Using a Quality Framework to Explore Air Ambulance Patients' Journey Outcomes in Central Queensland, Australia

Kristin H. Edwards, RN, MSN;[1] Richard C. Franklin, PhD;[1] Rhondda Jones, PhD;[1] Petra M. Kuhnert, PhD;[2] Sankalp Khanna, PhD[3]

1. James Cook University, College of Public Health, Medical, and Veterinary Sciences, Townsville, Queensland, Australia
2. The Commonwealth Scientific and Industrial Research Organization (CSIRO) Data61, Darwin, Northern Territory, Australia
3. CSIRO, Australian e-Health Research Centre, Brisbane, Queensland, Australia

Correspondence:
Kristin Edwards
James Cook University
College of Public Health, Medical, and Veterinary Sciences
1 James Cook Drive
Townsville, Queensland, Australia
E-mail: kristinedwards2016@gmail.com

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Keywords: air ambulance; health care quality; mortality; patient outcome assessment; prehospital emergency care

Abbreviations:
ANOVA: Analysis of Variance
ARIA+: Accessibility/Remoteness Index of Australia
CQHHS: Central Queensland Hospital and Health Service
ED: emergency department
ICD-10-AM: International Classification of Diseases, Australian Modification, 10th Revision
ID: identification
IOM: Institutes of Medicine
LOS: length-of stay
SSB: Statistical Service Branch

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Abstract

Introduction: In Australia, aeromedical retrieval provides a vital link for rural communities with limited health services to definitive care in urban centers. Yet, there are few studies of aeromedical patient experiences and outcomes, or clear measures of the service quality provided to these patients.

Study Objective: This study explores whether a previously developed quality framework could usefully be applied to existing air ambulance patient journeys (ie, the sequences of care that span multiple settings; prehospital and hospital-based pre-flight, flight transport, after-flight hospital in-patient, and disposition). The study aimed to use linked data from aeromedical, emergency department (ED), and hospital sources, and from death registries, to document and analyze patient journeys.

Methods: A previously developed air ambulance quality framework was used to place patient, prehospital, and in-hospital service outcomes in relevant quality domains identified from the Institutes of Medicine (IOM) and Dr. Donabedian models. To understand the aeromedical patients' journeys, data from all relevant data sources were linked by unique patient identifiers and the outcomes of the resulting analyses were applied to the air ambulance quality framework.

Results: Overall, air ambulance referral pathways could be classified into three categories: Intraregional (those retrievals which stayed within the region), Out of Region, and Into Region. Patient journeys and service outcomes varied markedly between referral pathways. Prehospital and in-hospital service variables and patient outcomes showed that the framework could be used to explore air ambulance service quality.

Conclusion: The air ambulance quality framework can usefully be applied to air ambulance patient experiences and outcomes using linked data analysis. The framework can help guide prehospital and in-hospital performance reporting. With variations between regional referral pathways, this knowledge will aid with planning within the local service. The study successfully linked data from aeromedical, ED, in-hospital, and death sources and explored the aeromedical patients' journeys.

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Introduction

Aeromedical retrieval in Australia is essential due to a lack of services such as diagnostic imaging in the small hospitals accessible to rural communities, the concentration of medical specialists in larger hospitals, and vast distances between major population centers.[1,2] Yet, there is limited understanding of aeromedical patient outcomes due to a lack of comprehensive patient data.[3,4]

This study builds upon an understanding of the patients' journeys (ie, the integrated, continuums of care that span multiple settings; prehospital and hospital-based pre-flight, flight transport, after-flight hospital in-patient, and disposition)[3,4] and outcomes by linking aeromedical data with emergency department (ED), in-hospital, and death data. When patients' journey data are pieced together by a unique patient identification (ID), it creates a more complete picture of prehospital and in-hospital emergency care.[5,6]

This study will explore whether a previously developed air ambulance quality framework[7,8] is useful when applied to existing air ambulance patients' journeys using outcomes from linked data analysis. It is hypothesized that the framework will help guide prehospital and in-hospital performance reporting and improve the planning and delivery of aeromedical services. Until now, the frameworks'[8] utility to accommodate actual patient outcome and service variables has not been explored. These variables include patient mortality, receiving hospital or ED disposition, aeromedical aircraft type, the patients' sending facility rurality, receiving facility admission type (ie, via ED or direct hospital admission), and number of flights per patient by regional referral pathways.

The recently published air ambulance quality framework[8] was developed based on a scoping review which examined air ambulance independent and dependent outcome variables used in the literature.[7,8] However, the framework has not been applied and using linked data should provide better understanding of outcome measures.[7,8] The aeromedical framework combined generally accepted quality measures from the Institutes of Medicine (IOM; Washington, DC USA)[9] and Dr. Avedia Donabedian.[10] The six IOM[9] service provision domains included: "*Effective,*" "*Efficient,*" "*Safety,*" "*Patient-Centered,*" "*Timely,*" and "*Equitable.*" The three Donabedian[10] measures included: "*Structure,*" "*Process,*" and "*Patient Outcome.*" The performance themes of air ambulance outcome measures were previously identified by using a four-phased content analysis process.[8] The process was chosen to increase transparency and reproducibility.[8] Performance theme categorization was done with qualitative content analysis using an origination approach[11] (ie, identifying meaning in the clinical and air ambulance context based on the authors' combined professional aeromedical and hospital experience). The co-authors agreed on eight performance themes (Asset/Team Type, Access to Definitive Interventions, Prehospital Factors, Mortality, Morbidity, Responsiveness of Service, Accessibility of Service, and Patient's Disposition).[8] The patient, prehospital, and in-hospital service outcomes (Supplementary Files S1, S2, S3; available online only) were selected for their relevance to the previously determined performance theme categories[8] (found in bold font in Table 1). The intention of the aeromedical framework presentation in Table 1 was to examine whether patient outcome and process measures of air ambulance and in-hospital services could be categorized into quality themes to help guide performance reporting and improvement planning.[7,8] It was not the intent to impose rigid replication of the selected outcome measures[12] for other air ambulances services due to the significant variation between service system structures, governance, and management.[8]

In Queensland, Australia, 16 jurisdictions (or regions) with political and economic boundaries were developed to manage health service needs.[2] However, hospital service capability levels vary among regions. Some regions exclusively provide rural hospital level capability (few specialties) which often require transfer to regions with higher capability; regional hospital level capability (more differentiated); and tertiary hospital level capability (highly specialized). Referral of patients toward appropriate levels of care is called referral pathways.

Central Queensland Hospital and Health Service (CQHHS; Supplementary Files S4, S5; available online only) is used here to explore prehospital and in-hospital aeromedical service outcomes. Rockhampton Public Hospital (Rockhampton, QLD, Australia), the main regional capability level hospital serving the entire CQHHS region, accepts patients from 16 small, rural capability level hospitals within its own boundaries, and from two large, adjacent rural/remote service regions (Central West and South West) which lack both regional capability level and tertiary hospital services.[13] Currently, CQHHS covers a geographical area of 44,016 square miles (114,000 sq kms) and had an estimated resident population of 217,449 during the study period.[13] However, the CQHHS region lacks tertiary-level health services. The closest tertiary services are 466+ miles (750+kms; approximate eight-hour ground transport time) from the CQHHS regional capability level hospital. Moreover, rural and remote patients with complex chronic illnesses may require frequent flights for interventions (eg, mental health crises or medical non-compliance) due to the large distances to the CQHHS regional capacity level hospital. Moreover, ground transportation options for patients may be limited: if patient lacks access to a car, utilizing a rural ambulance will remove the only emergency service transport and paramedic from the community for many hours; or ground transport is not safe for patients or ground staff.[14] The lack of rural health services and the vast distances are examples demonstrating the necessity of aeromedical retrieval in the CQHHS region.

Methods

This is a descriptive, retrospective cohort study of patients retrieved on a dedicated, medical-specific aircraft via one of the three referral pathways: (1) between facilities within CQHHS; (2) departed from a facility within CQHHS to a hospital outside the district; or (3) arrived into CQHHS from a facility outside the district. Data sources from aeromedical, ED, and hospital records were collected from January 1, 2011 through December 31, 2015. Death registry data covered the period from January 1, 2011 through June 30, 2019. Human research ethics approval was granted by the CQHHS HREC (CQC/16/HREC/8) and the Queensland Department of Health (Brisbane, QLD, Australia; RD007591).

Queensland Health (Brisbane, QLD, Australia),[2] the State's public health provider, requires data linkage to be completed by the internal Statistical Service Branch (SSB) to maintain patient confidentiality and reduce information bias.[6] The SSB utilized deterministic and probabilistic data linkage methods.[6] The SSB generated a set of data linkage keys to be used by researchers.[6] Each patient was given a unique patient ID. Record linkage used the dates and times associated with each patient ID to match the end of one patient care episode to the start of the next care episode for that patient. A total of 13,977 patient episodes were linked

IOM Domains	Donabedian Structure ***Material Resources, Organizational Structures***	Donabedian Process ***How Care is Given and Received***	Donabedian Patient Outcome ***Patient State Resulting from Care***
Effective *Providing Evidence-Based Care for Those that can Benefit, Refraining from Services to those Not Likely to Benefit*	†**Asset Type** *(Aircraft)*	†**Access to Definitive Interventions** *(Relating to Patient Management)*	†**Hospital Mortality**
	Service Performance Measure: Appropriate allocation of aircraft type.	Service Performance Measure: Receiving facility pathway (*admission via ED compared to direct hospital admission*).	Patient Outcome Measure: Hospital mortality.
	Overall Findings: 88% of the overall total (12,242 episodes) were fixed-wing flights.	Overall Findings: 47% (6,507 episodes) were admitted via the ED.	Overall Findings: 3% died in the hospital (188 patients).
	Pathway Variations: The 'OUT of Region' had 96% (7,453 episodes) fixed-wing flights, compared to Intraregional with 66% (2,345 episodes) fixed-wing flights, and 'INTO Region' 92% (2,444 episodes).	Pathway Variations: 'OUT of Region' had 26% (2,017 episodes) of admission via the ED, compared to Intraregional 77% (2,738 episodes), and 'INTO Region 66% (1,752 episodes).	Pathway Variations: 'INTO Region' 7% (62 patients) died in the hospital, compared to 2% in both Intraregional (17 patients), and 'OUT of Region' (109 patients).
Efficient *Avoiding Waste; Equipment, Energy, Supplies, Time*	† **Asset Allocation** (*Priority Category*)	†**Responsiveness of Service** *(Compliance of Clinical Standards Relating to Efficiency)*	†**Patient Outcome** *Effects of Direct Cost to Patient
	Service Performance Measure: Allocation of P4 & P5 tasks (ie, lower priority).	Service Performance Measure: Sending hospital length-of-stay (LOS).	
	Overall Findings: 61% (8,468 episodes) were P4 & P5 priority categories.	Overall Findings: The sending hospital LOS mean was 4.1 days.	
	Regional Pathway Differences: The 'INTO Region' had 75% (2,011 episodes) of P4&P5 compared to Intraregional of 32% (1,123 episodes).	Regional Pathway Differences: The 'INTO Region' sending hospital LOS mean was 10.3 days compared to Intraregional sending hospital LOS mean was 1.1 days.	
Safety *Avoiding Injury, Further Loss of Tissue, or Deterioration*	†**System Safety Indicators** (*Upward Utility Trends*)	†**Responsiveness of Service** *(Compliance to Established Clinical Standards Relating to Safety)*	†**Overall Mortality**
	*System safety indicators in place for upward utility trends (ie, governance of pre-threshold alarms).	Service Performance Measure: Sending ED length-of-stay (LOS).	Patient Outcome Measure: Overall mortality.
		Overall Findings: Sending ED LOS mean was 4.3 hours.	Overall Findings: 14% (1,928 patients) morality during the death data collection period (9 years).
		Regional Pathway Differences: The 'OUT of Region' sending ED LOS mean was 4.8 hours compared to Intraregional sending ED LOS mean was 2.9 hours.	Regional Pathway Differences: Intraregional had 9% of all death overall (304 patients) compared to 'INTO Region' 25% (675 patients).
Patient-Centered *Respectful and Responsive to Patient Preferences, Needs and Values*	†**Accessibility of Service** *(Aircraft/ Team Allocation Relating to Patient-Centeredness)*	†**Access to Definitive Interventions** (*Relating to Patient-Centeredness*)	**Patient Outcome** *Patient Comfort and Satisfaction
	Service Performance Measure: Number of aeromedical flights per patient.	Service Performance Measure: Aeromedical P4&P5 request-to-activation interval time.	
	Overall Findings: 79% (8,575 patients) required one flight during the study period.	Overall Findings: The P4&P5 request-to-activation interval mean was 21.9 hours.	
	Multiple Flight Differences: 2% of multiple flight users (53 patients) required two flights in 24 hours, one of which was a back-transfer.	Regional Pathway Differences: The Intraregional P4&P5 request-to-activation interval mean was 10.1 hours compared to the 'INTO Region' mean was 27.8 hours.	

Table 1. Patient and Service Outcomes Situated by Performance Themes in the Air Ambulance Quality Framework (*continued*)

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IOM Domains	Donabedian Structure ***Material Resources, Organizational Structures***	Donabedian Process ***How Care is Given and Received***	Donabedian Patient Outcome ***Patient State Resulting from Care***
Timeliness *Reducing Waiting and Delays for Those that Give and Receive Care*	**†Responsiveness of Service** *(Clinical Standards in Place Relating to Timeliness)*	**†Responsiveness of Service** *(Service Time Intervals Relating to Timeliness)*	**†Mortality 0-7 days After Aeromedical Flight**
	Service Performance Measure: Aeromedical task type.	Service Performance Measure: Receiving ED length-of-stay (LOS).	Patient Outcome Measure: Mortality 0-7 days after aeromedical flight.
	Overall Findings: 7% (945 episodes) were primary tasks.	Overall Findings: The receiving ED LOS mean was 3.6 hours.	Overall Findings: 12% (234 patients) of all death overall occurred 0-7 days after flight.
	Regional Pathway Differences: 'OUT of Region' had 2% (176 episodes) of primary tasks compared to Intraregional 17% (599 episodes) of primary tasks.	Regional Pathway Differences: The 'INTO Region' receiving ED LOS mean was 4.6 hours compared to 'OUT of Region' receiving ED LOS of 1.7 hours.	Regional Pathway Differences: The Intraregional had 18% of all death overall, occurred 0-7 days after flight (55 patients), compared to 'INTO Region' with 9% (60 patients).
Equitable *Care that Does Not Vary According to Gender, Ethnicity, Geographic Location, Socioeconomic Status, or Age*	**†Accessibility of Service** *(Service Allocation Relating to Equity)*	**†Patient Disposition** *(Discharge Relating to Equity)*	**†Mortality >1 Year After Flight**
	Service Performance Measure: Sending facility rurality.	Service Performance Measure: Receiving ED disposition.	Patient Outcome Measure: Mortality >1year.
	Overall Findings: 50% of sending ARIA+ was inner-regional (6,957 episodes).	Overall Findings: 89% were admitted to the hospital from the ED (5,780 episodes).	Overall Findings: 44% of deaths overall occurred >1 year after flight (838 patients).
	Pathway Differences: The Intraregional pathway had 94% (3,316 episodes) from remote locations, compared to 'INTO region' pathway 59% were from major cities (1,575 episodes) and 'OUT of region' pathway 84% (6,566 episodes) were from inner regional.	Pathway Differences: The Intraregional pathway had 84% admitted to the hospital from the ED (2,302 episodes), 11% discharged home from the ED (290 episodes), and 5% transferred (131 episodes); compared to 'OUT of Region had 95% admitted to the hospital from the ED (1,916 episodes), 4% discharged home from the ED (79 episodes), and 1% transferred (20 episodes); and 'INTO Region' had 89% admitted to the hospital from the ED (1,562 episodes), 7% discharged home from the ED (131 episodes), 3% transferred (47 episodes), and 1% (12 episodes) were LAMA.	Pathway Differences: The 'INTO Region' pathway had 37% of deaths overall occurred >1 year after flight (250 patients), compared to Intraregional 48% of deaths overall occurred >1 year after flight in (145 patients), and 'OUT of Region' had 47% (443 patients).

Table 1. *(continued).* Patient and Service Outcomes Situated by Performance Themes in the Air Ambulance Quality Framework
Note: Patient and service variables are found in Supplementary Files S1, S2, and S3.
Abbreviations: ARIA+, Accessibility/Remoteness Index of Australia; ED, emergency department; IOM, Institutes of Medicine; LAMA, left against medical advice; RFDS, Royal Flying Doctor Service.
†Performance theme findings from previous scoping review.
*Initiatives identified by the research team as areas for linked data to improve and include in future research.

(Figure 1). After the data linkage and analysis was complete, the patient outcomes and service performance variable results were categorized within the performance themes described earlier.[8] This study examined both overall patterns of aeromedical use and the variations among the three referral pathways.

Linked data inclusion criteria were patients retrieved/transported on a dedicated, medical-specific aircraft, all patient ages, genders, and illness/injury types. Exclusion criteria included advice calls and cancelled tasks. Regional referral pathways were defined by the origin and destination location of the flight in relation to the CQHHS jurisdiction. Patients that originated in CQHHS and were flown out of the regions' boundary were labelled "OUT of Region." Patients that originated in CQHHS and were flown within the CQHHS region boundary were labelled "Intraregional." Patients that originated outside of CQHHS and were flown into the CQHHS boundary were labelled "INTO Region."

Illness and injury categories used International Classification of Diseases, Australian Modification, tenth revision (ICD-10-AM)[15] and diagnosis-related groups, refined to represent the Australian hospital service Australian Diagnosis-Related Groups/AR-DRG (version 7.0).[16] In Queensland, the five air ambulance priority categories (P1 = most urgent and P5 = least urgent) were designated

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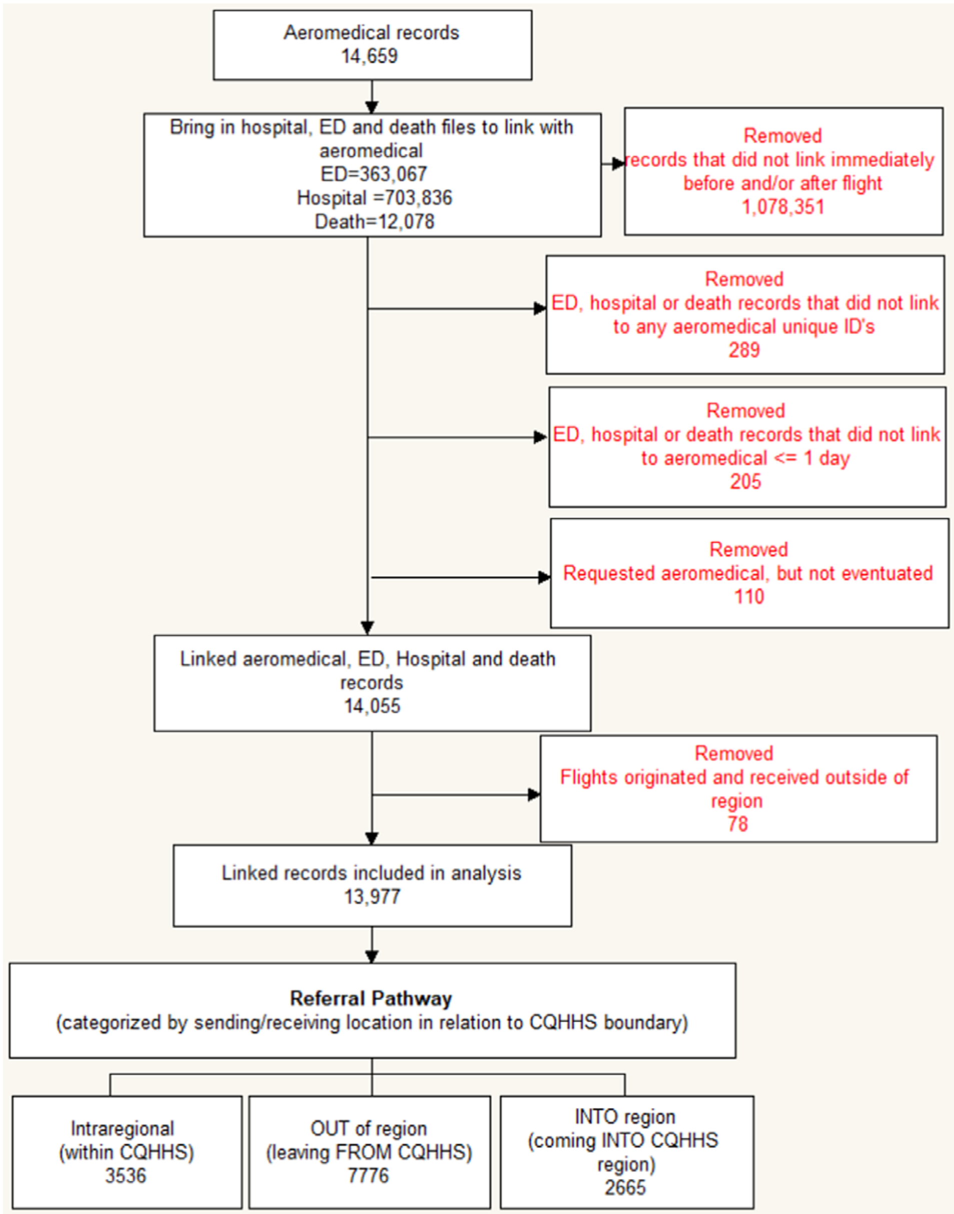

Figure 1. Flowchart of Data Collection where Boxes with Red Text Indicate Records that were Removed from the Study and Those in Black are Records Kept.
Abbreviations: ED, emergency department; CQHHS, Central Queensland Hospital and Health Service; ID, identification.

by Retrieval Services Queensland (RSQ; Kedron, QLD, Australia) for expected targeted crew response time and is a State-wide governance key performance indicator (Supplementary File S6; available online only).[17] Hospital and ED data time was determined by computer entry. Aeromedical data time was determined by standardized clocks or watches. Presentation of the study followed STROBE guidelines to ensure adequate reporting (Supplementary File S7; available online only).[18] The rurality profile of CQHHS was classified using the Accessibility/Remoteness Index of Australia (ARIA+)[19] to define scales of remoteness in Queensland. The ARIA+ was chosen as it is based on measurements of road distance measures to services and number of services available.[19] Age group levels were consistent with Australian recommendations.[20]

Mortality after flight intervals was based on air ambulance outcome measure findings: zero-to-seven days; seven to 31 days; one-to-six months; six to 12 months; and >one year.[21] The number of flights undertaken by each included patient during the study period was counted. Key variables were explored independently so that the variations in the regional referral pathways were better understood. These variables were: patient mortality (Supplementary File S1); patient's receiving hospital or ED disposition; aeromedical aspects (eg, aircraft and task type); patient's receiving and sending facility rurality and length-of-stay (LOS); aeromedical request for service to activation of service time interval; receiving facility admission type (ie, via ED or direct hospital admission); and number of flights per person (Supplementary Files S2, S3).

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Comparisons of data between referral pathways were made using a χ^2 test or Analysis of Variance (ANOVA), as appropriate. Continuous data were summarized using means and standard deviations (SD) and compared using ANOVA. Categorical data were summarized using percentages. Summaries of the frequencies of missing data are provided in Supplementary File S8 (available online only). Cohen's *d* standardized effect size characterized differences between means and Cohen's *h* standardized effect size characterized differences in proportions.[22] The "Intraregional" pathway was the control pathway to compare the "OUT of Region" pathway results and the control to compare "INTO Region" pathway results. Cohen's *d* and *h* reference values consist of: 0.20 (small effect); 0.50 (medium effect); and 0.80 or higher (large effect).[22] Hypothesis testing used a statistical significance level of <0.05. Statistical analysis used R (2019-07-05; version 3.6.1, The R Foundation for Statistical Computing; Vienna, Austria). The R package "*effsize*" (2020-10-05; version 0.8.1) was used to determine Cohen's *d* and R package "*pwr*" (2020-03-16; version 1.3-0) was used for Cohen's *h*.

Results

Results classified according to the air ambulance quality framework are found in the Supplementary Files S1, S2, S3. The overall findings and the results from the regional referral pathway variations are presented for each IOM and Donabedian domain in Table 1. For example, the space where the IOM *Timeliness* and Donabedian *Process* domains intersect falls into the performance theme "Responsiveness of Service." The performance measure "Receiving ED LOS" suited the theme, as it related to the clinical process of timely definitive management of the patient. In the overall study findings, the receiving ED LOS mean was 3.6 hours. However, there were statistically significant referral pathway variations between the "OUT of Region" pathway ED LOS mean of 1.7 hours, the "Intraregional" ED LOS mean of 10.1 hours, and the "INTO Region" ED LOS mean of 4.6 hours (Supplementary File S2).

Of the patients who were retrieved during the study period, 1,928 (14% overall study total) had died by June 30, 2019 (Table 1 [*Safety* row] and Supplementary File S1). Rates of mortality were highest in the "INTO Region" referral pathway (25% pathway total; χ^2=367.8; df=2; P <.001), although differences between pathways were small (Cohen's effect size 0.2). Mortality zero-to-seven days after aeromedical flight also differed between referral pathways with mortality following the "Intraregional" pathway (18% death zero-to-seven-day total) higher than for the "OUT of Region" pathway (9%; χ^2=75.9; df=24; P <.001). Again, differences were small (Cohen's effect size 0.2; Table 1 [*Timely* row] and Supplementary File S1).

Aircraft type also differed between pathways (χ^2=2949.5; df=2; P <.001) with the "OUT of Region" pathway having the largest use of fixed wing aircraft (96% of pathway total) with large differences (effect size 0.84) between "Intraregional" and "OUT of Region" groups (Table 1 [*Effective* row] and Supplementary File S2). Using an ARIA+ scale[19] (ie, remoteness of sending facilities), the total volume of flights from rural sending facilities was largest in the "Intraregional" pathway (95% of pathway total) compared to the total volume of flights from inner regional sending facilities was largest volume in the "OUT of Region" pathway (84% of pathway total; Table 1 [*Equitable* row] and Supplementary File S2).

Receiving ED disposition was most frequently "Admit to Hospital" (89% overall study total), but was less frequent in the "Intraregional" pathway (84% of pathway total) compared to the receiving ED disposition in the "OUT of Region" pathway (95% of pathway total; χ^2=156; df=8; P <.001; Table 1 [*Equitable* row] and Supplementary File S2). Receiving facility admission pathway via the ED (opposed to direct hospital admission) was least frequent in the "OUT of Region" pathway (26% of pathway total) and most frequent in the "Intraregional" pathway (77% of pathway total) with large differences between these two groups (Cohen's effect size 1.1; Table 1 [*Effective* row] and Supplementary File S2). The most common receiving ED ICD-10-AM-specific clinical condition code for the "Intraregional" pathway was appendicitis (6% of pathway total), whereas the most common "OUT of Region" code was myocardial infarct (4% of pathway total; Supplementary File S2).

In total, 10,864 patients flew during the study period (Supplementary File S5). Most of those patients (79%) required only one flight with 21% requiring two to 12 flights. Of the 2,289 patients with multiple flights, 675 were connected to the same episode of care (6% of total patients). There were 53 patients who had one flight toward definitive care and one back-transfer within 24-hours, and 59 patients required three flights within 24-hours. There were three performance areas where measures could not be identified in the available data: the effects of direct cost to patient; safety indicators for upward utility trends; and patient comfort and satisfaction scoring.

Discussion

With limited resources, such as air ambulances, there is an on-going need to ensure that health services are effective, efficient, safe, patient-centered, timely, and equitable. However, to date, there has been limited exploration of these service attributes for air ambulance patients due to a lack of linked outcome data and a framework to accommodate the findings.[8] In this paper, a previously developed air ambulance quality framework[8] was used and found that it could usefully be applied to aeromedical performance using linked data.

As the CQHHS population ages, the complexity of patient presentations increases and demand for health services outpaces population growth, the challenge will be to adapt the availability and the access to health services to meet health needs in the region.[23] This study demonstrated that service comparisons need to take regional referral pathways into account, since patient requirements and outcomes differ among pathways. According to the IOM, failure to identify this kind of variation hinders the ability to recognize service disparites.[12] On-going review of prehospital and in-hospital quality performance in each referral pathway will be critical for the CQHHS region in order to meet future health service needs.

A recent Australian Parliamentary inquiry explored the lack of imaging availability and accessibility outside urban centers.[1] In this study, the frequency of appendicitis admission via ED, rather than direct admission to hospital for surgery, confirms the lack of diagnostic imaging in rural hospitals.[1] This has implications for health outcomes, as the on-going reliance on aeromedical retrieval for diagnostic confirmation may delay treatment and remove patients from their community supports.[1] Future solutions may include training and provision of equipment, upskilling, or telehealth to improve prehospital and in-hospital effectiveness.

Future Research

This study demonstrated that the theoretical air ambulance quality framework can be used to explore the effective, efficient, safe, patient-centered, timely, and equitable nature of prehospital and in-hospital service delivery. There are, however, questions that remain regarding the benefits of a regional referral pathway model, as it functions within the whole State prehospital and in-hospital system, to meet community needs and health service variations over time.[24] While data linkage is not a new process, it is still not commonly undertaken with aeromedical data and clear definitions of patients' journeys which have developed for this study would be valuable to be applied to State-wide aeromedical data.

The authors propose three suggestions. First, future exploration of air ambulance quality frameworks[8] should include outcome measures which relate to: the effects of direct cost to patient (eg, patients' out-of-pocket costs for the health services rendered or bankruptcy due to health service cost); safety indicators in place for upward utility trends (eg, wait times for primary tasks or delays in ground transport coordination); and patient comfort and satisfaction scores. Second, a Queensland State-wide referral pathway analysis should be undertaken with the other 15 hospital jurisdictions in the State using similar methods described in this study. The analysis can create a prehospital and in-hospital service capability model for the State, based on patients' sending locations, medical conditions, and health service provision, noting that there may be a need to build capacity in regions. Third, further analysis of high frequency aeromedical illnesses, particularly stroke and cardiac-related pathologies, is needed.

Limitations

The generalizability of these results is subject to certain challenges. There is considerable heterogeneity among air ambulance service structures and processes internationally. The scope of the study was limited, as the study period data were from 2010-2015 with death data through 2019, although they include the total population who used the air ambulance service. However, the value of the study was to highlight how aeromedical patients' experiences and outcomes can be used for service evaluation within a previously created quality framework. Changes may well have occurred in the air ambulance service since the study period. Therefore, there is added value for future linked data studies to consider the regional referral pathways which were introduced in this study to evaluate changes in aeromedical service delivery over the intervening period. This study also provides a pre-COVID-19 baseline for comparison. Finally, there is an inherent limitation in the use of retrospective cohort studies since risk factors may vary over time and location.[18] However, this limitation was minimized by utilizing STROBE quality reporting guidelines (Supplementary File S7).[18]

Conclusion

The air ambulance quality framework was able to be applied to existing prehospital and in-hospital services data to report their provision of quality care and explored areas for future quality framework improvement. The study successfully linked data from aeromedical, ED, in-hospital, and death sources and explored the aeromedical patients' journeys. Three distinct pathways were identified with variation across the pathways: Intraregional, INTO Region, and OUT of Region. Three research suggestions include: future aeromedical quality frameworks incorporate outcomes measures which relate to patients' out-of-pocket costs for the health service provision, safety indicators for upward utility trends, and patient comfort and satisfaction scores; analysis of State-wide linked data through the regional referral pathway lens to enable a more nuanced understanding of the service; and analysis of stroke and cardiac-related aeromedical patient outcomes.

Author Contributions

Kristin Edwards was the main contributor and lead author responsible for the ideas, development of the study, and writing of the paper, and will contribute as part of her PhD candidature and thesis. Sankalp Khanna: Supervision, Reviewing, and Editing. Richard Franklin: Supervision, Reviewing, and Editing. Rhondda Jones: Supervision, Reviewing, and Editing. Petra Kuhnert: Supervision, Reviewing, and Editing.

Supplementary Materials

To view supplementary material for this article, please visit https://doi.org/10.1017/S1049023X22001480

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