Theme 1 – Clinical Judgment (n=9)

<table>
<tr><th>Citation</th><th>Method</th><th>N</th><th>Population</th><th>Intervention</th><th>Control</th><th>Outcome</th></tr>
<tr><td>Pringle 2005[1]</td><td>Retrospective review</td><td>310</td><td>Patients from all land 911 calls (ALS and BLS) in a one month period who were not transported to hospital were surveyed by phone.

Age: NR
Gender: NR

Exclusion: dead at scene patients, pronounced, no patient contact made.</td><td>N/A</td><td>N/A</td><td>Adherence to mandatory transport guidelines:

Non-transports
<table>
<tr><th>Reason for nontransport</th><th>Patient Refused</th><th>EMS Refused</th></tr>
<tr><td>All non-transports</td><td>66.1%</td><td>33.9%</td></tr>
<tr><td></td><td colspan="2">P=0.002</td></tr>
<tr><td>Sought medical care within 7 days</td><td>55.1%</td><td>56.2%</td></tr>
<tr><td>Of those who sought medical care, medical care was changed (new prescription or procedure):</td><td>57.5%</td><td>69.5%</td></tr>
<tr><td>Hospital admission:</td><td>7.3%</td><td>9.5%</td></tr>
<tr><td>Admitted to hospital and met mandatory criteria for transport</td><td>58.3%</td><td>44.4%</td></tr>
<tr><td>Patient died</td><td>0.5%</td><td>0.0%</td></tr>
<tr><td>Met mandatory transport criteria:</td><td>41.5%</td><td>23.8%</td></tr>
</table></td></tr>
<tr><td>Hauswald 2002[2]</td><td>Prospective survey tool and chart review</td><td>151</td><td>Land paramedics (ALS/BLS NR) transporting patients to a single academic ED during a one month period were surveyed.

Age: NR
Gender: NR
Years experience: NR</td><td>N/A</td><td>N/A</td><td>• Response to question: “Could this patient have been safely transported by a non-medical transport service?”
o 53% were felt to be appropriate for non-medical transport (24% of these needed ED care, kappa 0.47, 95% CI 0.34-0.60)
• Response to question: “Could this patient have been safely transported to a clinic or urgent care centre?”
o 38% were felt to be appropriate for alternate destination (45% of these needed ED care, kappa 0.32 95% CI 0.17-0.46)

Definition of “need transport” based on diagnoses that could benefit from EMS treatment unless no diagnostic tests or treatments were provided: pneumonia, asthma, bronchiolitis, reactive airway disease, ischemic chest pain, strep throat, alcohol or substance abuse, urinary tract infection or polynephritis, sinusitis, seizure, abdominal pain, shock, dehydration, abrasion, contusion, laceration, psychiatric diagnosis, cellulitis, abscess, headache, head injury, altered mental status, COPD, CHF, hypertension, diabetic emergency, pelvic inflammatory disease, pregnancy emergency, fracture/dislocation</td></tr>
<tr><td>Haines 2006[3]</td><td>Prospective observational study</td><td>527</td><td>Consecutive pediatric (<21 years) patients assessed by land</td><td>Pediatric Transport Guidelines</td><td>N/A</td><td>Outcomes of patients designated “non-transport” by paramedics utilizing the new Pediatric Transport Guidelines:
• 15/527 (2%) of cases were upgraded by the patch physician for transport.</td></tr>
</table>

			ALS paramedics in a single mixed urban-suburban-rural EMS service during a six month period. Age: median 8 years Gender: 50.7% male	Emergent: child with life or limb threatening conditions required ALS paramedic transport Urgent: child with symptomatic condition not expected to receive ALS intervention was transported by BLS unit EMS initiated non-transport: children with minor illnesses or injury, after consultation by patch with physician, were left in the care of a responsible adult and advised to followup with a health care provider.		○ 100% of these were discharged to outpatient followup after ED evaluation. • 53% of nontransported patients were evaluated by a medical professional within 72 hours. ○ 66% of these were in an ED and 34% were with a primary care physician. • 98% of patients who did not seek followup reportedly improved. ○ No family reported that the child's condition had worsened. • Median time to medical evaluation: 2.5 hours (IQR 1.5-13 hours) • 2.4% (95% CI 1.3-4.3) of patients not transported required admission to hospital. None required ICU care and there were no deaths. Median LOS was 3 days (IQR 2-4).
Cone 2001[4]	Prospective observational study	69	Convenience sample of land BLS EMTs delivering patients to two academic EDs who cancelled an ALS unit before it arrived on scene. Time period NR. Age: NR Gender: NR Years experience: NR	N/A	N/A	Inappropriate cancellation of ALS determined if: • Potentially serious chief complaint (cardiac, respiratory, altered mental status, seizure, GI/GU bleeding, overdose/poisoning) • Abnormal vital signs (SBP <90 or >190mmHg, DBP >120mmHg, respiratory rate <10 or >26, heart rate <50 or >110. • Significant physical findings (GI/GU bleeding, seizure, abnormal mini-neurological exam) Results: • 52/69 (75%) ALS cancellations by BLS occurred because the BLS crew thought they "could handle it". ○ 77% of these patients met the criteria for inappropriate cancellation. ○ 87% of the 52 patients received an intervention immediately upon ED arrival that could have been delivered by an ALS

<table>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>unit in the field.
o 31% of the 52 patients were admitted, and one died in the ED.</td></tr>
<tr><td>Clesham 2008[5]</td><td>Prospective survey tool</td><td>149 staff completed 396 surveys</td><td>All land EMS staff attending a single academic ED during a one month period were invited to fill out a questionnaire.

ALS Paramedic: 32.5%
BLS EMT or other: 67.4%

Age: NR
Gender: NR
Years experience: NR</td><td>N/A</td><td>N/A</td><td>Predictions Table for all patients
<table>
<tr><td></td><td colspan="3">Actual Disposition</td></tr>
<tr><td>Prediction</td><td>Admitted</td><td>Discharged</td><td>Total</td></tr>
<tr><td>Admitted</td><td>134</td><td>48</td><td>182</td></tr>
<tr><td>Discharged</td><td>53</td><td>161</td><td>214</td></tr>
<tr><td>Total</td><td>187</td><td>209</td><td>396</td></tr>
</table>
Sensitivity: 71.7% (95% CI 65-78)
Specificity: 77.0% (95% CI 71-82)
PPV: 73.6 (95% CI 67-80)
NPV: 75.2 (95% CI 69-81)

Predictions Table for trauma patients
<table>
<tr><td></td><td colspan="3">Actual Disposition</td></tr>
<tr><td>Prediction</td><td>Admitted</td><td>Discharged</td><td>Total</td></tr>
<tr><td>Admitted</td><td>24</td><td>9</td><td>33</td></tr>
<tr><td>Discharged</td><td>18</td><td>58</td><td>76</td></tr>
<tr><td>Total</td><td>42</td><td>67</td><td>109</td></tr>
</table>
Sensitivity: 57.1% (95% CI 42-71)
Specificity: 86.6% (95% CI 76-93)
PPV: 72.7 (95% CI 56-85)
NPV: 76.3 (95% CI 66-84)

Predictions Table for non-trauma patients
<table>
<tr><td></td><td colspan="3">Actual Disposition</td></tr>
<tr><td>Prediction</td><td>Admitted</td><td>Discharged</td><td>Total</td></tr>
<tr><td>Admitted</td><td>101</td><td>35</td><td>136</td></tr>
<tr><td>Discharged</td><td>32</td><td>73</td><td>105</td></tr>
<tr><td>Total</td><td>133</td><td>108</td><td>241</td></tr>
</table>
Sensitivity: 75.9% (95% CI 68-82)
Specificity: 67.6% (95% CI 58-76)
PPV: 74.3 (95% CI 66-81)
NPV: 69.5 (95% CI 60-78)

There was no significant difference between the prediction abilities for admission between paramedics and EMTs (p=0.31) however EMTs were significantly more accurate than paramedics at predicting discharge (specificity 83.8% vs 64.4%, p=0.001)</td></tr>
<tr><td>Gray 2007[6]</td><td>Retrospective review</td><td>354</td><td>Patients treated under newly introduced protocols by land BLS EMTs and ALS paramedics over a 4 month period.</td><td>4 non-transport guidelines were introduced:

- No injury
- Minor limb injury
- Resolved hypoglycemia</td><td>N/A</td><td>120 of the 354 forms were unclassified as to which protocol they utilized and are reported separately.

Results
<table>
<tr><td>Protocol</td><td>% Appropriate</td><td>% Inappropriate</td><td>*</td></tr>
<tr><td>No apparent injury</td><td>79.8</td><td>20.2</td><td>12/17</td></tr>
<tr><td>Hypoglycemia</td><td>97.1</td><td>2.9</td><td>1/2</td></tr>
</table></td></tr>
</table>

			Age: NR Gender: NR	- Resolved fit in a patient with known epilepsy		<table><tr><td>Minor limb injury</td><td>51.7</td><td>48.3</td><td>1/1</td></tr><tr><td>Epilepsy</td><td>95.7</td><td>4.3</td><td>0/23</td></tr><tr><td>Unclassified</td><td>22.5</td><td>77.5</td><td>9/93</td></tr></table>* n deemed inappropriate where patient refused transport

Mason 2008[7]	Cluster randomized controlled trial	3018
		
		C: 1469
		I: 1549
			Patients >59 years of age presenting to EMS between 0800h and 2000h with a complaint that fell in the scope of a paramedic practitioner during a 13 month period.
			
			Age mean (SD): 82.6 (8.3)
			Gender: 26.4% male
				Paramedic practitioner would approach patient in the field and offer extended scope of practice.	Paramedic practitioner would approach patient in ED but would not treat in the field.	Patients treated by a paramedic practitioner (intervention):
						• Were less likely to be seen in the ED (RR 0.72, 95% CI 0.68-0.75)
						• Were less likely to require hospital admission within 28 days (RR 0.87, 95% CI 0.81-0.94)
						• Experienced shorted total event times (235 min vs 278 min, 95% COI of difference -60min to -25 min)
						• More likely to report being highly satisfied with their health care episode (RR 1.16, 95% CI 1.09-1.23).
						• There was no statistically significant difference in 28 day mortality (RR 0.87, 95% CI 0.63 to 1.21)
						
						Of the 2025 patients not admitted to hospital during the index episode:
						• 10.8% went on to have an unplanned ED visit within 7 days
						  ○ 9.5% of controls (72% related to index visit)
						  ○ 11.9% of intervention (100% related to index visit)
						  ○ P = 0.49
						
						Reviewing physicians felt that suboptimal care was provided in 0.80% of patients not transported. There was no difference in suboptimal care between intervention and control groups (p=0.94).
						
						Scope of paramedic practitioner:
						Presenting complaint: falls, lacerations, epistaxis, burns, foreign body
						Practical skills: local anesthetic, wound care, suturing, splinting
						Special skills: joint examination, neurological, cardiovascular, ENT and respiratory system evaluation, dispense antibiotics, tetanus toxoid, analgesia, mobility and special needs assessment, referrals to radiology, ED, community care

Williams 2004	Prospective observational study that was part of a pragmatic randomized trial	239	Nurses and ALS paramedics working in a land 911 call centre who were trained to apply a triage tool to determine if an ambulance was needed.	Nurses and ALS paramedics would apply the triage tool and determine if an ambulance was necessary. These cases were then evaluated by an independent panel to determine if the decision was	N/A	Safety of paramedics and nurses using a telephone triage tool to determine that an ambulance is not needed: • 96.7% of calls deemed by nurse/paramedic not to require an ambulance were agreed with by the expert panel (the expert panel consisted of 2 emergency department physicians, 2 emergency nurses, 2 general practitioners and 2 paramedics). • 4/239 patients were determined by the majority of the panel to require an ambulance response in 14 minutes. All 4 of these patients were admitted to hospital.

				appropriate.		
McDermott 2005[8]	Prospective cohort study	243	Consecutive road trauma fatalities treated by a land EMS service staffed by BTLS (basic trauma life support) paramedics and PHATLS (prehospital advanced trauma life support) paramedics (mobile intensive care units) during a two year period. Age: mean 43.3 +/- 26.2 years (range 6 months to 97 years) Gender: male 70% Mean response time: 9.4 +/-6.4 min, median 8 min. Mean scene time: 29.0 +/- 23.7 min, median 22 min. Trapped requiring extrication: 21% RSI: No Pharmacology: Diazepam and Morphine			Errors categorized as: 1) system inadequacies (22% of error, 75% of which contributed to death) 2) error in treatment/management strategy (67% of error, 62% contributed to death) 3) error in technique (during diagnostic or treatment event) (8% of error, of which 69% contributed to death.) 4) error in diagnosis (misinterpretation, missed diagnosis) (1% of error, of which 100% contributed to death) 5) delay in diagnosis (3% of error, of which 100% contributed in death) Deaths categorized as: 1) Preventable (survival probability >75%) 2) Potentially preventable (survival probability 25-74%) 3) Non preventable (survival probability <25%) • 65% of the 591 deficiencies were judged to have contributed to the death of the patient. • 56% of patients had identified prehospital errors that contributed to death. • 13% of at-scene or en route deaths were judged to be preventable (one preventable, two possibly preventable, n=3).

Theme 2 – Adverse Events, Medication Errors and Error Reporting (n=16)

Citation	Method	N	Population	Intervention	Control	Outcome
Bernius 2008[9]	Randomized trial	523	Land ALS paramedics Age: NR Gender: NR I: mean 7.0 years experience C: mean 7.7 years experience	Pediatric code card N=246	Standard of care (no code card) N=277	Accuracy of drug dosage calculation on a written test I: 94% correct C: 65% correct P<0.001 "Severe" error rate I: 4.9% C: 20.9% P<0.001 Tenfold Error rate (Overdose by factor of 10) I: 0.8% C: 6.2% P<0.001 Hundredfold Error rate (Overdose by factor of 100) I: 0.05% C: 0.4% P<0.025 Correct ET size calc rate (Age/4+4): I: 98% C: 23% P<0.001
Vilke 2007[10]	Survey tool and retrospective review	352 / 425 (response rate 83%)	Ground ALS paramedics Pediatric transport rate 10.3% Age: NR Gender: NR Mean experience 8.5 years	N/A	N/A	Self-reported error • 9.1% report medication error in previous 12 months • 63% were dosing errors • 33% were protocol errors • 21% were wrong-route errors • 4% were wrong medication errors • 79.1% of errors were self-reported to CQI manager • 8.3% of errors reported by receiving RN • 8.3% of errors discovered in chart review • 4.2% recorded on prehospital chart but never found • 21.9% of errors occur in pediatrics
LeBlanc 2005[11]	Observational before-after	30	ALS flight paramedic students N=18 Critical Care flight paramedic students N=12	Stressful simulation (a panicked bystander) N=30 Critical Care N=12	Normal (no stressor) simulated emergency call N=30 Advanced Care N=18	Accuracy of drug dosage calculation in a practical scenario Stress as the intervention: I: 43.1% C: 57.9% P<0.01 Being a Critical Care paramedic as the intervention I: 61.1% C: 39.8% P<0.01
Seymour 2008[12]	Retrospective review	190	All mechanically ventilated interfacility patients transported to	N/A	N/A	In-flight adverse events • Major: zero ○ Death: zero

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<td>an academic hospital by helicopter by an aeromedical service during a 36 month period. Flight crew consists of ALS paramedic and nurse.

Excluded: scene calls, fixed wing patients, patients transferred out of the academic hospital

Age: 55 +- 16
Gender: 55% male
GCS: 5 (3-9)</td>
<td></td>
<td></td>
<td>

Cardiac or respiratory arrest: zero
Pneumothorax: zero
Seizure: zero

Minor: 22%

new SpO2 less than 85% = 4%
decrease in SpO2 by 10% = 4%
ventilator change including transition to manual ventilation: 2%
MAP<60mmHg requiring medication administration: 3%
new arrhythmia: 2%
administration of sedative or neuromuscular blockade for change in vital signs: 9%
administration of sedative or neuromuscular blockade for or ventilator dysynchrony: 8%

Factors associated with adverse events:

The presence of vasopressors pre-flight: 45% vs 21% (p<0.01)
Increased flight distance: 57 (35-95km) vs 47 (31-82km) (p=0.02)

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<tr>
<td>Dewhurst 2001[13]</td>
<td>Retrospective and prospective cohort study</td>
<td>414 retrospectiv e and 69 prospective</td>
<td>All aeromedical repatriations in a 2 year period were reviewed retrospectively followed by prospective review of all repatriations during a one year period.

Age (SD): 53 (20)
Male:Female ratio 1:0.7</td>
<td>N/A</td>
<td>N/A</td>
<td>Major adverse events in high risk groups (defined as a patient with dysfunction in one or more organ systems which is unstable and would require urgent medical intervention if it were to deteriorate):

Retrospective cohort: n=18 (9%)

Deaths in transit: n=0
Deaths within 24 hours of transit: n=3

Prospective cohort: n=7 (12%)

Deaths in transit: n=2
Deaths within 24 hours of transit: n=0

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</tr>
<tr>
<td>MacDonald 2008[14]</td>
<td>Retrospective review</td>
<td>598 volunteered reports and 125 additional reports

N=723

Complete records for 680</td>
<td>All reported adverse events (through both chart review and voluntary adverse event reporting) in a provincial air medical transport service (fixed and rotor wing) employing primary, advanced and critical care paramedics during a 3.5 year</td>
<td>N/A</td>
<td>N/A</td>
<td>Rate of adverse events (possible or actual harm caused): 11.53 (95% CI 10.7-12.4) per 1000 flights

Frequency and Categorization of adverse events.
<table>
<tr><th></th><th>N of total events</th><th>N with possible harm</th></tr>
<tr><td>Total</td><td>680</td><td>117</td></tr>
<tr><td>Aviation
Aircraft
Weather</td><td>
143
30</td><td>
12
6</td></tr>
<tr><td>Non-Aviation</td><td></td><td></td></tr>
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</td>
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</table>

			period. 58956 flights occurred during the study period. Age (IQR): 43.9 (22, 64) years Gender: Male 57.5% Years experience: NR			<table><tr><td>Communication</td><td>229</td><td>29</td></tr><tr><td>Medical equipment</td><td>88</td><td>7</td></tr><tr><td>Patient management</td><td>77</td><td>20</td></tr><tr><td>Clinical performance</td><td>68</td><td>16</td></tr><tr><td>Patient factors (underlying condition) causing death</td><td>21</td><td>21</td></tr><tr><td>Unclassified</td><td>24</td><td>6</td></tr></table> Reviewers agreed about presence of adverse event in 635/680 cases (kappa 0.84, 95% CI 0.82-0.87) and the categorization of the event in 472/680 cases (kappa 0.66, 95% CI 0.62-0.70) and the potential for harm in 479/680 cases (kappa 0.49, 95% CI 0.44-0.55).
Fairbanks 2008[15]	Semistructured interviews Focus groups Prospective observational study	Interview: N=15 Focus group: N=23 Prospective observation: N=11	EMS providers employed by at least one of 40 volunteer and career EMS agencies. Land or air not specified. For the interviews, purposive sampling targeted individuals most likely to yield information (“fairly experienced” EMS providers, both BLS and ALS). 73% ALS 40% volunteer 87% male Mean experience 10 years. For the focus groups, 70% ALS 30% volunteer 70% male Mean experience NR	Anonymous event reporting system (near misses and actual events) was linked to an online discussion board for 6 months. The system was publicized using posters in EMS stations and hospital write-up rooms. Word of mouth was also employed.	N/A	Qualitative Interview and Focus Group Results: 5 analytic domains emerged: • Error reporting and responses to reporting o Response to QA and feedback o Lack of proactive reporting o Blame and punishment perceived as important for resolution o Bad outcome or adverse event o Poor understanding of definition of near miss and adverse event Summary: participants desired a non-punitive error reporting system • Lack of standardization o Equipment compatibility across agencies and facilities o Environmental differences o Lack of adherence to protocols Summary: protocol confusion, lack of standardization and equipment compatibility between agencies/facilities • Pediatrics o Perceptions of pediatric care Summary: Inadequate training and experience with pediatrics leads to discomfort and adverse events • Interrelationships o Respect, antagonism, adversarial relationships o Politics o Bravado and fear of failure o Reluctance to “tell on colleagues” Summary: Adversarial relationships between EMS providers and hospital staff/public safety workers leads to impaired communication and decision making, leading to error. • Blame o Errors of other providers o Non-EMS errors Summary: Respondents focused on errors by others,

						particularly ED staff. Prospective online error reporting system: 4 near misses 7 adverse events All data sources: 61 events identified 44% were near misses, 56% were adverse events Age of patient involved: >18 years 56% <19 years 23% Unknown 21% Classification of Event: Clinical judgment 54% Skill performance 21% Medication event 15% Destination choice 5% Other 5% Reported to authority Physician 43% Supervisor 48% Never reported 19%
Hobgood 2006[16]	Survey tool	283	Convenience sample of EMT-Basic (24%) and ALS paramedics (76%) attending a statewide EMS conference. Land or air not specified. Age 18-29 27% Age 30-39 42% Age >39 32% Gender: 67% male Years experience: <4 12% 4 to 10 34% >10 54%	N/A	N/A	• Self-reported errors in previous year ○ None: 55% ○ 1-2: 35% ○ >2: 9% (no variables were associated with error reporting) • Error identification ○ 89% of errors were self-identified. ○ Severe errors were identified 93% of the time (95% CI 92-94) ○ Mild errors: drug error 98% (95% CI 97-100), treatment administration 36% (95% CI 30-41), equipment failure 12% (CI 8-16). • Reporting: ○ 6% of errors were identified and not reported.
Shaw 2005[17]	Retrospective review	156	18 health trusts where IT connectivity did not present a barrier to study completion provided data through an adverse event and near miss reporting system	N/A	N/A	Reported adverse events: Delays or failure in *treatment (28%) Delays or failure in *admission (33%) * not defined 398 events with catastrophic outcomes were reported for the aggregate of 28 998 event reports, however only 156 of these 0.5%) were from ambulance trusts. 11 events with catastrophic events occurred in a public place and 64 occurred in the patients

			12 acute trusts 3 mental health trusts 2 ambulance trusts			home, but it is not reported how many of these are unique to the ambulance trusts.
Hobgood 2006[18]	Cross-sectional survey tool	103 (Participation rate 89%)	Convenience sample of providers in a tertiary care hospital. Providers included: ED physicians 40% ED nurses 26% EMT Basics (BLS) and EMT paramedics (ALS) 35% Nurses were older, more often female, and had more years in practice than physicians and EMTs (P<0.01) Years experience: NR Exclusion: students	N/A	Survey of attitudes towards clinical vignettes presenting medical errors.	When asked if they: • Would report an error to a hospital committee: o Physician: 54% o Nurse: 68% (P=0.02) o EMT/paramedic: 78% yes (P<0.01) • Had been taught error reporting: o Physicians: 87% o Nurses: 92% o EMT/paramedic: 91% o Differences not statistically significant • Physicians were more likely than nurses and EMT/paramedics to report observing another health care provider disclose a medical error (60%, 36%, 17% respectively) P<0.01). When asked to classify an error as such: • Medication errors o Physician 78% o Nurse 71% (P=0.04) o EMT/Paramedic 68% (P<0.01) • Cognitive errors o Physician 66% o Nurse 54% (P=0.04) o EMT/Paramedic 55% (P=0.01)
Wang 2008[19]	Retrospective review	326	Insurance claims covering a two year period from a national insurer of EMS agencies (including fire agencies) arising from EMS response. Land claims included, air claims not specified. Excluded: cases where there was no injury to individuals, events involving employees only, claims of discrimination and harassment, and events with only vehicle or property damage, events occurring on EMS property (ie: slip	N/A	N/A	Adverse Event n=326 • Emergency Vehicle (37%, 95% CI 32-43) o Emergency vehicle crash 115 o Emergency vehicle movement 12 • Patient Handling 36% (95% CI 31-41) o Personnel dropped patient 36 o Stretcher or wheelchair tipped over 30 o Patient injured during stretcher/wheelchair movement 21 o Patient fell 14 • Clinical management 12% (95% CI 9-15) o Airway management 14 o Adverse drug reaction 5 o Other medical management events 15 o Lack of or failure to bring equipment on scene 5 o Failure or malfunction of equipment • Response or transport event 8% (95% CI 5-11) o Response, dispatch or navigation event, or delay of care 15 o Transportation events 12 • Other events 10% (95% CI 7-14)

<table>
<tr>
<td></td>
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<td>and fall), vehicle damage less than $10 000.

Median claimant age 52 years (IQR 32-69)
Gender Male 40%</td>
<td></td>
<td></td>
<td>Outcome of Adverse Events (death/lifethreatening or disability/nonlifethreatening, other or unknown/total)
o Emergency Vehicle 5/10/107/122
o Patient Handling 3/4/111/118
o Clinical Management 14/6/14/31
o Response or transport event 18/1/6/25
o Other events 12/4/17/33

57% of claimants from vehicle collisions were not patients.</td>
</tr>
<tr>
<td>Hobgood 2004[20]</td>
<td>Survey tool</td>
<td>116</td>
<td>Convenience sample of physicians, nurses and EMTs in the emergency department of an academic hospital during a one month period between 0900h and 0100h. None worked in the flight environment.

Age NR
Gender NR

35% EMTs
28% RN
36% physician

Years experience NR

Excluded: Students</td>
<td>N/A</td>
<td>N/A</td>
<td>Percentage of self-reported identification, disclosure and reporting of medical errors by provider types.
<table>
<tr><th></th><th>EMTs</th><th>RNs</th><th>MD</th></tr>
<tr><td>Number of errors committed in last year</td><td></td><td></td><td></td></tr>
<tr><td>None</td><td>44.7</td><td>56.2</td><td>21.4</td></tr>
<tr><td>1-2</td><td>39.5</td><td>34.4</td><td>26.2</td></tr>
<tr><td>3-4</td><td>13.2</td><td>9.4</td><td>26.2</td></tr>
<tr><td>5 or more</td><td>2.6</td><td>0.0</td><td>26.2</td></tr>
<tr><td>Other parties whom the respondent informed of error</td><td></td><td></td><td></td></tr>
<tr><td>Attending physician</td><td>52.1</td><td>76.9</td><td>67.7</td></tr>
<tr><td>Federal government agency</td><td>4.8</td><td>0.0</td><td>0.0</td></tr>
<tr><td>Fellow worker</td><td>57.1</td><td>23.1</td><td>64.5</td></tr>
<tr><td>Hospital patient safety committee</td><td>4.8</td><td>7.7</td><td>25.8</td></tr>
<tr><td>Nurse</td><td>38.1</td><td>38.5</td><td>51.6</td></tr>
<tr><td>Patient</td><td>19.1</td><td>23.1</td><td>74.2</td></tr>
<tr><td>Pharmacy</td><td>0.0</td><td>0.0</td><td>29.0</td></tr>
<tr><td>State government agency</td><td>9.5</td><td>0.0</td><td>0.0</td></tr>
<tr><td>Other</td><td>38.1</td><td>30.8</td><td>16.1</td></tr>
</table>
• Provider groups lacked formal instruction on how to inform patients of error (EMTs 10%, RNs 9%, physicians 12%).
• Recalls hearing colleague discuss their own medical error (EMTs 83%, RNs 78%, Physicians 89%)
• Few directly observed an error disclosure to a patient (EMTs 18%, RNs 31%, Physicians 39%)
• 66% of males disclose errors to coworkers compared to 34% for females (P value not reported)
• More experienced providers (>10 years) were more likely to identify their own errors than novice (<1 year) providers (30% vs 6%, p-value not reported). These experienced providers were more likely not to disclose an error to patients than novice providers (25% vs 3%, p value not</td>
</tr>
</table>

<table>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>reported)</td></tr>
<tr><td>Stella 2008[21]</td><td>Prospective Observational study</td><td>41</td><td>Adverse events reported during a three month pilot project during implementation of an Incident Monitoring System in a ground ambulance service.

No description of persons who reported the errors.</td><td>Anonymous web and paper based adverse events reporting form (N=24)

Chart Review for adverse events N=17

“Hot debriefing” was utilized where a senior ambulance representative and a consultant emergency physician interviewed the paramedics when further information was required.
N=9</td><td>N/A</td><td>

There were 77 incidents identified in 41 cases.
The mean number of incidents/case was 1.8 (95% CI 1.03-2.57).
72.7% of errors related to system inadequacies (95% CI 65.5-80.0).
34/77 (44.2%, 95% CI 39.3-49.1) cases were considered mitigated (partly or completely explained by circumstances) by the study committee.

Breakdown of adverse events
<table>
<tr><td>Incident Type</td><td>%</td></tr>
<tr><td>Resource problem</td><td>27.3</td></tr>
<tr><td>Communication problem</td><td>18.2</td></tr>
<tr><td>Prolonged times</td><td>15.6</td></tr>
<tr><td>Resuscitation problems</td><td>15.6</td></tr>
<tr><td>Other treatment problems</td><td>10.4</td></tr>
<tr><td>Equipment problems</td><td>5.2</td></tr>
<tr><td>Other</td><td>5.2</td></tr>
<tr><td>Injury</td><td>2.6</td></tr>
</table>
Breakdown of system problems
<table>
<tr><td>System Problem</td><td>%</td><td>95% CI</td></tr>
<tr><td>Prolonged time to scene</td><td>16.1</td><td>14.5-17.6</td></tr>
<tr><td>Prolonged time at scene</td><td>16.1</td><td>14.5-17.6</td></tr>
<tr><td>Inadequate number of crews on scene</td><td>12.5</td><td>11.4-13.6</td></tr>
<tr><td>Communication with other services</td><td>10.7</td><td>9.8-11.6</td></tr>
<tr><td>Dispatch communication problems</td><td>7.1</td><td>6.7-7.6</td></tr>
<tr><td>Delayed or unavailable helicopter</td><td>5.4</td><td>5.0-5.7</td></tr>
<tr><td>Hospital not notified</td><td>5.4</td><td>5.0-5.7</td></tr>
<tr><td>Equipment failure</td><td>5.4</td><td>5.0-5.7</td></tr>
<tr><td>Other</td><td>5.4</td><td>5.0-5.7</td></tr>
<tr><td>Inadequate monitoring of oxygen</td><td>5.4</td><td>5.0-5.7</td></tr>
<tr><td>Extrication problems</td><td>3.6</td><td>3.4-3.7</td></tr>
</table>
n>1 listed.

Outcomes of the critical incident
<table>
<tr><td>Outcome</td><td>%</td><td>95% CI</td></tr>
<tr><td>None / near miss</td><td>45.5</td><td>40.4-50.5</td></tr>
<tr><td>Minor</td><td>19.5</td><td>17-8-21.2</td></tr>
<tr><td>Moderate</td><td>23.4</td><td>21.2-25.6</td></tr>
<tr><td>Severe</td><td>7.8</td><td>7.3-7.8</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>
<table>
<tr><td>Death</td><td>2.6</td><td>2.5-2.7</td></tr>
<tr><td>Unknown</td><td>1.3</td><td>1.3-1.3</td></tr>
</table>
</td></tr>
<tr><td>Kaji 2006[22]</td><td>Before-after observational study</td><td>C: 104
I: 37</td><td>All pediatric cardiac arrests (age <13 years) during a three year “before” period and a 2 year “after” period who received epinephrine for cardiac arrest by land ALS paramedics in an urban EMS system.</td><td>Pediatric drug dosage charts and Broselow tapes provided to rescuers. Use of Broselow tape (pediatric resuscitation reference card) mandatory.</td><td>Pediatric drug dosage charts not supplied. Broselow tape not supplied.</td><td>Correct first dose of epinephrine:
<table>
<tr><td></td><td>Correct dose N(%)</td><td>Within 20% of correct dose N(%)</td><td>Administered through route N</td></tr>
<tr><td>Control IV</td><td>13 (28)</td><td>16(34)</td><td>47</td></tr>
<tr><td>Control ET</td><td>16 (28)</td><td>23 (40)</td><td>57</td></tr>
<tr><td>Control Total</td><td>29(28)</td><td>46(44)</td><td>104</td></tr>
<tr><td>Intervention IV</td><td>20(59)</td><td>23(67)</td><td>34</td></tr>
<tr><td>Intervention ET</td><td>1(33)</td><td>1(33)</td><td>3</td></tr>
<tr><td>Intervention Total</td><td>21(54)</td><td>24(65)</td><td>37</td></tr>
</table>
Differences between Control and Intervention cohorts:
• Use of Broselow tape 59% vs 97%, p<0.001
• IV route 45% vs 92%, p<0.001

Note: ETT administration of epinephrine not permitted by protocol during intervention group.</td></tr>
<tr><td>Hubble 2000[23]</td><td>Survey and test tool</td><td>109</td><td>Convenience sample of practicing land ALS paramedics attending continuing education from 6 heterogeneous EMS systems in a single state.

Age: NR
Gender: NR
Years experience: mean 9.73, SD 5.55</td><td>N/A</td><td>N/A</td><td>Use of mental aids:

Frequency of training in medication dose calculations:
<table>
<tr><td></td><td>Employer-initiated Frequency (%)</td><td>Self-initiated Frequency (%)</td></tr>
<tr><td>Monthly</td><td>1 (0.92)</td><td>18 (16.51)</td></tr>
<tr><td>Quarterly</td><td>9 (8.26)</td><td>23 (21.10)</td></tr>
<tr><td>Yearly</td><td>39 (35.78)</td><td>24 (22.02)</td></tr>
<tr><td>More than 1 year</td><td>27 (24.77)</td><td>17 (15.60)</td></tr>
<tr><td>Never</td><td>31 (28.44)</td><td>26 (23.85)</td></tr>
</table>
Mean score: 51.4% (SD 27.40, range 0-100)

• Medication bolus questions: 68.8% correct
• IV flow rate problems: 68.8% correct
• Non-weight based medication infusions: 33.9% correct
• Weight-based medication infusions: 32.5% correct
• Percentage-based medication infusions: 4.5% correct

For incorrect answers:
• 47.4% were underdosed
• 52.6% were overdosed

Association between score (%) and education:
• Highschool 30.58%
• Some college 51.14%</td></tr>
</table>

<table>
<tr>
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<td>

Technical degree 51.16%
Baccalaureate degree 55.00%
Some graduate work 62.50%
Graduate degree 67.5%
P=0.039

</td>
</tr>
<tr>
<td>Ricard-Hibon 2003[24]</td>
<td>Prospective observational study</td>
<td>603</td>
<td>Patients treated by a physician-based land ambulance service during a 12 month period in a city.

Mean age: 50 +/- 22 years
Gender: 58% male

Interhospital: 30%
On scene: 70%</td>
<td>An adverse event monitoring tool was introduced.</td>
<td>N/A</td>
<td>

Side effects occurred in 5.5% of spontaneously breathing analgesia cases

7 cases of nausea/vomiting
2 cases of respiratory failure
3 cases of hypotension
1 case of bradycardia
1 care of arrhythmia

<table>
<tr><th>#(%) [95% CI]</th><th>Anesthesia / continuous sedation</th><th>Anesthesia for tracheal intubation</th></tr>
<tr><td>Side effects</td><td>69(22) [17.6-26.4]</td><td>50(31) [24.1-37.9</td></tr>
<tr><td>Cardiac arrest</td><td>5(2)</td><td>4(2)</td></tr>
<tr><td>Dysrhythmia</td><td>6(2)</td><td>4(2)</td></tr>
<tr><td>Hypotension</td><td>34(10)</td><td>24(15)</td></tr>
<tr><td>Collapse</td><td>3(1)</td><td>2(1)</td></tr>
<tr><td>Difficult ETI</td><td>17(5)</td><td>15(9)</td></tr>
<tr><td>Esophageal intubation</td><td>7(2)</td><td>6(4)</td></tr>
<tr><td>Broncho/ laryngospasm</td><td>6(2)</td><td>5(3)</td></tr>
<tr><td>Hypoxemia</td><td>3(1)</td><td>1(1)</td></tr>
<tr><td>Pulmonary aspiration</td><td>3(1)</td><td>3(2)</td></tr>
<tr><td>Allergy</td><td>0</td><td>0</td></tr>
</table>
</td>
</tr>
</table>

Theme 3 – Intubation (n=15)

Citation	Method	N	Population	Intervention	Control	Outcome
Svenson 2007[25]	Retrospective study	62	All intubated patients >18 yrs of age transported by an aeromedical program during a three month period. Patients were intubated by helicopter physicians, sending hospital physicians, or land ALS paramedics. Age: NR Gender: NR	N/A	N/A	• Mean ET tube cuff pressure: 63 +-34 cmH2O • ET cuff pressure <20 cmH2O in 6% of patients • ET cuff pressure 20-30 cmH2O in 15% of patients • ET cuff pressure >30 cmH2O in 79% of patients • ET cuff pressure >40 cmH2O in 58% of patients (recommended cuff pressure 20-30 cmH2O with no cuff leak)
Parwani 2007[26]	Prospective observational study (manikin)	53	Licensed land ALS paramedics at CME. Age NR Gender NR Average 6.6 years experience Intubate average of 3.6 times per year	N/A	N/A	• ET cuff pressure >120 cmH2O in 66% of patients • ET cuff pressure >25 cmH2O in 100% of patients • 13% of paramedics can identify over inflation by palpation of the bulb
Jemmet 2003[27]	Prospective observational study	109	136 patients intubated orally by ground ALS paramedics in a mixed urban-suburban-rural setting and transported to an urban teaching hospital. 109/136 patients had data forms completed in the ED. Age: NR Gender: NR Medical: NR Trauma: NR RSI: No	N/A	ED Physician assessed placement on arrival at hospital using infrared CO2 detectors and auscultation and occasionally esophageal detector devices, direct visualization (laryngoscopy), and / or chest xray.	Per ED Physician: • 88% Successfully placed • 9% Esophageal • 2% Right Mainstem • 1% Supraglotic
Jones 2004[28]	Prospective observational	208 Oral: 180	Consecutive patients intubated orally or nasally by ground ALS	N/A	On arrival, and ED Physician assessed ETT	ED Physician findings: • 5.8% misplaced (95% CI 2.6-8.9%) • 5.0% of oral tubes misplaced

		Nasal: 28	paramedics and transported to academic hospitals in a metropolitan area during an undefined time period. Age: Gender: Medical: 76.9% Trauma: 48% RSI: No Excluded: Prisoners, air and interfacility patients		placement using a combination of direct visualization via laryngoscopy, colorimetric ETCO2, esophageal detector device, auscultation, chest rise/fall.	• 10.7% of nasal tubes misplaced • 6.3% of medical patients misplaced • 4.2% of trauma patients misplaced • P 0.737
Wirtz 2007[29]	Prospective observational trial	132	Consecutive patients intubated by ALS paramedics employed by ground EMS services in a metropolitan area and transported to one of 2 affiliated teaching hospitals during a 17 month period. Age: NR Gender: NR Medical: NR Trauma: NR RSI: NR	N/A	ED physician assessed placement of ETT via auscultation and, if questionable placement, via direct laryngoscopy. Colorimetric ETCO2 detectors were used after these methods were used.	Right mainstem considered proper placement Supraglotic placement considered misplacement ED Physician findings: • 9% of patients (n=12) had misplaced ETT (95% CI 5.3-15.2%) • 8% of patients had ETT in esophagus • 1% of patients has ET in hypopharynx • 1 of 12 patients survived to hospital discharge • 5 of 12 patients had vital signs prior to intubation in the field.

Wang 2001[30]	Retrospective chart review	592	Patients intubated by ALS paramedics in a ground ALS system transporting to one of 5 regional EDs during a 12 month period.
			
			Median age 57.1 years
			Gender: 44.9% male
			
			Medical: NR
			Trauma: NR
			Failed ETI:
			Medical: 44/49
			Trauma: 5/49
			RSI: No
				N/A	N/A	• Successful ETI 536/592 (90.5%)
						• Failed ETI 56/592 (9.5%) defined as ETT not successful (aborted or misplaced)
						• 49/56 failed ETI had charts accessible for review (87.5%)
						  ○ 49% of failed ETI in field were due to insufficient relaxation as reported by paramedics
						  ○ 10% of failed ETI in field were due to difficult anatomy as reported by paramedics
						• There were 2 unrecognized esophageal intubations (0.3%)

Bair 2005[31]	Retrospective chart and database review	1643 intubations	All patients arriving at a single academic ED during a 65 month period who had intubation performed by land ALS paramedics. Age: NR Gender: NR Medical: NR Trauma: NR RSI: No	N/A	N/A	• 35/1643 ETI were determined by the ED physician to be unrecognized nontracheal (esophageal or supraglotic) placement (2%). • 20% of misplaced ETI were trauma patients • 0% of misplaced ETI were children (<10yrs) • 60% of misplaced ETI had multiple confirmatory techniques used by paramedics • 13/15 patients that had no pulse prior to ETI died. Zero of these patients had a positive colorimetric ETCO2 detection. • 8/20 patients that had a pulse prior to ETI died. Nine of these patients had positive colorimetric ETCO2 detection. • Of 35 unrecognized misplaced ETTs, paramedics reported the following confirmation techniques were used: o Breath sounds 91% o Visualization of cords 52% o EtCO2 26% o Pulse oximetry 11% o Multiple methods 60%
Pratt 2005[32]	Prospective Observational Study	32 patients where ETI was attempted	All adult patients (>15 years) intubated by land emergency medical technician – basics and transported to an academic hospital during a 4 year trial of BLS intubation. Age 60.5 years (reported as average) Gender: 66% males Medical: 28/32 Trauma: 4/32 No RSI	4 BLS land emergency medical technicians who underwent a training program (34 hours plus 10 operating room ETIs) to study the feasibility of intubation by BLS providers. Colorimetric ETCO2 detectors were made available in the field.	N/A	Zero unrecogonized esophageal ETI 30/32 (94%, 95% CI 80-98%) ETI placed correctly by EMT-Bs Both patients for whom ETI was not achieved were successfully bag-valve-masked in the field.
Wang 2006 [33]	Prospective Observational Study	1953	Patients receiving attempted intubation by 42 ground (n=40) and air (n=2) ALS services participating in an airway procedures database during an 18 month period. 95% of intubations were performed by ALS paramedics and 5% were performed by nurses and physicians	N/A	N/A	• ETI error (any one of esophageal placement, dislodgement, four or more attempts, inability to intubate) 444/1953 o Failure to place ETT: 359/1953 o Four or more attempts: 62/1963 o Tube misplacement or dislodgement: 61/1953 ETI error rates ranged between 0 and 40% between services. Error rates for lower in services that performed more intubations annually but higher for services with greater numbers of patient contacts (more than 5000 per year). ETI errors were not associated with system configuration (ground vs air), personnel patterns (career vs mixed career/volunteer), the number of paramedic rescuers, the mean response or transport times, and

<table>
<tr><td></td><td></td><td></td><td>completing rotations in the field.

Age: NR
Gender: 61% male

Medical: 85.4%
Trauma: 14.6%
RSI was available.
65.4% in cardiac arrest</td><td></td><td></td><td>the population characteristics.

Failed ETI by age:<table><tr><td>Age (years)</td><td>Frequency of any ETI error</td></tr><tr><td><6</td><td>44.7% (OR 4.0 (95% CI 2.1-7.9)</td></tr><tr><td>6-17</td><td>23.4 (OR 1.5 95% CI 0.8-3.1)</td></tr><tr><td>18-39</td><td>36.8% (OR 2.9, 95% CI 2.1-4.0)</td></tr><tr><td>40-69</td><td>24.5% (OR 1.6, 95% CI 1.3-2.1)</td></tr><tr><td>>69</td><td>16.7% (reference)</td></tr></table></td></tr>
<tr><td>Tiamfook-Morgan 2006[34]</td><td>Prospective Observational Study</td><td>170 of 200 had SpO2 documented</td><td>Consecutive patients undergoing attempted intubation by ALS flight nurses and paramedics in a critical care air medical service (3 rotor-wing, 1 fixed-wing, 2 ground vehicles) during a 16 month period.

Median age 40 (IQR 22-62)
Gender: 58% male

Medical: 22.5%
Trauma: 77.5%
Scene 48%
Interfacility 52%
RSI available.</td><td>A new policy tracking SpO2 during ETI procedures. Peri-ETI SpO2 values were defined as the lowest value during the period surrounding ETI (commencing one minute before ETI or when medications were used, the time the first medication was administered, ending 5 minutes after placement or attempted placement of the final airway used.</td><td>N/A</td><td>• ETI success rate: 95.4%
• 8.5% of cases had a peri-ETI SpO2 <90% and a pre-ETI reading >90% or not recorded.
• Peri-ETI desaturation <90% was less likely in patients in which ETI was successful (Odds Ratio 0.23, 95% CI 0.07-0.83) and more likely when multiple attempts were required (OR 7.8, 95% CI 3.2-18.8).
• In nearly two thirds of patients requiring multiple attempts, SpO2 values remained above 90%.</td></tr>
<tr><td>Wang 2003[35]</td><td>Prospective Observational study</td><td>783

663 included</td><td>All patients for whom intubation was attempted in 43 ground EMS agencies serving urban, suburban and/or rural populations and 2 air EMS agencies.

92.1% of laryngoscopy events were performed by ALS paramedics. The remainder was performed by students, nurses and physicians.

Age: not reported for entire population</td><td>N/A</td><td>N/A</td><td>• Failure to place ET tube as reported by the paramedic. 13.4%
• 93% of cardiac arrest were successful
• 72.5% of non-arrests were successful

• Factors associated with of failed ETI:
o Trismus: OR 9.72 (95% CI 4.59-20.56)
o Inability to pass ET tube through cords: OR 7.65 (95% CI 3.56-16.45)
o Inability to visualize cords: OR 7.64 (95% CI 3.97-14.71)
o Intact gag reflex: OR 7.06 (95% CI 3.55-14.03)
o IV access prior to ETI attempt: OR 3.18 (95% CI 1.64-6.16)
o Increased weight (ordinal scale <100 lbs, 50 lb increments, highest scale >400lbs): OR 1.56 (95% CI 1.24-1.95)</td></tr>
</table>

			Gender: not reported for entire population Medical: NR Trauma: NR RSI: Excluded. Excluded: pregnant females, prisoners, age <18.			○ ECG Monitoring prior to ETI attempt: OR 0.20 (95% CI 0.08-0.47) Hosmer-Lemeshow goodness of fit: p=0.471 (good model fit). AUC of ROC curve 0.91 (excellent model discrimination)
Fakhry 2006[36]	Retrospective review	175	All trauma patients (all ages) who underwent rapid sequence intubation attempt by an ALS paramedic over a 4 year period and were transported to a large suburban teaching hospital by the aeromedical EMS service. Age: 31.9 years +- 19.2 Male 74% Medical: Not Applicable Blunt trauma 91% ISS 25.7 +/-13.9 GCS 4.8 +- 2.4 Agents: Midazolam or etomidate, then vecuronium	N/A	N/A	• RSI success rate: ○ 1st attempt: 70% ○ 2nd attempt: 89% ○ 3rd attempt: 96.6% • RSI failure alternative care rates: • Cricothyroidotomy: 2.3% • Bag valve mask: 1.1% • Adverse events: ○ Right mainstem intubation: 2.9% ○ ET tube dislodgement: 1.2% ○ Esophageal intubation: 0% ○ Arterial desaturation <92%: 2.3%
Newton 2008[37]	Retrospective review	175	All trauma patients who received attempted RSI during a 12 month period in a helicopter EMS service. Helicopters were staffed with a physician (emergency medicine, anesthesia or critical care background) and a paramedic. Only physicians perform RSI. Age (mean): 36.1	N/A	N/A	• Hypoxemia (defined as SpO2<90% or if initial SpO2<90%, a drop of >10%) occurred in 18.3% of patients. There was no statistical difference between age, GCS, initial SpO2, or Cormack-Lehane laryngoscopy grade. • Hypotension (defined as an SBP <90mmHg or if initial SBP<90mmHg, a drop of >10mmHg) occurred in 13% of patients. Those who became hypotensive had significantly lower initial SpO2 than those who did not (91.6 vs 96.2%, p=0.01) and significantly lower initial SBP readings (110.8 vs 133.7mmHg, p=0.0002). There was no statistically significant difference in age or GCS. • None of the patients were both hypotensive and hypoxemic,

			years(range 2-85) Gender: NR GCS mean: 10 (range 3-15) Excluded: surgical airway procedures Agents: Etomidate, suximethonium, pancuronium, and morphine or midazolam			however 6 of the 25 patients who were hypotensive had no SpO2 data.
Mackay 2001[38]	Retrospective review	359	All trauma patients undergoing RSI by physicians (10 anethesiologists and 9 emergency physicians) during a two year period by a helicopter EMS service. Helicopters are staffed with one physician and one paramedic and two pilots. Age (C): 34.5 (SD 30) Age (I): 35.7 (SD 33) Gender (C): 147/202 male Gender (I): 120/157 male Medical: N/A Trauma: 100% Agents: Etomidate, suximethonium, pancuronium, followed by propofol or midazolam or morphine	Emergency Physician performed RSI	Anesthesiologist performed RSI	• RSI procedures o C: 202 o I: 157 • Mean (SD) age of RSI patients o C: 34.5 (30) years o I: 35.7 (33.0) years o P=0.58 • Gender o C: 147 males and 55 females o I: 120 males and 37 females o P=0.43 • Baseline characteristics and transport characteristics: o No significant differences between pulse, SBP, SpO2. o Median baseline GCS: o C: 8 o I: 10 o P: <0.009) • Patients with GCS >12 o C: 46/202 o I: 58/157 o P=0.003 • Cormack-Lehene grade 3 or 4 o C: 5% o I: 18% o P<0.0001 • Gum elastic bougie use: o C: 122/202 o I: 80/157 o P=0.024 • Repeat attempts at intubation: o C: 0.5% o I: 1.9% o P=0.47 • Surgical airway performed: o C: 1.5%

						○ I: 3.2% ○ P=0.28
DiRusso 2005[39]	Retrospective Review		Trauma patients (<20 years old) transported to one of approximately 90 pediatric hospitals during an 8 year period (land or air not specified). Age: 8.5 years +/- 5.2 Gender: 64% male Trauma: 100% Exclusions: burns, drowning, poisoning	N/A	N/A	• Patients intubated in the field were more likely to die than those intubated in a trauma centre (visually presented) (unadjusted and after risk stratification) • This held true across all 3 classes of severity (mild, moderate, severe). • Transport times were longer for patients intubated in the field compared to those intubated in the trauma centre (119 minutes vs 88 minutes, P<0.01)

Theme 4 - Ground Vehicle Safety (n=9)

<table>
<tr><th>Citation</th><th>Method</th><th>N</th><th>Population</th><th>Intervention</th><th>Control</th><th>Outcome</th></tr>
<tr><td>Bull 2001[40]</td><td>Prospective Experiment</td><td>30</td><td>Infant manikins (8kg)
3 year old manikins (18kg)
6 year old manikins (27kg)</td><td>Various backrest and seatbelt positions</td><td>N/A</td><td>“Unsatisfactory” restraint in the positions tested (not described).</td></tr>
<tr><td>Levick 2005[41]</td><td>Prospective observational study</td><td>36 ambulances

>250 drivers</td><td>Metropolitan ground ambulance service</td><td>Real-time auditory feedback to driver regarding
-speed
-braking
-turning forces
-seat belt use</td><td>No feedback

(3 months)</td><td>• Violations in traffic rules were assigned points (penalties). Penalties were reported as “miles traveled per penalty”.
• Frequency of penalties
o I: 15.8 miles between penalty counts
o C: 0.018 miles between penalty counts
o P: not reported (report an 878 fold improvement)</td></tr>
<tr><td>Kahn 2001[42]</td><td>Retrospective review</td><td>339 crashes
405 fatalities
838 other injuries</td><td>US NHTSA database 1987-1997

All fatalities and injuries from ambulance crashes in the database (paramedics, patients, passengers, occupants of other vehicles, pedestrians)</td><td>N/A</td><td>N/A</td><td>• 339 ambulance crashes
• 405 fatalities (patients, paramedics, others)
• 838 other injuries
• Time of day 1200-1800: 39%
• Clear weather: 77%
• Intersection: 53%
• Year: NS p 0.33
• Season: NS p 0.74
• Weekday: NS p 0.57
• Lights and Sirens: 60% crashes, 58% fatalities</td></tr>
<tr><td>Becker 2003[43]</td><td>Retrospective review</td><td>305</td><td>US NHTSA FARS database and GES database 1988-1997

Ambulances, fire trucks, police cars involved in a collision

Cannot distinguish between a patient and a provider or other passenger</td><td>N/A</td><td>N/A</td><td>Number of crashes
<table>
<tr><th></th><th>Fatal crashes N (%)</th><th>Non-Fatal Crashes</th><th>Total crashes</th></tr>
<tr><td>Ambulances</td><td>305 (0.82)</td><td>36693</td><td>36998</td></tr>
<tr><td>Fire trucks</td><td>166 (0.55)</td><td>29790</td><td>29956</td></tr>
<tr><td>Police cars</td><td>1113 (0.60)</td><td>183871</td><td>184984</td></tr>
</table>
Fatalities
<table>
<tr><th></th><th>Emergency Vehicle Occupants N (%)</th><th>Others</th><th>Total</th></tr>
<tr><td>Ambulances</td><td>74 (21)</td><td>286</td><td>360</td></tr>
<tr><td>Fire trucks</td><td>43 (22)</td><td>152</td><td>195</td></tr>
<tr><td>Police cars</td><td>228 (19)</td><td>971</td><td>1199</td></tr>
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<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>Injuries<table><tr><td></td><td>Emergency Vehicle Occupants N (%)</td><td>Others</td><td>Total</td></tr><tr><td>Ambulances</td><td>10398 (45.3)</td><td>12545</td><td>22943</td></tr><tr><td>Fire trucks</td><td>3660 (34.8)</td><td>6851</td><td>10511</td></tr><tr><td>Police cars</td><td>49950 (54.7)</td><td>45442</td><td>91392</td></tr></table></td></tr>
<tr><td>De Graeve 2003[44]</td><td>Observational before-after</td><td>N not reported</td><td>Ground 911 - Mobile Intensive Care Units (2nd tier) staffed by physicians</td><td>Briefing with drivers on driving habits and expectations to not exceed 140km/hr and weekly feedback</td><td>“Fleetlogger” onboard computer installed on MICUs recorded data such as speed and harsh breaking but provided no active feedback</td><td>Occurrence of “Risky” behaviours: speed and harsh braking
Maximum Speed (Highway)
I: 143 +- 12 km/hr
C: 167 +- 18 km/hr
P<0.0001
Maximum Speed (Secondary Roads)
I: 108 +- 15 km/hr
C: 121 +- 29 km/hr
P<0.0004
Harsh Braking
I: 10.51 events per 10km
C: 18.25 events per 10km
P value NR</td></tr>
<tr><td>Johnson 2006[45]</td><td>Survey tool</td><td>302 respondents of 446 potential respondents (response rate = 67.7%)</td><td>All out-of-hospital providers (22% BLS EMT, 70% ALS Paramedic) in 2 public utility ground EMS services in a metropolitan area

Age: NR
Gender: 63% male

Years of Experience
25% 0-4
26% 5-9
16% 10-14
12% 15-19
21% 20+</td><td>N/A</td><td>N/A</td><td>Self-reported never receiving training on securing children for transport: 9.3%
Self-reported knowing “nothing, little, or some” regarding how to secure a critically ill infant for transport: 56.6%
Self-reported knowing “nothing, little, or some” regarding how to secure a critically ill child for transport: 52.3%
Self-reported knowing “nothing, little, or some” regarding departmental procedures for proper restraint of children in the ambulance: 33.4%
Self-reported knowing “nothing, little, or some” regarding the operation of child restraint system on the ambulance: 28.7%
Where to transport a nonpatient child: 42.1% correct
The best way to secure a child seat in the patient compartment: 59.9% correct
23% of providers report “sometimes, almost always or always” transporting stable children on the parent’s lap</td></tr>
<tr><td>King 2002[46]</td><td>Survey tool</td><td>90/153 (response rate 59%)</td><td>Program managers from ground and air pediatric / neonatal transfer services.</td><td>N/A</td><td>N/A</td><td>1 incident for every 1000 transports
0.546 injuries per 1000 transports
42% of respondents report being in at least one collision or crash in the previous 5 years.</td></tr>
</table>

						• 57/66 ground ambulance • 6/66 helicopter • 3/66 fixed wing plane All deaths (n=8) were in 2 fixed wing and 1 rotor wing crashes and were attributed to pilot error and weather. • 16/57 ground ambulances caused injury. o 23 injured persons. o Only 2 were patients. o One was a parent. o The rest (20) were crew. o 16 persons had minor injury (not defined) o 6 persons had moderate injury (not defined) o 1 person had serious injury (not defined) • 9/16 ground collisions were attributed to a third party. • 33% attributed to a team member. • 3 patients were inadvertently extubated during the incident. Self-reported - reasons for safe record: 1) safety policies and practices of the team 2) safety policies and practices of the owner or vendor of the vehicle The number of safety policies ranged from 0-8 with a mean of 4 per team. Features included: 1) restricting travel during inclement weather (59.6%) 2) speed restrictions (42.6%) and adhering to traffic rules during transport (65.4%) 3) having specific safety rules (78.8) and enforcing compliance with these rules (67.3%) 4) inspections and maintenance of equipment (69.2%) 5) shift limits for personnel (36.5%)
Ray 2005[47]	Retrospective review	2038 EMS and 23155 controls	Collisions of EMS and similar sized vehicles	N/A	N/A	Environment: Ambulance crashes occurred with increased frequency in the evenings and weekends compared with similar sized vehicles. No differences observed in environmental and road conditions. Crash Demographics: Ambulances were more likely to be involved in angled collisions while similar sized vehicles were more likely to be involved in rear-end collisions. Ambulances were more likely to be involved in collisions at four-way intersections and traffic signals. Patient Demographics: Ambulance crashes more often involved more than 2 people and more injuries.
Ray 2007[48]	Retrospective review	311 rural and 1434	Collisions of EMS vehicles	N/A	N/A	Day and Time: similar between rural and urban crashes Light conditions: rural crashes occurred more often in darkness

		urban				without streetlights, whereas urban crashes occurred more often on streets with streetlights Weather: rural crashes occurred more often in snowy weather, while urban crashes occurred in rain or on wet roads. Operator error was a more commonly cited cause of crash in urban crashes. Urban crashes were more likely to occur at intersections and traffic lights. Rural collisions were more likely to be head-on or involve striking a fixed object while urban crashes were rear-end or angled collisions. More people were involved in urban crashes than rural crashes, and suffered a greater number of injuries.

Theme 5 – Aircraft Safety (n=6)

Citation	Method	N	Population	Intervention	Control	Outcome
De Lorenzo 1999[49]	Retrospective review	13.13 million flight hours	Records pertaining to all flight hours between 1987 and 1995 flown by the US Army.	Aeromedical flight hours N=741000 hours	Non-aeromedical flight hours N=12389000 hours	Crash rates (events per 100 000 flight hours) control vs intervention: Class A: Serious (loss of life, total permanent disability, or damage >1M USD) 1.86 vs 2.02 Class B: Moderate (serious injury, permanent partial disability, damage 200 000 USD – 1M USD) Class C: Minor (moderate injury, temporary disability, damage <200 000 USD) Class A B and C: 7.37 vs 7.41
Bledsoe 2004[50]	Retrospective review	84	All medical helicopter accidents (defined as an event causing significant damage to an aircraft, injury requiring medical evaluation, resulted in death, or impacted patient care) in the National Transportation Safety Board and the Air and Surface Transport Nurses Association Concern Network Database between 1993 and 2002. Excluded: birdstrikes and precautionary landings.	N/A	N/A	• 80 (95%) were located in the NTSB database • 260 persons involved. • Cause of crash: ○ pilot error 64% • 72 fatalities (0.86 fatalities per event) • 64 injuries (0.76 injuries per event) • 44% of events did not involve injuries or fatalities • 23% resulted in fatalities only • 36% resulted in injuries only • 10% resulted in both injuries and fatalities. • 52% of events occurred between 0700h and 1800h • 48% of events occurred between 1800h and 0700h

Thies 2006[51]	Survey tool and retrospective review		All incidents involving civil EMS helicopters between 1980 and 2001 that were reported to the German Aviation Authority "Luftfahrtbundesamt"
			
			As this database does not include federal police and armed forces crashes, a survey of injuries and deaths from helicopter
				N/A	N/A	27 events between 1980 and 2001
						
						Incidence of injury: 1 per 70372 missions flown
						Incidence of fatality: 1 per 120 638 missions flown
						
						Of 16 events reported to German Aviation Authority:
						• 2/16 events occurred on takeoff
						  ○ (contact with obstacle = 2/2)
						• 2/16 events occurred while cruising
						  ○ (crash into forest during snow storm = 1/2)
						  ○ (crash with handglider = 1/2)
						• 12/16 events occurred while landing
						  ○ (contact with obstacle = 8/12)
						  ○ (car crashed into aircraft before engine shutdown =1/12)

			crashes was completed. The two data sources were amalgamated form a database of EMS helicopter crashes causing injury and death.			○ (helicopter fell over on slope =1/12) ○ (hard landing damaging landing gear = 1/12) ○ (paramedic disembarked before landing maneuver complete = 1/12)
Frakes 2007[52]	Survey tool 8 individual behaviour questions 11 program behaviour questions	126 respondents from 200 potential.	Cluster random selection of helicopter EMS programs in the USA. Respondents: Nurse: 61.1% Paramedic: 30.2% Pilot: 8.7% Hospital program: 60.3% Non-hospital program: 39.7%	N/A	N/A	Adherence to Program Traits • Annual safety review: 99.2% • Aircraft has seatbelts at every seat: 96.0% • Preflight walkaround required: 90.5% • Helmets provided to crewmembers: 89.7% • Routine pre-shift briefing: 86.5% • Initial orientation includes survival training: 84.1% • Written policy allowing mission refusal due to safety concern: 82.5% • Routine post-mission debriefing: 71.4% • Aircraft has clear headstrike envelope at each seat: 70.6% • Program has written policy allowing mission refusal due to fatigue: 50% • Pre-departure checklist required: 41.3% Adherence to Crewmember Traits: • Wear seatbelt and shoulder harness on approach and departure: 99.2% • Wear seatbelt and shoulder harness in cruise flight: 95.2% • Wear hearing protection around running helicopters: 91.3% • Wear helmet during flight operations: 86.5% • Wear over-the-ankle leather boots: 81.7% • Wear long-sleeved fire resistant flight suit: 81% • Wear visor: 55.6% Wear visor (if helmet provided) 61.9% Wear fire-resistant gloves: 15.1% Hospital based programs were less likely to have daily briefings (81.6 vs 94% p<0.05), less likely to have written policy allowing flight refusal for fatigue (40.1 vs 64%, P<0.01), less likely to have written policy allowing flight refusal for safety concern (77% vs 90% P=0.07)
Dery 2007[53]	Survey tool	806 completed and	Non randomized sampling of helicopter EMS pilots in the	N/A	N/A	Crew Resource Management (CRM) / Air Medical Resource Management (AMRM) Questions • I received CRM/AMRM training: 84% (95% CI 81-

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<td>included surveys

(13 duplicates excluded)

Estimated to be 27% of the helicopter EMS pilot population</td>
<td>USA. Advertisements were done in trade journals, through distribution lists and invitations were sent electronically to attract respondents.

Mean age 48.6 (SD 8.1)

Total flight time hours 6625 (SD 3612)

Total flight years Rotor/Commercial 17.8 (SD 11)</td>
<td></td>
<td></td>
<td>86%)
• CRM/AMRM is effective in making our program safer 81% (95% CI 78-84%)
• CRM/AMRM is ineffective because it is not supported by our program: 14% (95% CI 12-17%)
• CRM/AMRM is ineffective because it is not supported by our operator: 10% (95% CI 8-13%)
• CRM/AMRM is ineffective because it is not supported by some flight crews: 24% (95% CI 21-27%)
• CRM/AMRM is ineffective because it is not supported by some pilots: 25% (95% CI 22-28%)

Opinions of Factors Involved in EMS Accidents:
• Pushing weather minimums: 92% (95% CI 90-94%)
• Other pilot decision-making / situational awareness: 83% (95% CI 80-85%)
• Pilots inability to recognize and react to changing conditions: 80% (95% CI 77-83%)
• Pilot complacency: 78% (95% CI 75-81%)
• Lack of IFR training: 74% (95% CI 71-77%)
• Competition: 56% (95% CI 52-59%)

Other Opinions:
• Flight simulators improve safety: 74% (95% CI 71-77%)
• Access to simulators: 29% (95% CI 26-32%
• Night vision goggles are needed to improve safety: 55% (95% CI 51-58%)
• Number of pilots that have night vision goggles: 78/806 (10%)

Three most important factors to improve safety:
• Pilot decision making n=450, 56%
• Quality and frequency of training n=402, 50%
• Night vision goggles n=354, 44%</td>
</tr>
<tr>
<td>Thomas 2005[54]</td>
<td>Survey tool</td>
<td>508</td>
<td>Participants were invited via advertisements in association newsletters and mailing lists and through conventional mail and listservs as well as the internet. The survey was open for 3 months.</td>
<td>N/A</td>
<td>N/A</td>
<td>% of respondents who identified an issue as one of “Top 3 Safety Issues”
<table>
<tr><th>Issues</th><th>A %</th><th>B %</th><th>C %</th><th>D %</th></tr>
<tr><td>Administrative Awareness</td><td>8</td><td>8</td><td>10</td><td>10</td></tr>
<tr><td>Competition</td><td>18</td><td>13</td><td>13</td><td>10</td></tr>
<tr><td>Job satisfaction</td><td>7</td><td>15</td><td>13</td><td>0</td></tr>
<tr><td>Communication and flight following</td><td>4</td><td>12</td><td>5</td><td>14</td></tr>
<tr><td>Aviation training</td><td>9</td><td>10</td><td>5</td><td>14</td></tr>
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			Administrators: 36/508 Aviation: 107/508 Clinical: 357/508 Other: 8/508			

Crew resource management	13	7	11	10
Crew health and safety	12	11	17	10
Safety technology	15	13	12	10
Learning and applying past lessons	6	7	10	19
Aging industry	7	3	3	5

Types of Respondents:
A = administrators
B = aviation
C = clinical
D = other

Theme 6 – Interfacility Transportation (n=13)

Citation	Method	N	Population	Intervention	Control	Outcome
Lim 2008[55]	Prospective cohort study The objective was to quantify adverse events during emergency neonatal interhospital transfers	346	All emergent neonatal interhospital transfers during a six month period. Age: median 32 weeks (range 23 weeks to 9 months post-term) Gender: NR Exclusions: Elective transfers	Staff were asked to document on a specific form any event that could lead to a less than 100% perfect transfer. Unavoidable clinical problems due to the patients inherent clinical illness were not deemed adverse events.	N/A	Risk level of each adverse event was categorized as: 1) 0% catastrophic (potential to cause death) 2) 6/204 major (potential to cause permanent harm) 3) 22/204 moderate (potential to cause temporary incapacity) 4) 32/204 minor (potentially causes minor injury or non permanent damage) 5) 143/204 insignificant • Of 346 transfers, 36.1% had at least one adverse event. • 201 adverse events occurred in the 6 month period. • 21% of adverse events were due to equipment problems. o 9% of adverse events were due to incubator problems o 9% of adverse events were due to ambulance problems • 55% of adverse events occurred after the team arrived at the sending facility and before the team arrived at the receiving facility. • 30% of adverse events occurred before the team arrived at the sending facility. • 15% of adverse events occurred after arrival at the receiving facility. • 69/204 events occurred during preparation of the patient for the transfer. o 21 events due to faulty equipment o 16 events were due to incomplete documentation of the patient's details o 8 events occurred from failure to initiate intravenous access • 15/204 events occurred while transferring care to the receiving facility (incubator and ventilator switchover problems) • 49/204 events were due to communication problems o 25 events between the team and the referrer o 14 events occurred during handover at the receiving hospital o Most of these communication events occurred due to inaccurate information being given to the transfer team • 27 adverse events were associated with transport of the patient. o 8 vehicle breakdowns occurred

						• 10 adverse events were associated with dispatch (ie staffing problems and failure to bring appropriate equipment).
Flabouris 2006[56]	Prospective cohort study	272	Four interfacility retrieval organizations staffed by physicians and paramedics and nurses utilizing helicopters, fixed wing aircraft and ground vehicles during an unspecified time period. Age of patients with adverse events: median 42.4 years (range 0.01–84 years) Gender: 46% males	An incident report form designed to capture adverse events.	N/A	272 incidents on 125 forms (50% of forms described multiple incidents) Physicians reported 67%, nurses reported 32%, and paramedics reported 1%. • Preparedness problems 20/272 • Equipment problems 98/272 o Equipment failure 38% o Equipment unavailable 15% o Breathing circuit problem 8% o Other 7% o Oxygen not available 7% o Loss of vascular access 7% o Inadequate/inappropriate equipment 5% o Damaged equipment 4% o Safety equipment not available 4% o Incorrectly secured equipment 2% • Patient Care problems 69/272 o More severe condition than expected 22% o Patient not prepared by sending facility 19% o Receiving hospital not prepared 12% o o Airway problems 12% (includes esophageal intubation, accidental extubation, endobronchial intubation, airway obstruction) o Medication effort 10% o Deterioration of patient condition 10% o Inadequate preparation for transport 6% o Procedure technically difficult to perform 6% • Transport problems 30/272 o Difficulty with patient transfer or loading 20% o Problem with vehicle configuration for transport 20% o Other problems relating to vehicle 13% o Delay in arrival of ambulance to meet patient 10% o Retrieval aborted or postponed due to weather 10% o Aviation problem 7% o Unsuitable landing site 7% o Weather forecast delayed 4% o Vehicle failure 4% • Interpersonal communication problems o Receiving hospital not aware of patient's condition 28%

						○ Problem with staff communication 24% ○ Inaccurate patient information from site 20% ○ Staff unhelpful or uncooperative 16% ○ Unprepared documentation 12% System Based contributing factors • Equipment / monitoring / support services 19.7% • Team cognitive problems 11.3% • Management / corporate culture 9.6% • Protocols / policies 6.9% • Staff training / staffing levels 5% • Supplies / labeling 1.2% Human Based contributing factors • Violation / rule based 18.8% • Skill based 15% • Knowledge based 9.1%
Hatherill 2003[57]	Retrospective review	202	Children (age not defined) transported to the pediatric intensive care unit of a single pediatric academic hospital by paramedics (82%) or physicians during a 12 month period. Mode of transport included helicopter, fixed wing aircraft and ground units. Median age 2.78months, IQR 1.1-14. Excluded: children with less than a 1% probability of death predicated by pediatric index of mortality.	N/A	N/A	• Technical adverse events (36% of children) ○ No venous access 6% ○ Venous access lost 13% ○ No cardiovascular monitoring 11% ○ ETT malpositioned 25% (of ETI patients) ○ ETT esophageal 6% (of ETI patients) • Clinical adverse events (27% of children) ○ Shock 14% ○ Hypoxia 13% ○ Hypoglycemic 6% • Critical adverse events 9% ○ Of non-intubated patients, 13% required immediate intubation and ventilation on arrival at the ICU ○ Cardiac or respiratory arrest 6% Children transported by ICU staff had less chance of misplaced ETT (0% vs 29% p=0.01), less chance of technical adverse event (0% vs 40%, p=0.0002).
Belway 2006[58]	Systematic review	6 cohort studies	3 studies examined adult patients, 1 involved pediatric patients and 2 involved patients of all ages.	N/A	N/A	Only 1 study demonstrated improved outcomes when specialist staff transported the patient. There is a lack of rigorous studies in the field of interfacility transport.
Deasy 2007[59]	Retrospective	105	Consecutive patient	N/A	N/A	• 59% of cases involved advanced notification of the

	review		transfers arriving at an academic hospital during a 3 month period			receiving facility. • 22% of trauma cases were transported with a physician. • 52% of trauma cases has intravenous access on arrival. • 11% were transferred without notes or radiology reports. • 5% of patients had inadequate spinal immobilization in place on arrival.
Fan 2006[60]	Systematic review	5 studies	All 5 studies were case-series and two were prospective designs. Air and ground transport was represented. Results were reported qualitatively.	N/A	N/A	• Heterogeneity in study design precluded pooling of results. • Death during transport was rate (n=1). • One study reported 19% incidence of respiratory alkalosis. • One study reported an overall 30% ICU mortality rate. • Insufficient data exists regarding interfacility patient transport.
Ligtenberg 2005[61]	Prospective cohort study	100	Consecutive interhospital transfers of ICU patients during a 14 month period by a physician and ICU nurse (57%) or ICU nurse and ambulance nurse (23%) or ambulance nurse (20%). Mean age (SD): 54.7 +-1.7 Gender: 51% male			Adverse events were recorded in 34/100 (34%) of transfers. • 50% of these were attributed to ignoring advice by the receiving facility • 30% attributed to technical problems during transport
Moss 2005[62]	Retrospective cohort study	2402 transfers 562 transfers with at least one adverse event	All neonatal intensive care land transports to an academic children's hospital by a physician and nurse paediatric ICU team during a 8 year period. Age: NR Gender: NR	Cases between 2002-2004 Agreement with ambulance service and hospital transport team to ensure ambulance availability and specified response times and cooperation between hospital and ambulance service to ensure equipment compatibility	Cases between 1997-2001	Progressive decline in adverse events 395 events /1381 transfers vs 167 events /1021 transfers, p<0.001 Ambulance delays decreased from 11.4% of all events in the first time period to 3.9% of al events during the second time period (P<0.001) Ambulance equipment failure decreased from 5.2% of all events to 2.5% of all events (p=<0.005). Major incidents decreased from n=42/1381 to n=16/1021 p<0.03. Error was a contributor to events in 95/1381 transfers vs 41/1021 transfers, p=0.004).
Lees 2008[63]	Retrospective review	555	All patients with primary cardiac	N/A	N/A	`75% of patients did not require intervention.

			problems transferred to a tertiary care centre by a nurse or intensive care paramedic or physician via land or helicopter or fixed wing aircraft during an 18 month period. Age: NR Gender: 63.8% male Excluded: <15 years old, repatriations, died prior to transport team arriving, were not transported, referred and transferred by another service			17% of cases were low dependency requiring interventions routinely given by paramedics and nurses 8% were critical or high dependency requiring intervention that can only be administered by physicians. During-transport interventions: Medication administration: 101 Defibrillation: 3 Pacing: 2 CPR: 1 Intubation and ventilation: 4
Limprayoon 2005[64]	Retrospective review	36	All pediatric patients (up to 13 years of age) transported to an academic pediatric ICU by land ambulances staffed with nurses and paramedics during a 2 year period Age: 4 months to 13 years range. Mean or median not reported. Gender: 44.5% male	N/A	N/A	30.5% of patients died before being discharged from the receiving hospital. On arrival, 1 patient had ETT obstruction due to secretions and 5 patients were hypotensive.
Lee 2008[65]	Prospective observational study	102	All adult (age not defined) patients undergoing interfacility transfer by ground from a single hospital with a physician-led or nurse-led team. Age: NR Gender: 57% male Exclusion: obstetrics	Application of TISS-28 score to predict deterioration en route. Application of MEWS score to predict deterioration en route.	N/A	There was no difference of TISS-28 scores between patients who deteriorated during transport and those who did not. AUC 0.53 (95% CI 0.4-0.66). Higher MEWS scores were associated with patients with more frequent occurrences of deterioration en route (P<0.001). AUC 0.71 (95% CI 0.6-0.81) Deterioration occurred in 27% of cases (28/102). Cardiac or respiratory arrest: 1 Desaturation (SpO2<90% or drop in >4%): 4 Systolic hypotension (<90mmHg): 14 Tachycardia >140: 7 GCS drop >2: 5

						Hypothermia (<35C): 2
Uusaro 2002[66]	Retrospective review	66	Consecutive critically ill patients undergoing interfacility transfer to a tertiary ICU because of severe respiratory failure (79% had acute respiratory distress syndrome) by ground transport during a six year period. The transport team included one intensive care physician, one nurse, and two paramedics. Age: 39 +/- 16 years Gender: 65% male	N/A	N/A	• Lowest mean arterial pressure: 65 +/- 11mmHg • pH decreased from 7.32 +/- 0.08 before transfer to 7.30 +/- 0.11 after transfer (p=0.043) • PaCO2 increased from 7.08 kPa +/-2.17 before transfer to 8.14 kPa +/- 2.05 after transfer (p=0.002) • There were no major medical or technical complications during the transfer. • ICU mortality was 30% • No deaths were related to the transfer.
Duke 2001[67]	Retrospective case-control	73 cases	All adult patients requiring intensive care services and needing interfacility transfer by ground ambulance with a medical escort from the sending facility during a three year period. Age: median 54.8 years (IQR 36.4-67.2) Gender: 53%	Patients who were transferred, but could have received diagnostic and therapeutic interventions at the sending facility	Patients admitted to ICU at a tertiary care centre who did undergo interfacility transfer	84% of patients required transfer due to closure of beds at the sending facility No deaths occurred during transfer Transferred patients experienced a higher mortality risk (51% vs 27%, P=0.006) although the odds of death were no different (OR 1.5, 95% CI 0.68-3.4).
Linden 2001[68]	Prospective observational study	29	Patients (all ages) requiring extracorporeal membrane oxygenation (ECMO) deemed too unstable for transport to a tertiary care centre and subsequently transported by a mobile ECMO team by land, fixed wing or helicopter during a five year period. Age: NR	N/A	N/A	No patient complications occurred during transport Two technical complications occurred during transport: 1) malfunction of ambulance compressor, vehicle had to reduce speed to complete transfer 2) malfunction of electric supply circuit resulting in no lights in the cabin (flashlights used) 21/29 (72%) of patients survived to hospital discharge. There were deaths during transport.

			Gender: NR			
Gebremichael 2000[69]	Retrospective review	39	Intensive care patients transferred to a tertiary care hospital Ground interfacility transfer staffed by a physician, nurse and respiratory therapist during a two year period. Age: mean 36 years (range 14-62) Gender: male 59%	N/A	N/A	2/39 patients experienced complications during transfer. • One died while being transferred from the sending facility bed to the transport bed. • One patient experienced transient hypotension relieved by fluid bolus en route 2 additional patients died within 6 hours of admission 19 patients survived to hospital discharge (49%)

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