Original Research

A Program Profile of Air Medical Transport in Regional Central Queensland, Australia

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A B S T R A C T

Objective: The purpose of this study was to investigate the epidemiology of air medical patients and referral patterns in Central Queensland Hospital and Health Service (CQHHS).
Methods: Analysis of air medical transport from January 2010 to December 2014. Air medical tasks within the local health service boundary were included. All patients transported on rotor or fixed wing aircraft for medical purposes were included. Patterns of air medical tasks in and out of the region by referring and receiving location, aircraft type, flight priority, time of day, month, sex, age, illness, and referral indexes were analyzed.
Results: There were 11,456 air ambulance tasks in CQHHS region during the study period, an average of 2,291 retrievals per annum or 191 per month. Frequent referrals were to a tertiary facility, located 800 km across economic and political boundaries. Referral pattern indexes highlight a net patient flow of 1.2 to 1. Cardiology was the largest illness category (24%). Males represented 59% overall as well as patients 66 years and older (33%). Fixed wing aircraft carried out 87% of the tasks with a frequent response time of 6 to 24 hours.
Conclusion: Air medical transports are an integral part of the health system in Central Queensland communities with vast geographic distances. Identifying regional referral pattern rates and ratios aid in the planning of resource allocation.

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In Queensland, Australia, centralized air medical coordination helps to address challenges around the management of complex health needs distributed across a vast geographic area.[1] Recent decentralization of health and hospital regions in Queensland created regional health systems that cross political and economic boundaries.[2] Referrals of ill and injured patients requiring specialized services across health service boundaries may be resource efficient, but the effectiveness of service delivery is not clear. Analysis of local usage, market share division, and net patient flow indexes may help to define regional referral patterns.[3]

Referral decisions are complex, often an interplay between medical and nonmedical characteristics such as previous experience, health provider recommendations, patient treatment preferences, and resource availability.[4,5] A better understanding of air medical referral and transport patterns may identify hospital capacity variations and health care system effectiveness. The aim of this study is to explore the epidemiology of patients and referral patterns of air medical services in Central Queensland, Australia.

Background

Queensland health regions were established in 2012 to decentralize care and improve the management of local health needs.[2] The Central Queensland Hospital and Health Service (CQHHS) district boundary covers a geographic area of 114,000 km² and had an

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estimated resident population of 226,273 in 2012,[6] with an average annual population growth of 2%.[7]

Rockhampton Public Hospital has a 246-bed capacity.[8] Services include a 24-hour emergency department; a general outpatient department; general medical and surgical, critical care, pediatric, obstetrics, radiology, rehabilitation, and palliative care wards. Rockhampton Public Hospital emergency department admissions were 77,212 in 2012 to 2013 and 126,000 patients in 2013 to 2014, an increase of 63% over the study period.[8] Seventeen small rural hospitals, clinics, and multipurpose health services are located within CQHHS and one main public hospital in Rockhampton and two smaller private hospitals. The towns include Baralaba, Biloela, Blackwater, Yeppoon, Emerald, Gladstone, Moura, Mount Morgan, Rockhampton, Springsure, Theodore, and Woorabinda.[8] The closest tertiary and quaternary facilities are located in the capital city of Brisbane (Fig. 1).

Methods

Statewide air medical retrieval data were collected by the Retrieval Services Queensland (RSQ), a division of Queensland Department of Health. Nonidentifiable information was extracted for this study. RSQ orchestrates statewide emergency agencies and providers to exchange asset availability, aviation, and clinical risk levels.[9] Study period dates of January 1, 2010, to December 31, 2014, were chosen because of the availability of data. A total of 11,456 CQHHS air medical tasks were recorded using fixed and rotor wing aircraft. The fixed wing service used two Beechcraft King Air. The rotor wing service used one Sikorsky S-76 (Capricorn Helicopter Rescue Pilot Mitch Vernon, personal communication, March 2017). The data did not differentiate the type of task (ie, interhospital transfer, scene, or back transfer) nor did it indicate the number of patients in the aircraft per flight. Therefore, all air medical patient transfers are referenced as "tasks."

The selection of participant inclusion criteria included all air medical patients transported within the CQHHS boundary, coming into the boundary, and those leaving the health service boundary during the study period. The health and hospital region of Central Queensland is determined by Queensland Health. Local government area (LGA) postcodes were used to determine participation inclusion. The LGA regions of Central Queensland include Banana Shire Council, Central Highlands Regional Council, Gladstone Regional Council, Rockhampton Regional Council, Woorabinda Aboriginal Shire Council, and Livingstone Shire Council.[10] Road transport, commercial flights and Australian Search and Rescue cases were excluded.

Patient priority status is designated by RSQ to ensure that retrieval requests are triaged by need to allow for efficiency. These categories are arranged by the urgency of the case, which may differ from the severity of patient illness. Tasking the priority category may not correlate with patient trauma scoring and evaluation or mortality prediction. Generally, patient priority status determines aircraft and crew response time; ready for departure[9] (Table 1).

The patient illness and injury presentation were classified by RSQ. The data did not follow *International Statistical Classification of Diseases, 10th Revision* categories. Data were analyzed using SPSS Version 22 (IBM Corp, Armonk, NY).

Regional transfer pattern indexes show rates and ratios of air medical patient flow across health service districts. Localization, market share, and net patient flow indexes help to visualize patient movement patterns. Each of the 3 indexes were modified from Wallace et al[3] because the resident zip code was not available. First, the *modified localization index* is the percentage of air medical patient tasks treated in the Central Queensland region and originated in the Central Queensland region (equation 1). Indexes closest to 100% represent the patient treatment rate within the health boundary.

$$\frac{Treated\ in\ CQHHS}{Originate\ in\ CQHHS} \times 100 = Modified\ Localization\ Index\% \quad (1)$$

Second, the *market share index* is the percentage of air medical patient tasks treated in the Central Queensland region over the total
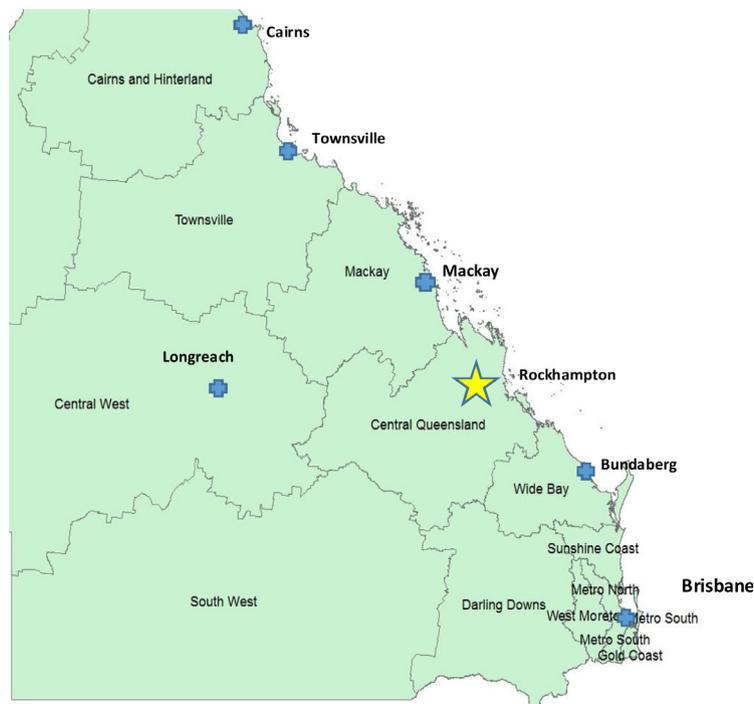

Figure 1. A Partial Map of Eastern Queensland Starring Regional Central Queensland.

Table 1
Patient Priority Status

Priority Status	Priority 1	Priority 2	Priority 3	Priority 4	Priority 5
Aircraft and crew ready for departure:	FW: 30 minutes in day light 0800-2000, 45 minutes in night 2000-0800.	1-3 hours	3-6 hours	6-24 hours	>24 hours
	RW: 15 minutes in day light 0800-2000, 30 minutes in night 2000-0800.	Both FW and RW aircraft day or night	Both FW and RW aircraft day or night	Both FW and RW aircraft day or night	Both FW and RW aircraft day or night

Queensland Emergency Helicopter Network Tasking Guidelines (2011)[9] FW=Fixed Wing, RW=Rotor Wing.

share of air medical tasks (equation 2). Indexes closest to 100% represent the total market share within the health service boundary.

$$\frac{Treated\ in\ CQHHS}{Total\ Task\ Share} \times 100 = Modified\ Market\ Share\ Index\ \% \qquad (2)$$

Finally, the *net patient flow* is the ratio of air medical patient tasks originated in Central Queensland but are treated in another region over the air medical patient tasks originated in CQHHS but are treated in another region (equation 3). The index reflects the net movement of patients among referral regions.

$$\frac{Originated\ in\ CQHHS,\ treated\ in\ another\ region}{Originated\ in\ CQHHS,\ treated\ in\ CQHHS} \times 100$$
$$= Modified\ Net\ Patient\ Flow \qquad (3)$$

Results

There were 11,456 air ambulance tasks in the CQHHS region during the study period, an average of 2,291 retrievals per annum or 191 per month. There were 6,481 tasks received into Rockhampton Public Hospital, and 4,459 tasks referred out of Rockhampton Public Hospital in the study period. There was a small linear increase of 1%, equal to 28 cases per annum. Incomplete data included 516 tasks (4%) without referral region, missing data for illness and injury 53 tasks (<1%) and aircraft type for 441 tasks (4%)

Priority 4 was the largest category with 4,770 (42%) of all tasks. Over half of all flight tasks were males (59%). Patients aged 66 and older represented one third (33%, comprised 3,699 tasks) of all retrievals. Fixed wing aircraft carried out 9,931 tasks (87%). Busy peaks for tasks within a 24-hour period rise at 0800 and begin to slow at 1600. Monthly tasks rise during July (1,069 tasks, 9%) and August (1,054 tasks, 9%) (Table 2).

The ratio of males to females with an injury condition was 2:1, with the exception of those 40 to 65 years old, where the ratio between men and women increased to 3:1. Males with cardiology conditions across all ages represented 16% of the total tasks. Men in the 40 to 65-year age bracket had just over twice the number of cardiology flights compared with women the same age and with the same condition. However, the cardiology ratio increases in men aged 66 and older (ratio of 1.7:1) (Table 3).

Fixed wing aircraft carried out 9,931 tasks (86.7%), whereas rotor wing aircraft accounted for 1,084 tasks (9%). The largest illness category for rotor wing was 413 (38%) injury tasks, and for fixed wing, it was cardiology (2,570, 26%).

Receiving Tasks (Coming Into) Rockhampton Public Hospital

Retrieval Services Queensland coordinated 11,456 tasks coming into and out of the CQHHS region (Fig. 1). Rockhampton Public Hospital received 6,481 tasks coming in from 68 different health facilities across Queensland, New South Wales, and South Australia. Of these

Table 2
Demographic Summary of Air Medical Tasks in the Central Queensland Health and Hospital Service Region

Variable	Air Medical Tasks
Air medical tasks (2010-2014)	11,456
Adult patient (18 years and older), n (%)	9,862 (86)
Pediatric patient, n, (%)	1,594 (14)
Male, n (%)	6,714 (59)
Female, n (%)	4,742 (41)
Fixed wing, n (%)	9,931 (87)[a]
Rotor wing, n (%)	1,084 (9)[a]
Priority status categories, descending mean, n (%)	1. Priority 4, 4,770 (42)
	2. Priority 3, 2,511 (22)
	3. Priority 1, 1,549 (14)
	4. Priority 2, 1,607 (14)
	5. Priority 5, 871 (8)
Busiest time of day, mode	0800-1600
Busiest month/season of year, mode, n (%) adjusted	July/Winter, 1,066 (9)
Furthest referral task from Rockhampton, air km	Mt. Isa, QLD 1,172 km
Furthest receiving task to Rockhampton, air km	Royal Adelaide Hospital, South Australia 1,730 km
Facility referral from Rockhampton, mode	Royal Brisbane & Women's Hospital (public, urban tertiary)
Facility receiving to Rockhampton, mode	Emerald Hospital, QLD (public, rural hospital)

[a] Incomplete aircraft type data (441 tasks, 4%).

receiving tasks, 6,008 (93%) were brought to Rockhampton Public Hospital; smaller private hospitals in Rockhampton received the remaining 7%. Rockhampton hospitals received 3,552 tasks (55%) from within the CQHHS boundary from rural hospitals, clinics, and multipurpose health centers. The most common receiving tasks to Rockhampton, from within the CQHHS boundary, came from rural Emerald Hospital (1,297, 20%), which is 270 km west of Rockhampton. For receiving tasks into Rockhampton from outside of the CQHHS boundary, 45% (2,929) come from tertiary and quaternary hospitals in the capital city of Brisbane (Fig. 2). Brisbane private hospitals sent 27 tasks (<1%), and pediatric flights accounted for 15 tasks (<1%) to Rockhampton. The furthest flight coming into Rockhampton Public Hospital was from the Royal Adelaide Hospital in South Australia, approximately a 1,730-km flight path. These receiving tasks from capital cities were likely step-downs, required lower levels of care, closer to patients' communities.

Referring Tasks (Leaving) Rockhampton Public Hospital

Rockhampton Public Hospital referred out 4,459 tasks (Fig. 3). Most tasks from Rockhampton Public hospital, comprising 4,296 (97%), were sent outside of the CQHHS boundary. The furthest flight was to Mount Isa, 1,172 km to the northwest. The greatest number of

Table 3
Condition, Sex, Age, and Flight Priority Status Flight Occurrences

Top 7 Conditions, (n, %)	Male (n)	Female (n)	Age 0-4 Years(n)	Age 5-18 Years(n)	Age 19-65 Years(n)	Age 66 Years and Older(n)	Priority 1(n)	Priority 2(n)	Priority 3(n)	Priority 4(n)
Cardiology (2,688, 24%)	1,756	923	31	10	1,293	1,345	376	340	469	1,234
Medical (1,930, 17%)	1,026	748	414	97	714	556	180	168	235	572
Surgical (1,564, 13%)	951	704	21	131	1,007	496	212	185	314	723
Injury (1,175, 10%)	765	348	80	262	701	70	146	112	191	393
Musculoskeletal (1,082, 9%)	652	413	11	108	587	359	10	13	23	34
Neurologic (763, 7%)	470	289	49	58	410	243	104	92	129	295
Respiratory (550, 5%)	322	227	231	37	173	109	29	34	54	132

tasks referred from CQHHS was to the Royal Brisbane and Women's Hospital with a total of 1,951 flights (44%). The Prince Charles Hospital received 855 flights (20%), and The Princess Alexandra Hospital received 161 flights (4%). Overall, these three tertiary facilities in the capital city of Brisbane received 2,967 (68%) from CQHHS. Brisbane's private hospitals received 310 tasks (7%). The Brisbane Children's Hospital received 270 tasks (6%). Only one tertiary hospital, Townsville, is located outside of Brisbane (850 km north of Rockhampton), which referred 20 tasks (<1%) (Fig. 3).
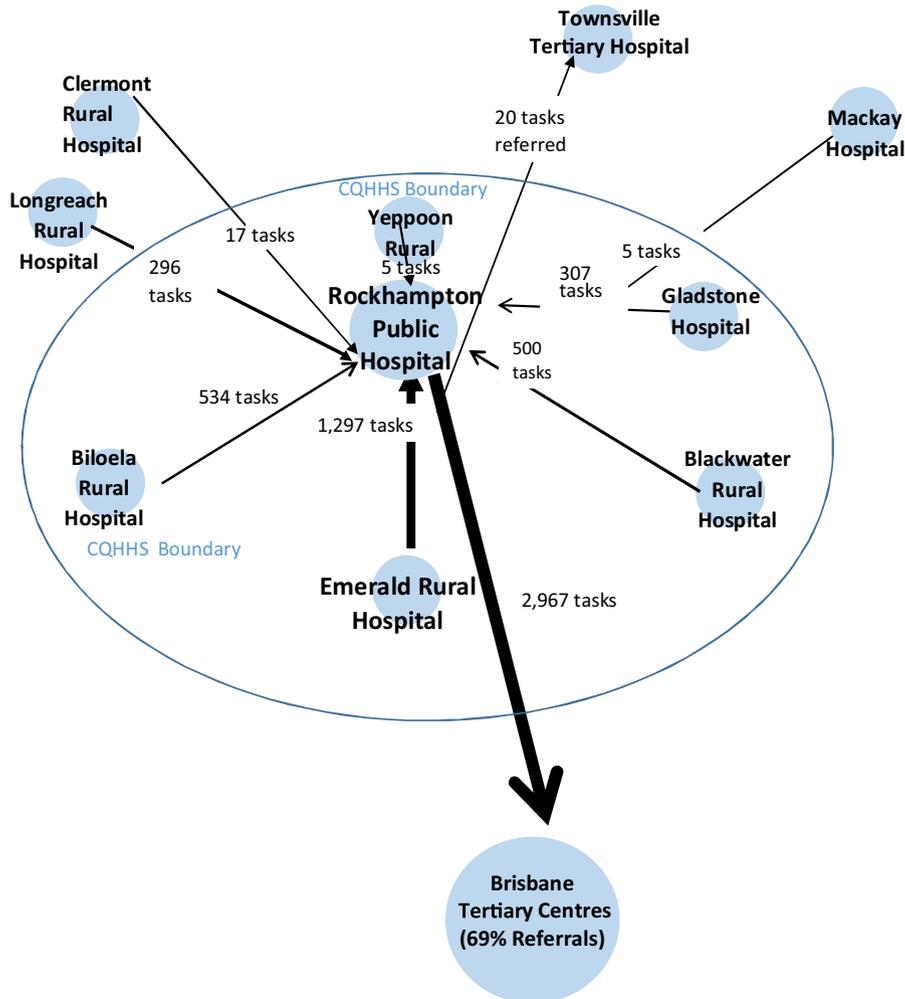
Regional Transfer Patterns

Transfer pattern indexes show rates and ratios of patient flow across health service districts. In CQHHS, transfers to tertiary facilities cross boundaries of economic, political, and vast geographic distances. Localization, market share, and net patient flow indexes visualize patient movement patterns (Figs. 4–6).

Discussion

Air medical transfer patterns reflect regional health system effectiveness and efficiency.[3] Patterns that move the patient out of health service districts may reflect local hospital capability levels.[3] Increasing trends of patient movement act like the canary in the coal mine, where movement patterns out of health service boundary may indicate gaps in local service provision and/or delivery. Patient transport, which requires significant time over great distances using limited aircraft with no guarantee of availability, may not deliver equitable quality care to rural communities. Analyses into the air medical transfer patterns are better understood with localization,

Figure 2. CQHHS Air Medical Regional Transfer Pattern Sample.
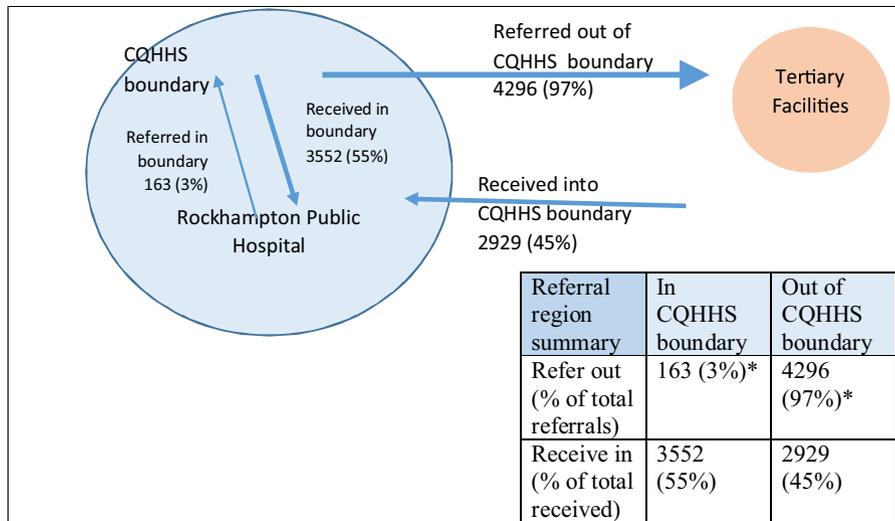
Figure 3. The tasks into and out from the CQHHS region. The total referred was 4,459, the total received was 6,481, and the total sum was 11,456. *Five hundred sixteen tasks without the referral region indicated.
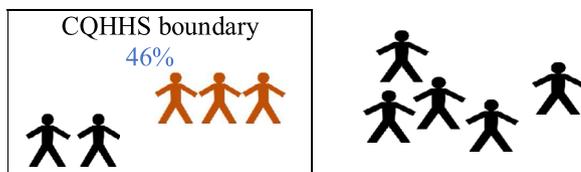
$$\frac{Treated\ in\ CQHHS}{Originate\ in\ CQHHS} \times 100 = Modified\ Localization\ Index\%$$

$$\frac{3552 + 163 = 3715}{3552 + 163 + 4296 = 8011} \times 100 = 46\%$$

Figure 4. The modified localization index is the percentage of air medical patients treated in the Central Queensland region (red icons = 3552 patients received within the CQHHS boundary + 163 patients referred within CQHHS boundary = Total 3715 patients treated in CQHHS region) over air medical patients who originate in the Central Queensland region (black icons = 3552 CQHHS originated patients received in boundary + 163 CQHHS originated patients referred in boundary + 4296 CQHHS originated patients, but flown out of boundary = Total 7,848 patients originate in CQHHS). Tasks originating from a tertiary hospital and arriving to a facility with lower-level capabilities were assumed to be step-down or return flights to patient communities. All icons (Figs. 4-6) roughly illustrate patient movement in and out of CQHHS boundary and are not intended for exact representation.
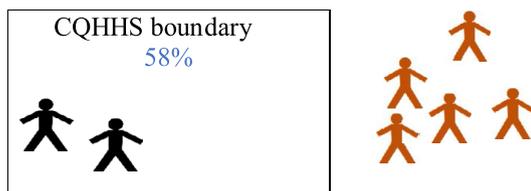
$$\frac{Treated\ in\ CQHHS}{Total\ Task\ Share} \times 100 = Modified\ Market\ Share\ Index\%$$

$$\frac{3552 + 163 + 2929 = 6644}{11456} \times 100 = 58\%$$

Figure 5. The market share index is the percentage of patients who are treated in the Central Queensland region (black icons= 3552 patients received in CQHHS boundary and treated in CQHHS boundary + 163 patients referred in CQHHS boundary and treated in CQHHS boundary + 2929 received into CQHHS boundary for treatment from out of CQHHS boundary= Total 6,644 patients treated in CQHHS) over the total tshare of all air medical tasks (red icons = 11,456 patient transfers).
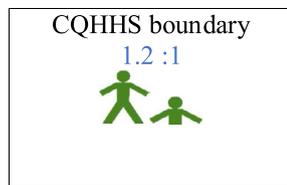
$$\frac{Originated\ in\ CQHHS, treated\ in\ another\ region}{Originated\ in\ CQHHS, treated\ in\ CQHHS} \times 100$$
$$= Modified\ Net\ Patient\ Flow$$
$$\frac{4296}{3552 + 163 = 3715} \times 100 = 1.2 : 1\ ratio$$

Figure 6. The net patient flow is the ratio of patients who originate in CQHHS but are treated in another region (black icons = 4296 patients) over the patients who originate in CQHHS and are treated in CQHHS (green icons = 3552 patients orginate in CQHHS, received in CQHHS + 163 patients orginate in CQHHS and referred in CQHHS, all treated in CQHHS, Total =3715 patients). The index reflects the net movement of patients among referral regions.

market share, and net flow indexes. Further understanding of flight frequency and patient characteristics of established health service districts may indicate to policy makers if service delivery is hitting their intended mark.

Prior studies comparing direct transport with a tertiary center and interhospital transfer (IHT) patient outcomes have mixed outcome results and often isolate trauma in metro and urban scenarios.[11] One particular study[12] compared the transport of a ground ambulance versus a helicopter for neurosurgical trauma. Due to the great vastness in our Central Queensland study (8+ hours by ground), these findings have little homologous value. Timeliness and efficiency will impact patient outcome. Significant consideration in transport tasking may also involve the "second hit" of trauma—multiorgan failure and sepsis as a result of the systemic inflammatory response to significant injury.[13] A better understanding of patient transfer outcomes and resource utilization is necessary for quality patient care.

Cardiovascular disease carries the greatest burden of disease in Australia.[14] The results in our study show the most common tasks were cardiac related. This may reflect disparities in cardiovascular health for rural communities. Improved future accessibility to acute cardiac service, recovery, and rehabilitation may include bringing medical teams directly to rural clinics. Understanding the patterns of these condition-specific transfers will help plan community needs and improve service efficiencies.

Strengths and Limitations

This is the first study to explore air medical transport patterns in CQHHS. However, the data did not indicate if tasks were single-step flights, multiple-step flights, back transfers, primary transfers (also referred as scene or trauma tasks), or secondary (interhospital or interfacility) transfers. Future research using a linked data approach will help to better understand the multistep patient journey and the primary and secondary missions. Further linkage of air medical data to emergency department, hospital, and discharge databases will provide information on patient outcomes and allow for a more comprehensive service delivery assessment.

Coding of illness groups did not use the *International Classification of Diseases* at the time of data collection. Patients may have been classified in multiple illness categories, therefore making it difficult to study the illness distribution and concentration for the district. Future research into this area is needed to identify reasons for condition-specific transfers.

Conclusion

This is the first retrospective, descriptive analysis to explore the air medical transport patterns in CQHHS within an Australian context; a large landmass with sparse rural and remote population. There was a small increase in the number of tasks carried out over the study period. The majority of transfer patients were men over 66 years of age with cardiac-related illness flown on fixed wing aircraft. The most common designated departure time was 6 to 24 hours with 69% of referrals sent to tertiary centers 800 km outside of the health and hospital district. These preliminary results require further exploration into condition-specific patient outcomes and the timeliness of service delivery.

References

1. FitzGerald G, Tippett V, Schuetz M, et al. Queensland Emergency Medical System: a structural and organizational model for the emergency medical system in Australia. *Emerg Med Australas*. 2009;24:72–78.
2. Queensland Health. Central Queensland Hospital and Health Service Annual Report 2012-13. 2012. https://www.health.qld.gov.au/cq/annual-report-2012-13/docs/cqhhs-annual-report-web.pdf. Accessed November 2018.
3. Wallace DJ, Mohan D, Angus DC, et al. Referral regions for time-sensitive acute care conditions in the United States. *Ann Emerg Med*. 2018;72:147–155.
4. Victoor A, Delnoij DM, Friele RD, Rademakers JJ. Determinants of patient choice of healthcare providers: a scoping review. *BMC Health Serv Res*. 2012;12:272.
5. Mohr NM, Wong TS, Faine B, Schlichting A, Noack J, Ahmed A. Discordance between patient and clinician experiences and priorities in rural interhospital transfer: a mixed methods study. *J Rural Health*. 2016;32:25–34.
6. Rockhampton Regional Council. Rockhampton Community Profile. 2015. http://forecast.id.com.au/rockhampton. Accessed November 2018.
7. Queensland Government Statistician's Office. CQ average annual growth. 2010. http://www.qgso.qld.gov.au. Accessed November 2018.
8. Queensland Health. Rockhampton Base Hospital. 2015. https://www.health.qld.gov.au/services/central-queensland/rockhampton.asp. Accessed November 2018.
9. Queensland Government. Queensland Emergency Helicopter Network Tasking Guidelines. 2011. http://www.floodcommission.qld.gov.au/__data/assets/pdf_file/0011/7877/QFCI_Exhibit_363_-_Queensland_Emergency_Helicopter_Network_-Tasking_Guidelines.pdf. Accessed November 2018.
10. Queensland Government Statistician's Office. Estimated resident populations by local government area (LGA) and statistical local area (SLA), Queensland, 2001 to 2011 (archived). 2011. http://www.qgso.qld.gov.au/products/tables/erp-lga-reformed-qld/index.php. Accessed.
11. Mans S, Reinders Folmer E, de Jongh MAC, Lansink KWW. Direct transport versus inter hospital transfer of severely injured trauma patients. *Injury*. 2016;47:26–31.
12. Walcott BP, Coumans J-V, Mian MK, Nahed BV, Kahle KT. Interfacility helicopter ambulance transport of neurosurgical patients: observations, utilization, and outcomes from a quaternary level care hospital. *PLoS One*. 2011;6:e26216.
13. Lord JM, Midwinter MJ, Chen Y-F, et al. The systemic immune response to trauma: an overview of pathophysiology and treatment. *Lancet*. 2014;384:1455–1465.
14. Australian Institute of Health and Welfare. Australian Burden of Disease Study: impact and causes of illness and death in Australia 2011. Australian Burden of Disease Study series no. 3. BOD 4. Canberra, Australia: AIHW; 2016.