IS THERE A DOCTOR ON BOARD?: MEDICAL EMERGENCIES ON COMMERCIAL FLIGHTS

Theodore Macnow, MD
In-Flight Medical Emergencies

- 50% of physicians have responded to a medical emergency on an airplane
- 10% have responded to more than one
- As pediatric emergency physicians, we are uniquely capable to respond
Itinerary

1. Epidemiology
2. Pathophysiology of Commercial Flight
3. Equipment and Interventions
4. Common Midair Emergencies
5. Anticipatory Guidance

ETA: 8:55 a.m.
Epidemiology
In-Flight Medical Emergencies

- More than 2 billion passengers board commercial airplanes each year.
- 1 / 40,000 passengers has a medical emergency.
- Number of emergencies is increasing:
  - Population is aging
  - Airplanes are larger
  - Flights are longer
Epidemiology

- Incidence is unknown because there is no centralized reporting system

- Minor in-flight emergencies may not be called in for ground-based support
Incidence

- 5% of travelers have a chronic illness
  - Represent 2/3 of medical emergencies

- Vasovagal syncope most common problem for healthy passengers

- 7-13% of medical emergencies result in aircraft diversion

- ~3% of events are fatal
Flight Crew Reports for British Airways, 1999
N=910
MedLink Registry-1999

N=12,000

- Vasovagal Episodes
- Cardiac Events
- Gastrointestinal problems
- Neurologic Symptoms
- Respiratory Difficulties
- Psychiatric
- Endocrine

Garrett JS. Air Medical Journal 2000
# Pediatric Emergencies on a US-Based Commercial Airline

Brian R. Moore, MD,* † Jennifer M. Ping, BA,‡ † David W. Claypool, MD†

<table>
<thead>
<tr>
<th>Emergency</th>
<th>In-flight Consultations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infectious</td>
<td>45 (27)</td>
</tr>
<tr>
<td>Neurological</td>
<td>25 (15)</td>
</tr>
<tr>
<td>Respiratory tract</td>
<td>22 (13)</td>
</tr>
<tr>
<td>Gastrointestinal tract</td>
<td>17 (10)</td>
</tr>
<tr>
<td>Allergy</td>
<td>15 (9)</td>
</tr>
<tr>
<td>Psychiatric</td>
<td>8 (5)</td>
</tr>
<tr>
<td>Trauma</td>
<td>9 (5)</td>
</tr>
<tr>
<td>Obstetric/gynecologic</td>
<td>3 (2)</td>
</tr>
<tr>
<td>Syncope</td>
<td>3 (2)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>3 (2)</td>
</tr>
<tr>
<td>Other</td>
<td>19 (11)</td>
</tr>
<tr>
<td>Total</td>
<td>169</td>
</tr>
</tbody>
</table>

Pediatric Emergency Care 2005
Pathophysiology of Commercial Air Travel
Hypobaric hypoxia

- Partial pressure of oxygen decreases exponentially with altitude
  - Cruising altitude 30,000-40,000 feet
  - Cabin pressure maintained as though at 5,000-8,000 feet
Hypobaric hypoxia

- $P_{A\text{O}_2} = (F_{i\text{O}_2} \times (P_{atmos} - P_{H2O})) - (P_{a\text{CO}_2} / \text{RQ})$

- $P_{a\text{O}_2}$ decreases from 100 to 50-60 mmHg
Hypobaric hypoxia

Barometric pressure decreases exponentially with altitude.

At sea level, $PO_2 = 160$ mmHg.
At 2400m $PO_2 = 120$ mmHg.

Hypobaric hypoxia

Barometric pressure decreases exponentially with altitude.
At sea level, $PO_2 = 160$ mmHg.
At 2400m $PO_2 = 120$ mmHg.

Gas Expansion

- **Boyle’s Law:** $p_1V_1 = p_2V_2$
  - Volume of gases in flight can increase 30%
- HEENT $\rightarrow$ barotalgia, barodentalgia, barosinusitis
- Lungs $\rightarrow$ PTX
- CV $\rightarrow$ decompression sickness
- GI $\rightarrow$ wound dehiscence, bowel perforation, hemorrhage
- Medical equipment $\rightarrow$ air embolism, rupture, compartment syndrome, or local trauma
Air Quality

- Infection
  - Transmitted through close proximity, not air recirculation
  - Most common influenza and parainfluenza

- Low Humidity
  - COPD or asthma exacerbations
  - Epistaxis
  - Thick mucous → tracheostomy plugging
  - Insensible fluid loss
“Economy Class Syndrome”

- Prolonged sitting → stasis → DVT → PE
- Drink, walk, wear compression stockings
Travel Considerations

 Physical and mental stress → MI, psychiatric emergencies

 Disrupted circadian rhythms → decrease seizure threshold

 Medication noncompliance from forgetfulness, time changes, flight delays, checked drugs

 Decreased access to food → hypoglycemia
In-Flight Environment

- Turbulence $\rightarrow$ motion sickness or traumatic injury
- Falling luggage
- Food allergies and poisoning
Equipment and Interventions
History of Equipment and Regulations

- 1986 - Emergency medical kits (EMKs) required on large aircraft
- 1994 - Protective gloves mandated
- 2001 - AED and enhanced medical kit
FAA-Compliant First Aid Kit
Emergency Medical Kit
## FAA Regulated EMK-Equipment

<table>
<thead>
<tr>
<th>Type of Equipment</th>
<th>Contents and Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diagnostic</strong></td>
<td>1 Sphygmomanometer&lt;br&gt;1 Stethoscope</td>
</tr>
<tr>
<td><strong>Airway management</strong></td>
<td>Oropharyngeal airways: 1 pediatric, 1 small adult, 1 large adult&lt;br&gt;  1 Self-inflating manual resuscitation device&lt;br&gt; Cardiopulmonary resuscitation masks: 1 pediatric, 1 small adult, 1 large adult</td>
</tr>
<tr>
<td><strong>Intravenous administration set</strong></td>
<td>1 tubing set with 2 Y connectors&lt;br&gt;2 Alcohol sponges&lt;br&gt;1 Roll of 1-inch adhesive tape&lt;br&gt;1 Pair of tape scissors&lt;br&gt;1 Tourniquet&lt;br&gt;1 500 cc bag saline solution</td>
</tr>
<tr>
<td><strong>Medication administration</strong></td>
<td>Needles: 2-18 gauge, 2-20 gauge, 2-22 gauge, or other sizes necessary to administer medications&lt;br&gt;Syringes: 1-5 cc, 2-10 cc, or sizes necessary to administer medications</td>
</tr>
<tr>
<td><strong>Protective equipment</strong></td>
<td>Nonpermeable gloves: 1 pair</td>
</tr>
</tbody>
</table>

Adapted from Federal Aviation Regulation 14 CFR 121.803, Appendix A (Public Domain).
## FAA Regulated EMK--Drugs

<table>
<thead>
<tr>
<th>Category</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analgesics</td>
<td>Nonnarcotic analgesic tablets, 325 mg: 4</td>
</tr>
<tr>
<td></td>
<td>Aspirin tablets, 325 mg: 4</td>
</tr>
<tr>
<td>Antihistamines and bronchospasm</td>
<td>Antihistamine tablets, 25 mg: 4</td>
</tr>
<tr>
<td></td>
<td>Antihistamine injectable, 50 mg (single dose): 2 ampoules</td>
</tr>
<tr>
<td></td>
<td>Metered dose bronchodilator inhaler: 1</td>
</tr>
<tr>
<td>Resuscitation</td>
<td>Atropine, 0.5 mg, 5 cc (single dose): 2</td>
</tr>
<tr>
<td></td>
<td>Dextrose, 50%/50 cc injectable, (single dose): 1</td>
</tr>
<tr>
<td></td>
<td>Epinephrine 1:1000, 1 cc, injectable (single dose): 2</td>
</tr>
<tr>
<td></td>
<td>Epinephrine 1:10,000, 2 cc, injectable (single dose): 2</td>
</tr>
<tr>
<td></td>
<td>Lidocaine, 5 cc, 20 mg/ml, injectable (single dose): 2</td>
</tr>
<tr>
<td>Heart disease</td>
<td>Nitroglycerin tablets, 0.4 mg: 10</td>
</tr>
</tbody>
</table>

Adapted from Federal Aviation Regulation 14 CFR 121.803, Appendix A (Public Domain).
AsMA ATM Committee Recommend EMK

<table>
<thead>
<tr>
<th>Medications</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epinephrine 1:1000</td>
<td>Stethoscope</td>
</tr>
<tr>
<td>Antihistaminic, inj.*</td>
<td>Sphygmomanometer (electronic preferred)</td>
</tr>
<tr>
<td>Dextrose 50%, inj. 50 ml (or equivalent)</td>
<td>Airways, oropharyngeal (appropriate range of sizes)</td>
</tr>
<tr>
<td>Nitroglycerin tablets or spray</td>
<td>Syringes (appropriate range of sizes)</td>
</tr>
<tr>
<td>Major analgesic, inj. or oral</td>
<td>Needles (appropriate range of sizes)</td>
</tr>
<tr>
<td>Sedative anticonvulsant, inj.</td>
<td>IV Catheters (appropriate range of sizes)</td>
</tr>
<tr>
<td>Antiemetic, inj.</td>
<td>Antiseptic wipes</td>
</tr>
<tr>
<td>Bronchial dilator inhaler</td>
<td>Gloves (disposable)</td>
</tr>
<tr>
<td>Atropine, inj.</td>
<td>Sharps disposal box</td>
</tr>
<tr>
<td>Adrenocortical steroid, inj.</td>
<td>Urinary catheter</td>
</tr>
<tr>
<td>Diuretic, inj.</td>
<td>System for delivering intravenous fluid</td>
</tr>
<tr>
<td>Medication for postpartum bleeding</td>
<td>Venous tourniquet</td>
</tr>
<tr>
<td>Sodium chloride 0.9% (minimum 250 ml)</td>
<td>Sponge gauze</td>
</tr>
<tr>
<td>Acetyl Salicylic Acid for oral use</td>
<td>Tape adhesive</td>
</tr>
<tr>
<td>Oral beta blocker</td>
<td>Surgical mask</td>
</tr>
<tr>
<td>List of medications—generic name, plus trade name if indicated on the item</td>
<td>Flashlight and batteries (operator may decide to have one per aircraft in an easily accessible location)</td>
</tr>
<tr>
<td></td>
<td>Thermometer (non-mercury)</td>
</tr>
<tr>
<td></td>
<td>Emergency tracheal catheter (or large gauge intravenous cannula)</td>
</tr>
<tr>
<td></td>
<td>Umbilical cord clamp</td>
</tr>
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<td></td>
<td>Basic Life Support cards</td>
</tr>
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<td>Bag-valve mask</td>
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<td></td>
<td>List of equipment</td>
</tr>
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<td></td>
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If a cardiac monitor (with or without defibrillator) is available, add to the above list:
Epinephrine 1:10000 (can be a dilution of epinephrine 1:1000)

* Injectable.
### Table 1. Emergency Medical Kit

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- Epinephrine 1:10000 (can be a dilution of epinephrine 1:1000)

* Injectable.
Additional resources often not available

- **Drugs**
  - Narcotics
  - Naloxone
  - Insulin
  - Antibiotics
  - ACLS drugs

- **Equipment**
  - Glucometer
  - Intubation equipment
Limitations of EMK

- Multiple doses are not always available
- Kits not always maintained
- Contents vary among airlines and countries
Pediatric Limitations of EMK

- Liquid or suppository medications not available
- High concentration of IV medications
- Infant sized masks and airways not usually available
- Beta agonist delivery
- Small gauge IVs
Other Resources Available

- Other passengers and flight crew
- Oxygen
  - Available by facemask at 2-4 L/min
- AED
  - Can be used as monitor
• Retrospective review of AED use on American Airlines 1997-1999

• Used in 200 instances, 191 in midair

• Shock advised and given in 15 patients
  – First shock successfully defibrillated V fib in 100%
  – V fib recurred in eight patients and again was successfully converted in all but one
  – 40% survived to hospital discharge with full neurologic and functional recovery

• No contraindicated shocks delivered
MedLink

- Ground-based physician support
- Maintains a list of intermediate airports and medical capabilities
- Serves 88 airlines
- Multilingual
Divert from Planned Flight Path?

- May request diversion, expedited landing, or emergency personnel to meet on arrival
- Under ideal conditions, it takes 20 minutes to land the aircraft
- Flying at a lower altitude may improve oxygenation
- $15,000-$890,000 to divert a plane
Common Emergencies
Approaching a Midair Patient

• Identify yourself and level of training
• ABCs, CPR, AED
• Request EMK and oxygen if needed
• Find space
• Obtain medical history and physical exam
• Get help from the ground-based consultation and other passengers
• Consider diversion or altitude reduction
• Document

Adapted from: Peterson DC et al. NEJM. 2013
Unresponsive

- ABCs
- AED
- O2
- Fluid
- Dextrose
- ±Naloxone
Cardiac Arrest

- ABCs
- AED
- CPR
- ACLS
  - Epinephrine
  - Atropine
  - Lidocaine
Group Cases

- Discuss
  - Where do I want to position myself and the patient?
  - What do I have available onboard?
  - What interventions can I perform?
  - What are my decision points for diversion?
Group Cases

1. 53 yo M with history of stable angina and GERD p/w worsening L sided chest pain and diaphoresis

2. 3 yo F with history of RAD p/w tachypnea, retractions, likely asthma exacerbation with URI

3. 62 yo disheveled M travelling alone p/w midair agitation screaming “we’re all going to die!”, nervously eyeing exit door and frightening other passengers

4. 31 yo G3P2 at 35 weeks gestation p/w ROM and contractions q3 minutes
Chest Pain

- ABCs
- Oxygen
- Cardiac monitor or AED
- MONA-B
- Lower altitude
- Antacid trial
Respiratory

- ABCs
- Oxygen
- Lower altitude
- Bronchodilators
- Steroids
- Epinephrine
- Bag valve masks
Psychiatric

- Panic attacks, anxiety, phobias
- Ask other passengers for medications, offer PO anxiolysis
- May have IM benzodiazepine available
- Question intoxication
- Physical restraint
  - 4-5 people
  - Constant reassessment
Obstetric

- Gather supplies
  - Towels
  - Blankets
  - Suture material or ties
  - Bulb suction

- EMK
  - Pitocin?
  - Umbilical clamps?
  - No neonatal resuscitation equipment
Pneumothorax
Anticipatory Guidance
Discharge instructions

• Provide guidance around scheduling medications

• Recommend extra carry-on medications

• Avoid flying after recent surgeries, recent casting, and scuba diving
Can I be Sued?

- Aviation Medical Assistance Act of 1998
  - Protects volunteer physician from malpractice if:
    - Is medically qualified
    - Acts voluntarily for no monetary compensation
    - Acts in good faith and does not engage in gross negligence or willful misconduct

- No physician has ever been successfully sued in US for rendering medical care
Can I be Sued?

- International laws differ among countries
  - U.S., Canada, and UK have similar Good Samaritan laws
  - Much of the European Union, Australia, and New Zealand obligate the physician to respond
Advice for the Doctor on Board

- Carry your license or other ID that identifies you as an MD
- Avoid alcohol, anxiolytics, and sleep aids
- Elicit help and medications from others
- Act to the best of your ability within your training
How do we do?

- When asked, health care worker responded to 75% of emergencies.
- High correlation of in-flight and hospital diagnosis.
- 60% of cases improved with help from health care provider.
Summary

- Medical emergencies on airplanes are increasing
- Physiologic changes of flight are generally well tolerated - except in those with predisposing conditions
- Most in-flight emergencies are not serious and are handled adequately by flight crew
- Equipment and drugs on board can be extensive, but are variable
- If you do the best you can within your training you are protected under the law
Happy Passover
Seizure

- Keep passenger safe from objects
- Oxygen
- Benzodiazepine if available
- ±Antipyretic
Allergy

- ABCs
- Oxygen
- PO/IV Diphenhydramine
- IM/SC Epinephrine
- IV Steroids
- IVF
<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>CONTRAINDICATION</th>
<th>SOURCE OF FURTHER INFORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Low probability of surviving</td>
<td>ASMA&lt;sup&gt;19&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Any contagious disease</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unstabilized behavioral problem</td>
<td></td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>Myocardial infarction within previous 3 wk</td>
<td>Cummins,&lt;sup&gt;17&lt;/sup&gt; AMA,&lt;sup&gt;18&lt;/sup&gt; ASMA,&lt;sup&gt;19&lt;/sup&gt; Alexander,&lt;sup&gt;22&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Unstable angina</td>
<td>Harding and Mills,&lt;sup&gt;24&lt;/sup&gt; Blumen et al.,&lt;sup&gt;26&lt;/sup&gt; Bettes and McKenas&lt;sup&gt;27&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Coronary-artery bypass graft within previous 2 wk</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decompensated heart failure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Uncontrolled arrhythmias</td>
<td></td>
</tr>
<tr>
<td>Pulmonary</td>
<td>Contagious pulmonary infection</td>
<td>AMA,&lt;sup&gt;18&lt;/sup&gt; ASMA,&lt;sup&gt;19&lt;/sup&gt; Gong,&lt;sup&gt;20&lt;/sup&gt; Lien and Turner,&lt;sup&gt;21&lt;/sup&gt; Harding and Mills,&lt;sup&gt;24&lt;/sup&gt; Blumen et al.,&lt;sup&gt;26&lt;/sup&gt; Bettes and McKenas,&lt;sup&gt;27&lt;/sup&gt; Cheatham and Safcask&lt;sup&gt;48&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Base-line partial pressure of arterial oxygen &lt; 70 mm Hg at sea level without supplemental oxygen</td>
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<tr>
<td></td>
<td>Exacerbation of obstructive or restrictive lung disease</td>
<td></td>
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<tr>
<td></td>
<td>Large pleural effusion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pneumothorax within previous 3 wk</td>
<td></td>
</tr>
<tr>
<td>Neurologic</td>
<td>Cerebrovascular accident within previous 2 wk</td>
<td>AMA,&lt;sup&gt;18&lt;/sup&gt; ASMA,&lt;sup&gt;19&lt;/sup&gt; Blumen et al.,&lt;sup&gt;26&lt;/sup&gt; Bettes and McKenas&lt;sup&gt;27&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Uncontrolled seizures</td>
<td></td>
</tr>
<tr>
<td>Surgical</td>
<td>Gastrointestinal, thoracic, otorhinolaryngologic, or neurologic surgery within previous 2 wk</td>
<td>AMA,&lt;sup&gt;18&lt;/sup&gt; ASMA,&lt;sup&gt;19&lt;/sup&gt; Blumen et al.,&lt;sup&gt;26&lt;/sup&gt; Bettes and McKenas&lt;sup&gt;27&lt;/sup&gt; Cheatham and Safcask&lt;sup&gt;48&lt;/sup&gt;</td>
</tr>
<tr>
<td>Pregnancy-related</td>
<td>≥ 35 weeks’ gestation</td>
<td>AMA,&lt;sup&gt;18&lt;/sup&gt; ASMA,&lt;sup&gt;19&lt;/sup&gt; Barry and Bia&lt;sup&gt;49&lt;/sup&gt;</td>
</tr>
<tr>
<td>Pediatric</td>
<td>First week after birth</td>
<td>AMA,&lt;sup&gt;18&lt;/sup&gt; ASMA&lt;sup&gt;19&lt;/sup&gt;</td>
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<tr>
<td>Other</td>
<td>Severe anemia (hemoglobin level, &lt; 8.5 g/dl)</td>
<td>AMA,&lt;sup&gt;18&lt;/sup&gt; ASMA,&lt;sup&gt;19&lt;/sup&gt; Gong,&lt;sup&gt;20&lt;/sup&gt; Lien and Turner,&lt;sup&gt;21&lt;/sup&gt; Alexander,&lt;sup&gt;22&lt;/sup&gt; Rosenberg and Pak,&lt;sup&gt;23&lt;/sup&gt; Divers Alert Network&lt;sup&gt;50&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Sickle cell crisis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decompression sickness</td>
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</tr>
</tbody>
</table>

*Adapted from guidelines of the Aerospace Medical Association (ASMA) with the permission of the publisher.<sup>19</sup> AMA denotes American Medical Association.
References

Hafner K. When doctors are called to the rescue in midflight. NY Times. 23 May 2011.
The effect of high altitude commercial air travel on oxygen saturation

- Prospective observational study of oxygen saturation and HR in flight
- N=84 passengers aged 1-78 years
- Measured O2 saturation and HR and ground level and maximum altitude
- 54% of passengers had SpO2<94% at cruising altitude

Commercial airline travel decreases oxygen saturation in children

<table>
<thead>
<tr>
<th>Sea level</th>
<th>3 h</th>
<th>7 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>All $O_2$sat (80)</td>
<td>98.5 ± 1.2</td>
<td>95.7 ± 1.7</td>
</tr>
<tr>
<td>All HR (58)</td>
<td>100 ± 16</td>
<td>105 ± 15</td>
</tr>
</tbody>
</table>

Age groups

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>&lt;2 y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$O_2$sat (10)</td>
<td>98.8 ± 1.6</td>
<td>96.6 ± 1.6</td>
</tr>
<tr>
<td>HR (10)</td>
<td>121 ± 15</td>
<td>126 ± 8</td>
</tr>
<tr>
<td>2 to 6 y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$O_2$sat (29)</td>
<td>98.4 ± 1.2</td>
<td>95.4 ± 1.6</td>
</tr>
<tr>
<td>HR (20)</td>
<td>104 ± 12</td>
<td>109 ± 11</td>
</tr>
<tr>
<td>7 to 14 y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$O_2$sat (41)</td>
<td>98.4 ± 1.1</td>
<td>95.7 ± 1.8</td>
</tr>
<tr>
<td>HR (28)</td>
<td>90 ± 8</td>
<td>95 ± 8</td>
</tr>
</tbody>
</table>

Supine $O_2$sat: N/A (0) 94.5 ± 1.7 (4) N/A (0)

Sitting $O_2$sat: 99.0 ± 0.8 (46) 96.0 ± 1.6 (52) 94.8 ± 1.7 (52)

Lee, AP and Yamamoto LG Pediatric Emergency Care 2002
Inflight oxygen
Sept 2001 article in JAMA analyzed cost-effectiveness of placing AEDs on airplanes with >200 persons and found that it cost 35,300 per QALY. This study assumed AED cost of $3000. Used similar statistics to those found in the NEJM study.