6.2
Miscellaneous	52	4.6	5	9.6	3.4
Gastrointestinal	90	8.0	7	7.8	4.8
Psychological	38	3.4	2	5.3	1.4
Vasovagal	254	22.4	10	3.9	6.9
Allergic reaction	27	2.4	1	3.7	0.7
Trauma	60	5.3	1	1.7	0.7
Total	**1,089**	**96.2**[1]	**145**	**N/A**	**100.0**

[1] Total does not equal 100 percent because "not reported" and "unknown" categories are not included.

Note: Vasovagal symptoms involve action of the vagus nerve on the blood vessels; vasovagal syncope (fainting), for example, is a loss of consciousness and postural tone caused by reduced blood flow to the brain.

N/A = Not applicable

Source: U.S. Federal Aviation Administration

Table 11
Flight Diversions by In-flight Medical Kit Use

Diversion	IMK Used: Yes	No	Total
Yes	82	45	127
No	451	498	949
Total	**533**	**543**	**1,076**

IMK = In-flight medical kit

Source: U.S. Federal Aviation Administration

Table 12
Flight Diversions and Medical Kit Users

IMK User	Frequency of Diversions	Percent of Diversions
Physician	43	30
Nurse	28	19
Emergency medical technician	3	2
Other	8	6
None	45	31
Not reported	18	12
Total	145	100

IMK = In-flight medical kit

Source: U.S. Federal Aviation Administration

an example, diversions cost British Airways up to UK£500,000 (US$893,000) in 1996.[18] In addition, a series of time-consuming steps must be taken for any diversion to take place. Not only must arrangements be made to receive and transport the ill passenger on landing, but the available medical facilities at a potential alternate destination must be considered. It would be unwise to divert to another airport and determine too late that ground transportation is not available for the patient, or that the local medical facility cannot provide the care required for the patient's condition. Also, the pilot, along with flight dispatch, must determine a suitable landing airport, which may or may not be serviced by the company or be familiar to the flight crew. Landing weight is also a consideration, and valuable fuel may have to be jettisoned to attain a suitable landing weight for a premature touchdown.

Consequently, methods of avoiding flight diversions are constantly being sought. Three possibilities include: (1) the presence of an on-board physician, (2) passenger education and (3) IMK improvements. However, results showed that physicians were on board only 40 percent of the time and were associated with the highest diversion rate among in-flight medical care providers. Educating travelers about the nature of the aircraft cabin environment has been suggested, because many passengers believe that cabin pressure is the same as sea level and know very little about hypoxia, dehydration or the heightened effects of medication or alcohol at altitude.[19] Assertions that the IMKs were inadequate for dealing with in-flight emergencies,[20] passengers did not benefit from the equipment or drugs available,[21] and no deaths were prevented,[22] have led researchers to suggest several improvements.[23]

Approximately 28 of the 145 (19 percent) flight diversions in this study were probably unnecessary in light of subsequent follow-up information. In three of the 28 cases (two cardiac cases and one respiratory case), the passengers refused further medical advice; therefore, there was no postflight follow-up. The remaining 25 cases did not appear to be serious enough to have warranted a flight diversion for medical reasons, according to postflight treatment-facility discharge information. Of the 25 cases, nine were eventually diagnosed as vasovagal syncope, five as dehydration, four as gastroenteritis, two as viral infections, two as noncardiac chest pain, one as anxiety, one as false labor, and one as sickle-cell anemia. However, it must be emphasized that these determinations were arrived at after careful consideration of postflight treatment data that were not available during the flight. Earlier studies reported an even higher percentage of unnecessary diversions. In their study, Schoken and Lederer estimated that about half of the unscheduled landings could have been avoided, while Cummins and Schubach stated that all seven of the unscheduled landings in their study were probably unnecessary.[24,25]

It is interesting to note that those categories of in-flight medical events that occurred with the highest frequency did not necessarily account for the greatest number of flight diversions. As an example, while vasovagal incidents represented the greatest number of cases, the percentage of diversions for that category was low compared with other, more serious, categories. Other studies showed similar results. The three categories that accounted for the most diversions in this study were cardiac, neurological and vasovagal, while a 1970 American Airlines study (Schoken and Lederer) listed the three most common reasons as syncope, heart attack and dyspnea (difficult or labored breathing).[26]

In this study, there was a proportionately greater likelihood that the IMK was used when there was a flight diversion. Although this association is statistically significant, it is probably confounded by differences in severity between categories. This may be because the IMK is used more frequently in severe incidents, which are more likely to result in a diversion; whereas, minor incidents, which are less likely to cause the IMK to be used, are also less likely to result in a diversion.

The results imply that when the IMK is not used ("none" in Table 12), flight diversions occur less frequently. Again, this may be because when the IMK is not used, the incident may not be as serious, and a diversion will be less likely.

While EMTs experienced the lowest percentage of diversions among identifiable medical provider groups responsible for diversions (2 percent), physicians had the highest (30 percent). The higher proportion of diversions for physicians might have resulted for a number of reasons. Physicians would normally be expected to take charge during the most serious in-flight events that would ordinarily require a flight diversion. Also, when they did suggest that a flight should divert, their medical opinion may have weighed more heavily with the flight crew and the MedAire physician than when less highly trained health care professionals made the same suggestion under similar circumstances. Some of the groups were represented by such low frequencies, however, that small changes in the number of cases could have produced large changes in the percentage of diversions for that group, preventing meaningful analysis.

Nearly One-third of Passengers Refused Medical Advice

Many patients who experienced an in-flight medical event refused medical advice (RMA), as shown in Table 13. RMA implies that a need for treatment was indicated, but the patient refused further medical treatment following the flight. Of those patients who received medical treatment, most were treated at the airport, either in an airport clinic or by EMTs or paramedics. The next largest group of patients was seen in the emergency room (ER).

Of 1,119 passengers who experienced an in-flight medical event with a known outcome, 345 (31 percent) refused medical advice. This proportion is much greater than the proportion reported in the 1989 study by Cummins and Schubach, which found that only 1 percent of passengers with in-flight emergencies declined recommended advice.

In those cases where further medical assistance at a ground facility was canceled, it was not possible to determine if cancellations were made because the situation changed and the patient no longer required medical attention, or the patient refused further medical support. Of the 102 cancellations for further medical assistance shown in Table 13, 60 percent were made by the MedAire physician, 33 percent by the aircrew (usually the captain), 3 percent by the patient, and 4 percent of the time it was not known who canceled the response.

A cancellation implied that either the medical situation changed and treatment was no longer indicated, or the patient declined further medical treatment. Although it appears that few treatment cancellations were made by the patient, there is no way of determining how many cancellations may have originated with the patient and been relayed by the aircrew. Cancellations made by the aircrew or patient imply that a physician may not have been involved in the decision. Fortunately, the MedAire physician was responsible for the majority of cancellations, which is the best situation, as it reflects a decision made by a medical professional in possession of the best available information.

Study Considers Additions To In-flight Medical Kit

Frequency tables of usage rates for specific items or categories of items were used to determine potential additions to the IMK. Items that were frequently obtained from other passengers and used, but not available in the currently mandated IMK (Appendix B, page 17) were primary candidates for additions. The criteria for selection of potential additions to the IMK resulted from a review of the data, which suggested that additional items should be considered for inclusion in the IMK if: (1) the item was used in more than 2 percent of all cases, or (2) the item was used in more than 1 percent of all cases where one-third or more of those cases occurred in a single category. For example, diphenhydramine, an antihistamine medication used in treating allergic reactions, is available in injectable form in the IMK but may also be commonly obtained as Benadryl, an oral preparation, from another passenger. Oral Benadryl use was therefore compared to injectable diphenhydramine use to evaluate whether the oral form of the drug should be included in the IMK. Although an attempt was made to collect data on in-flight medical provider preferences, there were not enough responses from in-flight medical care providers to that item on the questionnaire to properly evaluate the question.

Unfortunately, this approach does not address items that are not included in the IMK and not routinely carried by passengers, but could have been useful if they had been available to the health care provider in flight. Such items could

Table 13
Patient Postflight Disposition

Patient Disposition	RMA	Airport	Emergency Room	Hospital	Canceled	Not Reported	Untransported Fatalities	Total
Number of patients	340	289	196	179	102	17	9	**1,132**
Percent of patients	30	26	17	15	9	2	1	**100**

RMA = Refused medical advice

Source: U.S. Federal Aviation Administration

not be defined in this study because of insufficient responses to the appropriate question on the questionnaire.

The CAMI study indicated that bronchodilator inhalers, oral antihistamines and non-narcotic analgesics were used frequently enough to suggest including them in the IMK to deal with several common in-flight medical events. While Cottrell et al. also concluded that a bronchodilator inhaler should be added to the IMK, Thibeault suggested the addition of a bronchodilator inhaler, an antihistamine and an analgesic, among other items.[27,28]

In addition, oxygen, supportive care and close patient monitoring were associated with an improvement in patient condition. Good medical practice should include oxygen therapy when a bronchodilator is used, especially given the mildly hypoxic cabin environment. For example, the oxygen saturation of a normal individual at a cabin altitude of approximately 8,000 feet is about 85 percent. While the majority of patients who received both bronchodilator and oxygen therapy improved, there were not enough cases that did not receive oxygen with bronchodilator therapy to analyze.

Other specific analyses included examining the quality of in-flight medical care delivery; patient response to in-flight medical care, including final outcome; and a comparison between in-flight diagnosis and treatment and hospital diagnosis and treatment.

The IMK was used in 533 of 1,132 in-flight medical incidents (47 percent), it was not used 543 times (48 percent), and its use status was not reported in 56 cases (5 percent).

Data provided by MedAire (Appendix C, page 17) indicates physicians were available approximately 40 percent of the time, nurses 25 percent of the time, and EMTs 4 percent of the time, as shown in Table 14. “Other” includes physician assistant, nurse practitioner, dentist and other individuals, who may not have been health care professionals. “None” implies that the IMK was not used.

Table 14
Medical Personnel on Board

Medical Personnel	Frequency	Percent
Physician	449	40
Nurse	278	25
None	249	22
Emergency medical technician	48	4
Other	47	4
Not reported	34	3
Paramedic	27	2
Total	**1,132**	**100**

Source: U.S. Federal Aviation Administration

Table 4 (page 4) shows that, in general, use of the IMK was associated with patient response ($\chi^2 = 8.74$, $p = 0.013$). While there was no significant difference in the number of patients who improved in flight as a result of IMK use, more patients’ conditions worsened with IMK use compared to those without IMK use ($Z = -0.096$, $p = 0.011$). This association may have been confounded by differences in the severity of the cases and, although statistically significant, may not be of clinical importance.

Table 15 shows how frequently each type of medical care provider used the IMK. Cases where the IMK user was not reported are not shown in the table. It is interesting to note that physicians did not appear to use the IMK proportionately more often than other groups of health care professionals.

Table 15
Medical Kit Users

IMK User	On Board	Used Kit	Percent of Time Used
Physician	449	275	61
Nurse	278	190	68
Emergency medical technician	48	28	58
Other	41	25	61
Paramedic	27	11	41
Physician assistant	4	2	50
Nurse practitioner	1	1	100
Dentist	1	1	100

IMK = In-flight medical kit

Source: U.S. Federal Aviation Administration

Table 16 (page 11) summarizes the items that met the researchers’ suggested criteria for inclusion of additional items in the IMK.

Oxygen, supportive care (i.e., orange juice, recline, cover with blanket, etc.), close patient monitoring and analgesics met the first criterion (greater than 2 percent of all cases) by wide margins. Nitroglycerin, other than from the IMK, met both criteria (greater than 2 percent of all cases and more than one-third of cases in a single category). A bronchodilator inhaler and an oral antihistamine met the second criterion (greater than 1 percent of all cases and more than one-third of cases in a single category).

After identifying items that might be considered for inclusion in the IMK, the influence of these items on patient response to in-flight medical care was investigated. In Table 17 (page 11), frequencies are shown above while percentages associated with changes in patient condition are shown below in parentheses. On average, a passenger’s condition improved approximately 84 percent of the time when these measures

Table 16
Summary of Response Frequencies for Potential Additions to the Medical Kit

IMK Item	Percent of Total Cases	Category	Category Frequency	Total Frequency
Oxygen	58.2	N/A	N/A	N/A
Supportive care	40.8	N/A	N/A	N/A
Monitor patient	36.1	N/A	N/A	N/A
Analgesic	4.1	N/A	N/A	N/A
Nitroglycerin (not from IMK)	3.4	Cardiac	35	38
Bronchodilator inhaler	1.6	Respiratory	14	18
Oral antihistamine	1.0	Allergic reaction	8	11

N/A = Not available IMK = In-flight medical kit

Source: U.S. Federal Aviation Administration

Table 17
Effect on Patient Response of Treatments/Potential Additions to the Medical Kit

IMK Item	Worse	Unchanged	Improved
Monitor patient	9 (3%)	21 (7%)	271 (90%)
Nitroglycerin (not from IMK)	1 (3.1%)	3 (9.4%)	28 (87.5%)
Bronchodilator Inhaler	1 (6.3%)	1 (6.3%)	14 (87.5%)
Oral antihistamine	0 (0%)	1 (12.5%)	7 (87.5%)
Supportive care	13 (3.6%)	51 (14.2%)	296 (82.2%)
Oxygen	25 (4.6%)	79 (14.5%)	442 (81%)
Analgesic	0 (0%)	8 (29.6%)	19 (70.4%)
Mean	**2.9**	**13.4**	**83.7**

IMK = In-flight medical kit

Source: U.S. Federal Aviation Administration

Table 18
Oxygen Use in Bronchodilator Therapy

	Bronchodilator Therapy Cases		
Oxygen Used	Worsened	Unchanged	Improved
Yes	1	1	12
No	—	—	2

Source: U.S. Federal Aviation Administration

were employed. Interestingly, close patient monitoring was associated with improvement about 90 percent of the time. Of those items that could be added to the IMK, a bronchodilator inhaler and an oral antihistamine appeared to have the greatest effect on positive patient response to treatment; however, analgesic therapy also showed good results.

Table 18 summarizes cases where bronchodilator therapy was used in flight, while reflecting whether oxygen was used and the passenger's response to the treatment.

The overwhelming majority of patients who received both bronchodilator and oxygen therapy improved; however, there were not enough cases that did not receive oxygen therapy in conjunction with bronchodilator therapy to allow a proper comparative analysis. In fact, the two cases improved that did not receive oxygen with a bronchodilator.

The data suggest that oxygen, supportive care and close patient monitoring were associated with an improvement in patient condition. The data also support the addition of a non-narcotic oral analgesic, a bronchodilator inhaler and an oral antihistamine to the IMK. These items have been recommended in other studies and are currently carried by several international air carriers. Unfortunately, due to the poor response to certain questions by on-board care givers, this survey could not address potential IMK items that are frequently needed for relatively common conditions, but are rarely available because they are not routinely carried by other passengers.

Since CAMI study data were collected from airlines that did not have cardiac AEDs on board, no recommendations are presented regarding the value of adding cardiac medications to the IMK that could be used to support the use of an on-board AED. The IMK should be reevaluated once AEDs become widely available on U.S. domestic air carriers to determine additions to the IMK that would be appropriate to support the use of AEDs.

Fewer In-flight Medical Incidents Involved Fatalities in This Study

A fatality was defined as a passenger death that occurred at any time in flight, during transport to a treatment facility or at a treatment facility. Fifteen of 1,132 cases were fatalities for a case fatality rate of 13.3 per 1,000 patients. A summary of the postflight diagnostic categories for fatalities (CAMI diagnostic categories) is shown in Table 19. The mean age for fatalities was 59.3 years and the range was 32 years to 80 years.

Nine of the 15 fatalities were not transported to a treatment facility and are tabulated separately in Table 13 (page 9) as "untransported fatalities." The remaining six fatalities were transported to treatment facilities but eventually died, and they are categorized according to the type of treatment facility involved.

In this study, two fatalities that were initially misclassified as "respiratory" cases (as shown in parentheses in Table 19) were later determined to be "cardiac" deaths when additional information became available from the hospital. In other cases, the status of the patient was unknown at the end of the flight; however, details were subsequently available from the admitting hospital or ER.

Officially, none of the 15 fatalities died on the aircraft. They were either pronounced dead at the gate or at the hospital. However, information on three of the patients suggests that they may have died on the aircraft (cases indicated with an asterisk

Table 19
Summary of Fatalities

Age	Sex	Presentation	Category	IMK User	Diversion	Outcome
61	F	Short of breath and vomiting.	Cardiac (Respiratory)	Nurse	No	Pronounced dead at hospital.
79	F	Passenger died according to the nurse on board. Pulseless, apneic [not breathing], pupils fixed and dilated.*	Cardiac	Nurse	No	Pronounced dead at gate.
75	M	Problems breathing and unconscious.	Cardiac	Physician	No	Pronounced dead at gate.
27	F	Not breathing. CPR was initiated. In cardiac arrest.	Cardiac	Not reported	Yes	Died at hospital.
65	M	Pale, not breathing, not moving, cold to the touch.*	Cardiac	Not reported	No	Pronounced dead at gate.
67	F	Unconscious, unresponsive, unable to find pulse.	Cardiac	None	Yes	Died at hospital.
71	M	Short of breath.	Cardiac (Respiratory)	None	No	Admitted to hospital; ICU for three days and telemetry for six days before dying.
71	M	Difficulty breathing.	Cardiac	None	No	Pronounced dead at gate.
68	M	Difficulty breathing. Respiratory arrest.	Cardiac	Nurse	No	Pronounced dead at gate.
70	F	Respiratory arrest.	Cardiac	None	No	Pronounced dead at gate.
80	M	Syncopal episode [fainted] in lavatory; vomited and unconscious.	Cardiac	None	No	Died at unreported time.
32	F	Abdominal pain.	Obstetrical/ gynecological	Other	No	Admitted to hospital where patient later died.
36	F	Unconscious and not breathing.	Drug overdose	Paramedic	Yes	Patient died at hospital.
48	M	Cardiac arrest.*	Cardiac	Physician	No	Patient was later pronounced dead.
40	M	Non-responsive.	Cancer	None	Yes	Transported to hospital where he later died.

Note: Asterisk (*) indicates cases where information suggests that patient may have died on the airplane.
CPR = Cardiopulmonary resuscitation ICU = Intensive-care unit IMK = In-flight medical kit

Source: U.S. Federal Aviation Administration

in Table 19, page 12). This implies that more passengers may die on board airplanes than are reported each year.

The fatality rate was 0.107 fatalities per million enplanements. This rate is about one-third of that found in similar studies. Of the 120 International Air Transport Association (IATA) member airlines, 42 airlines reported a total of 577 in-flight deaths between 1977 and 1984 averaging 0.31 fatalities per million enplanements.[29] A 1996 Qantas study reported a fatality rate of 0.38 per million enplanements.[30] The comparatively lower in-flight death rate in this CAMI study might be due to two factors: (1) the data were limited to U.S. domestic flights that might have been able to divert in less time than many of the IATA or Qantas flights, which were mostly international flights, and (2) all MedAire-contracting flights were managed by an air-to-ground radio patch with an ER physician, which should have resulted in an improved outcome.

The Air Transport Association of America (ATA) reported 42 in-flight deaths in 1996.[31] Adjusting for the size of the ATA sample, which represented approximately 90 percent of U.S. domestic enplanements for that year, yields an industrywide in-flight death rate of approximately 47 fatalities per year. Assuming the experience of the five MedAire-contracting companies in this study could reasonably be considered representative of the airline industry at large, and adjusting for sample size, an industrywide rate of approximately 75 in-flight fatalities per year is derived. The disparity in the number of deaths between the two studies is probably due to reporting differences. The ATA study only accounted for individuals who were pronounced dead on the aircraft or on the jetway while, in the current CAMI study, individuals who were pronounced dead in flight and postflight at the gate, in transit or at the hospital were included. In fact, only three cases would probably have been reported as fatalities in the current CAMI study if data collection had been limited to individuals who died on board the aircraft. The other 12 cases were determined from information collected during follow-up.

Only four cases of the 15 fatal cases were diverted, implying a flight diversion rate for fatalities of 27 percent. In a similar study, Cummins found a diversion rate for in-flight fatalities of only 14 percent, citing the unavailability of diversion locations on international flights as a possible explanation.[32] This unavailability could account for the difference in rates, as all flights in this study were U.S. domestic flights with many suitable diversion locations available. It may not be unusual that 11 cases of 15 fatal cases were not diverted. Although each patient was officially pronounced dead at the gate or at a later time, it appears that at least some may have actually died on board the aircraft, and a diversion might not have been indicated in these cases. In other cases, the destination may have been as close as any suitable diversion location, or the medical facilities at the destination may have been better than those available at a diversion city.

The most common cause of death in flight was cardiac (12 of 15 cases or 80 percent), followed by preexisting medical conditions (two of 15 cases or 13 percent). Cummins also found cardiac deaths to be the most common (56 percent), followed by deaths due to preexisting medical conditions (19 percent),[33] while a Qantas Airlines study listed myocardial infarction (heart attack) as the leading cause of in-flight death (11 of 25 cases or 44 percent), followed by cerebral vascular accident (stroke; two of 25 cases or 8 percent).[34]

Although the fatality rate included passengers who died after removal from the aircraft, cases were limited to domestic flights that were managed by air-to-ground communication with a physician, which could explain the lower fatality rate found in this study compared to earlier studies; however, the rate would have been even lower if only passengers who died on board were included. In addition, the diversion rate for fatalities is about double the rate for nonfatal events, probably because fatal cases were generally more serious and required a flight diversion more often than nonfatal cases.

Analysis of Follow-up Care Added Value to In-flight Data

The experience of airlines that contract with MedAire for support during in-flight medical emergencies may not be representative of the entire airline industry. First, many of the more serious incidents may be reported on the Medaire-contracting airlines simply because [the same reporting method is used consistently]. Second, the management of in-flight medical incidents may differ from the management of incidents on other airlines. For example, because knowledgeable emergency medical staff are involved, the number of flight diversions for medical reasons may decrease. Although conclusions about the value of specific medical equipment or supplies can be made about incidents managed under the auspices of MedAire, the application of those conclusions to the airline industry in general may not be appropriate. Essentially, any conclusions about the larger population of medical incidents are somewhat speculative.

While conclusions about the airline industry in general are speculative, this study contains valuable data because it represents a systematic attempt to follow patients from the air transport system into the health care system.

The frequency of in-flight medical incidents was low when compared with similar studies; however, the true rate may actually have been greater because cases not serious enough to warrant an air-to-ground radio patch were not included. Cardiac events were the most common serious in-flight medical incidents and accounted for the greatest percentage of aircraft diversions for medical reasons.

The six most common causes of in-flight medical events were vasovagal, cardiac, neurological, respiratory, gastrointestinal and trauma. Category frequencies in similar studies vary widely, as shown in Table 20 (page 14).

Table 20
Common Causes of In-flight Medical Incidents (Percent of Total Incidents)

	CAMI/ MedAire (N=1,132)	Donaldson and Pearn (1996) (N=454)	Cummins and Schubach (1989)[1] (N=1,107)	Davies and Degotardi (1982)[2] (N=45)	Speizer et al. (1989)[3] (N=260)	Cottrell et al. (1989) (N=362)	Harding and Mills (1993)[5] (N=2,139)
Vasovagal	22	35	4	10	6	29	20
Cardiac	20	16	20	29	20	16	3
Neurological	12	4	8	4	4	4	0[3]
Respiratory	8	6	8	2	9	10	5
Gastrointestinal	8	13	15	6	12	0[4]	12
Trauma	5	4	14	7	6	0[4]	0[4]

N = Number of cases studied CAMI = U.S. Federal Aviation Administration Civil Aeromedical Institute

Notes:

[1] In-flight cases only.

[2] Physician-reported incidents only.

[3] Includes only the 123 cases where emergency department diagnosis was given.

[4] Category was not listed among the six most common in this study.

[5] Data from April 1990 to March 1991 British Airways study.

Vasovagal symptoms involve action of the vagus nerve on the blood vessels; vasovagal syncope (fainting), for example, is a loss of consciousness and postural tone caused by reduced blood flow to the brain.

The following studies were compared:

Donaldson, E.; Pearn, J. "First Aid in the Air." *Australian New Zealand Journal of Surgery* Volume 66 (1996), 431–434.

Cummins, R.O.; Shubach, J.A. "Frequency and Types of Medical Emergencies Among Commercial Air Travelers." *JAMA* Volume 261(9) 1989, 1295–1299.

Davies, G.R.; Degotardi, P.R. "In-flight Medical Emergencies." *Aviation, Space and Environmental Medicine* Volume 53(7) 1982, 694–700.

Speizer, C.; Rennie, C.J.; Breton, H. "Prevalence of In-flight Medical Emergencies on Commercial Airlines." *Annals of Emergency Medicine* Volume 18 (1989), 26–29.

Cottrell, J.J.; Callaghan, J.T.; Kohn, G.M.; Hensler, E.C.; Rogers, R.M. "In-flight Medical Emergencies." *JAMA* Volume 262(12) 1989, 1653–1656.

Harding, R.M.; Mills, F.J. "Medical Emergencies in the Air." *Aviation Medicine.* London, England: BMJ Publishing Group, 1993, 7–24.

Source: U.S. Federal Aviation Administration

The five airlines in the study carried approximately 1.4 million passengers during that time; therefore, the in-flight medical incident rate was about eight per million enplanements. This rate is low compared with rates found in earlier studies. For example, a 1996 ATA survey yielded 17 incidents per million enplanements while a British Airways study found 31 incidents per million enplanements and a Qantas study reported 48 incidents per million enplanements.[35,36,37] Differences between this study and similar studies are probably due to the different methodologies employed. Only those incidents that involved an air-to-ground radio patch are included in the MedAire data. Minor in-flight medical incidents, which would have presumably been included in the other studies, would not have been included in this study because they would not have required an air-to-ground patch.

Differences in data-collection methods and classification schemes employed in the various studies make meaningful comparison between studies difficult. For example, some studies were limited to a single airline and included only cases where the IMK was opened and a medical record form, contained in the IMK, was completed.[38] Other studies limited data collection to passengers arriving at a single airport.[39,40] In addition, the categorization of in-flight events varied from one study to another. As an example, some studies clearly defined cases as "vasovagal syncope" while others were not as clear as to what was included in the classification of "syncope."[41,42]

If the influence of in-flight medical care delivery and IMK use is to be fully analyzed, it may be necessary to design a voluntary study to include a larger segment of the air transport industry. One method of facilitating data collection might be to include an event-reporting form in the IMK to be completed at the time of the incident. If this is not possible, mandatory reporting might be necessary; however, the researchers' experience is that voluntary cooperation is superior to mandatory reporting and yields better results.[43]♦

[Editorial note: This article has been edited for style and clarity from the original report "The Evaluation of In-flight Medical Care Aboard Selected U.S. Air Carriers: 1996 to 1997" by C.A. DeJohn, S.J.H. Véronneau, A.M. Wolbrink and J.G. Larcher of the U.S. Federal Aviation Administration (FAA) Civil Aeromedical Institute; D.W. Smith of the University of Oklahoma, U.S., and J. Garrett of Medaire. The report was published in April 2000 by the FAA Office of Aviation Medicine (OAM) as OAM Report No. DOT/FAA/AM-00/13.]

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Appendix A

Frequency of Use of Medical Kit Items for Five Air Carriers Over a 12-month Period

IMK Item	Frequency	Percent
Sphygmomanometer	522	46.1
Stethoscope	518	45.8
Nitroglycerin	45	4.0
Syringes and needles	17	1.5
Diphenhydramine	9	0.8
Epinephrine	8	0.7
Dextrose	4	0.4
Airways	0	0.0

Notes: A sphygmomanometer is an instrument used to measure arterial blood pressure using an inflatable cuff and gauge. Diphenhydramine hydrochloride is an antihistamine medication used, for example, in treating allergies and colds. Epinephrine is a neurohormone (also known as adrenaline) in the body and is used as a medication to treat health problems such as bronchial asthma, acute allergic disorders, glaucoma and heart block. Dextrose is one form of glucose, a blood sugar used by cells in the body for energy, and is used, for example, to treat a person's abnormally low blood-sugar level.

IMK = In-flight medical kit

Source: U.S. Federal Aviation Administration

Appendix B

Frequency of Use for Medical Items Not in Kits

IMK Item	Frequency	Percent
Oxygen	659	58.2
Supportive therapy	462	40.8
Monitor	409	36.1
Analgesic	46	4.1
Nitroglycerin	38	3.4
Bronchodilator inhaler	18	1.6
Oral antihistamine	11	1.0
Antiacid	9	0.8
Other	7	0.6
Anticoagulant	6	0.5
Narcotic analgesic	5	0.4
Benzodiazepines	4	0.4
Hyperglycemic	3	0.3
Hypoglycemic	3	0.3
Antiemetic	2	0.2
Diuretic	2	0.2
Antiarrhythmic	1	0.1
Topical antihistamine	1	0.1
Vasodilator, other	1	0.1

Notes: Benzodiazepines are medications used to relieve anxiety, helping a person to relax by reducing nerve activity in the brain. Hyperglycemic means abnormally high levels of sugar (glucose) in a person's blood. Hypoglycemic refers to abnormally low levels of blood sugar. Antiemetic medications are used to prevent, stop or control nausea and vomiting.

IMK = In-flight medical kit

Source: U.S. Federal Aviation Administration

Appendix C

Information Provided by MedAire

Radio patch number

Date of event

Aircraft type

Origin

Destination

Company station (whether the diversion airport had facilities operated by the airline)

Age of patient

Gender of patient

Presentation (signs and symptoms)

In-flight diagnosis

Medical history

Medication history

In-flight treatment

Medical personnel on board

In-flight medical kit (IMK) use (whether the IMK was used)

IMK user

IMK items used

Respirations

Pulse

Blood pressure

Items that could have been used but were not available in the IMK

Recommendations for IMK changes

Overall patient response in flight

continued on page 18

Appendix C

Information Provided by MedAire

Category of medical response waiting at gate (i.e., advanced cardiac life support, basic life support, etc.)

Patient response to medical care at gate

Outcome

Narrative

Discharge diagnosis

Diversion (whether the flight diverted and diversion airport)

Diversion status (whether the diversion was coordinated by MedAire)

Appendix D

Data Coded by U.S. Federal Aviation Administration Civil Aeromedical Institute

Gender

Patient presentation

In-flight diagnosis

In-flight diagnostic category

Treatment

In-flight medical kit (IMK) usage

IMK tems used

Diversion

Outcome

Discharge diagnostic category

Agreement between in-flight diagnostic category and discharge diagnostic category

Appendix E

U.S. Federal Aviation Administration Civil Aeromedical Institute Diagnostic Code Categories

Allergic reaction

Cardiac

Endocrine

Ear-nose-throat

Gastrointestinal

Neurological

Obstetrical/gynecological

Psychological

Respiratory

Trauma

Urological

Vascular

Vasovagal

Miscellaneous

Unknown

Appendix F

Treatment Code Categories

Analgesic
Antiacid
Antiarrhythmic
Anticoagulant
Antiemetic
Benzodiazepine
Bronchodilator inhaler
Diuretic
Hyperglycemic
Hypoglycemic
Monitor
Narcotic analgesic
Oral antihistamine
Oxygen
Supportive therapy
Topical antihistamine
Vasodilator
Other
Not reported

Appendix G

Discharge Diagnostic Code Categories

Allergic reaction
Cardiac
Endocrine
Ear-nose-throat
Gastrointestinal
Miscellaneous
Neurological
Not applicable
Not reported
Obstetrical/gynecological
Psychological
Respiratory
Trauma
Unknown
Urological
Vascular
Vasovagal

Appendix H

Outcome Code Categories

Admitted to hospital
Days in hospital
Admitted to intensive/critical-care unit
Days in intensive/critical-care unit
Type of intensive-care unit
Days in intermediate-care unit
Type of intermediate-care unit
Admitted to floor/service
Days on floor/service
Floor service admitted to
Admitted to telemetry unit
Days in telemetry unit
Treated and released in airport clinic
Treated and released from emergency room
Medical response canceled
Who canceled medical response
Refused medical advice
Fatality
Where pronounced
Miscellaneous
Not reported

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