Abstract—Background: The Royal Flying Doctor Service (RFDS) has been providing emergency aeromedical retrieval services in Queensland, Australia since 1928. Study Objectives: This article details service and delivery structure plus a description of 12 years of experience managing patients with critical clinical conditions. Methods: This study is a retrospective longitudinal analysis of the demographics and diagnostic classification of all cases of critical clinical severity conducted March 1, 1994 through February 28, 2006. Results: There were a total of 72,054 retrievals, with trauma the single most common clinical diagnosis. There were 4259 retrievals for patients with critical clinical conditions (6%). The most common categories of clinical diagnosis were: trauma with 1493 (35.1%), respiratory diseases 1386 (32.5%), and circulatory diseases 908 (21.3%). Trauma accounted for 69 of the 90 (77%) primary retrievals from locations without health care facilities. The death rate in transport was 1%, with most of these involving males from locations with minimal health facilities. Conclusion: The RFDS in Queensland is an effective provider of fixed-wing aeromedical retrieval services, operating in an unusual environment with vast distances, low population density, and a high number of Indigenous people. © 2009 Elsevier Inc.

Keywords—aeromedical; retrieval; emergency; Australia; fixed-wing

INTRODUCTION

Aeromedical retrieval was born in the First World War, with soldiers in France being evacuated with military aircraft (1). In 1928 the Royal Flying Doctor Service (RFDS) in Australia became the first civilian provider and remains the world’s oldest continuously operating aeromedical retrieval service. Founded in 1928 in remote western Queensland to overcome the “tyranny of distance,” RFDS now operates a fleet of aircraft equipped with intensive care facilities and staffed by flight nurses and, when required, doctors. The service provides primary response aeromedical retrieval between rural and remote cattle stations, remote mines, small hospitals, and Indigenous communities, as well as inter-hospital transfers (2).

After limited use on the battlefields of World War II, rotary-wing air ambulances were introduced en masse into the military in 1945 and by the mid 1960s were an integral part of trauma care in the United States (US) and elsewhere, providing emergency response services (3). Since then, rotary-wing helicopters have become the mainstay of civilian and military aeromedical retrieval services across the globe. However, when retrieval flight distances are extended beyond 200 km/126 miles, fixed-wing aircraft remain the only realistic and viable option (4). For example, the US military utilizes fixed-wing aeromedical retrieval for intercontinental transport to definitive care (5,6). A 1990 study found that in-hospital mortality for fixed-wing aeromedical retrieval of trauma up to 800 miles was found to be not statistically different to in-city ground transport of clinically similar patients (7). However, there are few objective studies that detail the full spectrum of fixed-wing aeromedical retrieval, although
there are studies that focus on specific patient populations such as Obstetrics, Pediatrics, or only one aspect of these transports, such as repatriation (8–10).

Although there are many studies considering the use of helicopter base retrieval services for the transport of patients with critical injuries or illnesses, there is relatively little information about long-distance fixed-wing aeromedical retrieval providing this service (11–16). This article attempts to address this gap by providing a descriptive study of aeromedical retrieval for patients with critical conditions transported by the RFDS Queensland section.

**MATERIALS AND METHODS**

**Study Design**

This study was a retrospective longitudinal report.

**Time Frame**

This study considered all aeromedical retrievals performed by RFDS (Queensland) from March 1, 1994 through February 28, 2006. As this organization performed retrievals with only fixed-wing aircraft, road and helicopter retrievals performed by other services were not considered in this study. Helicopter services are provided by Careflight Queensland, whose operation details are provided elsewhere (17). The Queensland Ambulance Service provided fixed-wing aeromedical retrieval from Brisbane (until 1995), Rockhampton (until 1995), Townsville (until 1996), and Bundaberg (until 2002), when each service was taken over by the RFDS. All road ambulance services are operated by the Queensland Government through the Queensland Ambulance Service. All retrieval modalities operate in a coordinated fashion to provide services to the entire population of Queensland, with decisions concerning which mode of transport (fixed-wing, helicopter, or road) determined on the logistical considerations of each case rather than funding or operating organization.

**Setting**

The RFDS is a private not-for-profit charitable organization that is funded by a combination of donations and Federal and State Government grants. All services are provided free to the consumer. There are seven RFDS bases across the state of Queensland (Qld) providing aeromedical services. Each provides continuous cover with RFDS (Qld)-owned and -operated aircraft. Queensland covers 1.7 million km² (22.5% of the Australian mainland), and of the total population of just over 4 million, 2/3 live in the southeast corner (18,19). The population density varies from 679.3 people/km² in the southeast corner, to 1.8 people/km² in the eastern half, to 0.1 people/km² in the western half of the state (19).

The RFDS bases were established at different times: Charleville (1943), Mt. Isa (1964), Cairns (1972), Brisbane (1995), Rockhampton (1995), Townsville (1996), and Bundaberg (2002), with a base at Longreach providing only mental health/psychology/counseling outpatient services (2005). During the period under study, the RFDS (Qld) bases at Cairns, Mt. Isa, Rockhampton, and Charleville had RFDS staff doctors, whereas the other bases used medical staff from the public hospital system, Queensland Health (QH). When required, other specialized nurses and doctors would form part of the flight crew, for example, when retrieval involved neonatology.

The RFDS (Qld) has a fleet of 12 aircraft, including nine twin-engine Beechcraft Super Kingairs and, since 2002, three single-engine Pilatus PC12s. Both types are fully pressurized and hence able to fly above 20,000 feet and usually above the prevailing weather. They are capable of flying with the cabin at sea-level pressure when required for medical reasons, able to land on relatively short dirt strips, capable of speeds of up to 500 km per hour and a range of approximately 1500 km. Each aircraft is configured to carry 2 patients on stretchers and 2–3 clinical staff as well as 1 or 2 pilots. In the Beechcraft, the stretchers are against each side wall with the walkway between, whereas in the Pilatus, the stretchers are in series across the starboard side wall. Each aircraft carries a full range of emergency and resuscitation medications and equipment, including facilities for extensive electronic patient monitoring. This includes facilities for invasive and non-invasive monitoring, volume- and pressure-controlled mechanical ventilation, multiple infusion devices, a range of trauma and extraction devices, an extensive pharmacy, and substantial oxygen reserves. Specialized equipment such as a neonatal isolette also can be carried when required.

Retrieval flight RFDS staff doctors are required to have extensive relevant training and experience in anesthesiology, intensive care, and emergency medicine. Formal Fellowship (Board Certification) in emergency medicine, anesthesiology, or intensive care medicine is not essential, with greater emphasis placed on the actual range and content of prior clinical experience, including in remote medicine and Indigenous Health. All RFDS clinical staff are salaried, can choose to work part or full time, and provide telehealth services (detailed below). They can also participate in RFDS face-to-face clinics in remote locations, and at some locations, clinical services in public hospital Emergency Departments. Retrieval flight nurses are required to be registered midwives and have extensive relevant experience in emergency medicine.
...and intensive care. RFDS nurses are salaried, work full or part time, and can choose to also provide RFDS infant welfare clinics in remote locations. Both doctors and nurses participate in an extensive ongoing education program run within the organization. This extends beyond clinical issues to include training in emergency aircraft procedures. Doctors sourced from QH are either emergency medicine/intensive care specialists or are typically senior registrars (residents) in the advanced stages of their emergency medicine training program, which leads to Fellowship (Board Certification) of the Australian College of Emergency Medicine.

As part of their medical duties, RFDS staff doctors also provide a structured telehealth program providing a telephone-based remote consultation service for the general public. This works in conjunction with the Medical Chest program, where a broad range of oral, topical, and intramuscular medications are pre-positioned across remote Australia for prescription and remote dispensing by the doctor during telehealth consultations. The telehealth program also provides a structured and dedicated medical support service for health care staff working in rural and remote locations. This allows the seamless integration between retrieval and local health care services with the same organizational unit providing consultations concerning the patient at a remote location, decision to retrieve, planning of retrieval, medical treatment before arrival of the retrieval crew, and handover from local personnel to the retrieval doctor and nurse. This process is further enhanced by the dual role of most of the RFDS staff doctors and nurses: aeromedical retrieval flight crew as well as, at other times, visiting staff to the same remote health centers to provide “on the ground” primary and secondary health care services.

Due to the extensive distances involved, the time period is most often measured in hours between initiation of the retrieval process and arrival at the patient’s location. During this time, the retrieval doctor provides telehealth services, in particular, advice and assistance to those providing the immediate care for the patient. This is particularly important for primary response retrievals to locations without any health care facility. Through the Medical Chest program, the retrieval doctor is able to order medications to be administered before arrival for retrieval. These are dispensed and administered by members of the lay public or, when available, registered nurses.

Aeromedical retrievals are planned and coordinated at the regional level between the RFDS on-call staff doctors, ambulance coordinators, QH public hospital emergency/ICU physicians, and rotary-wing aeromedical providers. Primary response to locations without health care centers or with outpatient-only services is usually case-managed by the RFDS staff doctor. Inter-hospital transfers are case-managed by either the RFDS staff doctor or the QH physicians. The clinical case manager decides whether aeromedical retrieval is required, the degree of clinical urgency, and whether a doctor is required on the flight. Decisions on whether to utilize fixed-wing, helicopter, or road services are based on the logistical considerations of distance, terrain, road conditions, aircraft operational issues, and prevailing weather, as well as the degree of clinical urgency. Requests for aircraft are not refused for other reasons. In complex situations, teleconferencing between all parties, including requesting clinicians, accepting clinicians, RFDS clinical staff and coordinators is utilized to reach consensus.

All retrieval flights for patients with critical conditions are staffed by a doctor and a nurse. The coordinating doctor liaises with the ambulance service for road services to transport the patient to and from the scene or hospital to the airport. If the patient is too unstable for handover at the airfield, the retrieval doctor and nurse travel from the aircraft in the road ambulance to the scene/hospital to assess, stabilize, initiate treatment, and directly supervise the road transport sector.

Methods of Measurement

All data reported in this study were abstracted from the electronic database compiled from the handwritten notes completed during each retrieval episode by the retrieval doctor. The notes were finalized after the retrieval had been completed. Data abstraction was performed by trained RFDS office staff who confer with the clinical flight crew when there are any ambiguities. Electronic data verification processes are in place. Critical clinical severity was defined as requiring full critical care intervention, including multiple infusions and mechanical ventilation, and was decided by the clinical staff on the aircraft providing the retrieval. Up to three clinical diagnostic categories and up to one external cause of morbidity/mortality were recorded for each patient retrieval episode. Before July 1, 2004, diagnoses and external causes of morbidity and mortality were recorded in the database according to the World Health Organization (WHO) International Classification of Diseases (ICD), Version 9 and, subsequently, the WHO ICD Version 10, 3rd Edition (20,21). In this analysis, all diagnoses and external causes recorded in ICD-9 were re-categorized according to WHO ICD Version 10, 3rd Edition. In the absence of a validated method to recode the subcategories of ICD 9 into ICD 10, the analysis was limited to clinical diagnostic chapter headings rather than subcategories (22).

RFDS staff receive specific training in categorizing the patient’s clinical severity and clinical diagnostic category. These are assigned by the RFDS doctor on board the aircraft at the time of the retrieval. When no RFDS doctor was present, the RFDS nurse would make this determina-
tion. The clinical diagnostic category is determined utilizing all the information that is available at the time of the retrieval. In those cases where the RFDS clinical staff are unable to make a diagnosis at that time, the diagnostic category of “symptoms and signs . . .” is utilized.

The database detailed the names of the locations from which patients were retrieved and to which they were delivered. In this analysis, each of these locations was categorized by the size of the publicly funded health care resources at that location: nil, outpatient only, primary care hospital (1–49 beds), secondary care hospital (50–199 beds), and tertiary care hospital (> 200 beds).

Primary Data Analysis

The Statistical Package for Social Sciences, version 14 (SPSS Inc., Chicago, IL) was used. Simple frequency analysis was performed. Population-based rates were calculated from the average of the number of retrievals recorded in each of the 12 years of the study and the corresponding population of Queensland (excluding the southeastern corner, whose resident population does not require fixed-wing retrievals due to the short distances from tertiary hospital services) (23). Categorical data were analyzed using chi-squared analysis. Continuous variables were analyzed by analysis of variance. Statistical significance was defined as \( p < 0.05 \).

Institutional Review Board Approval

This study of de-identified data was approved by the Human Research Ethics Committees of both the University of Queensland and James Cook University.

RESULTS

During the study period there were a total of 72,054 retrievals, with an average age of 44.3 ± 25.4 years; male-to-female ratio of 1.4:1, and 17,225 (24%) were Indigenous Australians. The three most common diagnostic categories were trauma (25%), respiratory diseases (24%), and circulatory diseases (24%). There were 4843 (7%) obstetric cases and 10,588 (15%) involving children aged ≤16 years old. There were 4259 retrieval cases for patients who were critically ill (6% of all retrievals). The estimated rate for all categories of retrievals was 49/10,000 people/year and an estimated rate for retrievals of people with critical conditions was 3/10,000 people/year. During the period under study there were no staff injuries related to aviation and no serious damage or loss of aircraft due to aviation accidents.

For those being retrieved for critical clinical conditions, the male-to-female ratio was 1.8:1, the average age was 34.4 ± 26.7 years, 1278 (30%) were children aged ≤16 years, and 839 (20%) were Indigenous (Table 1). Transport was mostly to locations with larger hospitals (83%), with 17% to locations with a hospital of similar size and <1% repatriation to locations with a smaller size hospital. There were 43 people who died in transport (1% death rate in transport).

The most common categories of clinical diagnosis were trauma with 1493 (35.1%), respiratory diseases 1386 (32.5%), and circulatory diseases 908 (21.3%). There were 85 (2%) obstetric cases. Trauma accounted for 69 of the 90 (77%) primary retrievals from locations without health care facilities. The proportion of retrievals for trauma progressively declined with increasing size of the hospital at the location of the origin of the retrieval, unlike respiratory diseases, which demonstrated a marginal rise with increasing hospital size, and cardiovascu-

<table>
<thead>
<tr>
<th>Number of retrievals</th>
<th>Total</th>
<th>Nil</th>
<th>2% Outpatient Only</th>
<th>Primary Care Hospital (1–49 Beds)</th>
<th>Secondary Care Hospital (50–199 Beds)</th>
<th>Tertiary Care Hospital (&gt; 200 Beds)</th>
<th>Statistical Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>4259</td>
<td>90</td>
<td>2216</td>
<td>1387</td>
<td>1932</td>
<td>634</td>
<td>p = 0.02</td>
</tr>
<tr>
<td>Male</td>
<td>2680</td>
<td>63%</td>
<td>141</td>
<td>876</td>
<td>1213</td>
<td>388</td>
<td>p &lt; 0.0001</td>
</tr>
<tr>
<td>Age, years – mean [SD]</td>
<td>34.4 [26.7]</td>
<td>34.0 [18.8]</td>
<td>38.5 [22.7]</td>
<td>36.0 [25.9]</td>
<td>34.9 [27.8]</td>
<td>27.8 [26.6]</td>
<td>p &lt; 0.0001</td>
</tr>
<tr>
<td>Indigenous</td>
<td>826</td>
<td>19%</td>
<td>11 12%</td>
<td>107 50%</td>
<td>304 22%</td>
<td>239 12%</td>
<td>165 26%</td>
</tr>
<tr>
<td>Most common diagnosis*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Trauma</td>
<td>1493</td>
<td>35%</td>
<td>69 77%</td>
<td>96 44%</td>
<td>520 38%</td>
<td>603 31%</td>
<td>205 32%</td>
</tr>
<tr>
<td>Respiratory</td>
<td>1386</td>
<td>33%</td>
<td>18 20%</td>
<td>74 34%</td>
<td>461 33%</td>
<td>648 34%</td>
<td>185 29%</td>
</tr>
<tr>
<td>Circulation</td>
<td>908</td>
<td>21%</td>
<td>15 17%</td>
<td>51 24%</td>
<td>303 22%</td>
<td>386 20%</td>
<td>153 24%</td>
</tr>
</tbody>
</table>

* Up to three clinical categories and up to one external cause of morbidity could be recorded for each retrieval episode.
lar diseases, which showed no significant change with increased hospital size.

An analysis of those dying in transport revealed that they were far more likely to be male (82% vs. 64% of the survivors) but with no statistically significant difference in age, Indigenous status, or category of clinical diagnosis. Those dying in transport were far more likely \( (p < 0.0001) \) to be retrieved from a location with no health services (23% vs. 2%) or outpatient-only services (33% vs. 5%) than from locations with a higher level of health care facilities.

Compared to non-Indigenous people being retrieved for critical conditions, Indigenous people were, on average, more likely to be female (41% vs. 35%, \( p = 0.002 \)) and younger (28.4 ± 24.3 years vs. 36.0 ± 27.1 years, \( p < 0.0001 \)). They were less likely to have trauma as their clinical diagnosis (25% vs. 38%, \( p < 0.0001 \)) due to higher rates of metabolic, neurological, genitourinary, obstetric, and infectious diseases.

**DISCUSSION**

Even though RFDS (Qld) operated in an unusual environment with vast distances, low-population density, and high number of Indigenous people, there were a number of important features the RFDS retrieval service for patients with critical clinical conditions shared with other high-quality retrieval services.

The delivery of fixed-wing aeromedical services in Queensland is centralized in one organization, the RFDS (Qld). This has assisted in the development of a culture of strong clinical governance, creating an environment where clinical excellence can flourish (24). Centralization of services to the RFDS has also led to a high level of experience and skill maintenance for individual clinicians working in the organization, an important factor leading to improved outcomes (25). One organization providing services across a region as large as Queensland also avoids the inevitable problems associated with multiple providers utilizing different standards, policies, protocols (e.g., myocardial infarction, head injury, acute psychosis), and procedures, providing a fragmented service (26).

The establishment and maintenance of trauma care systems leads to better outcomes through integrated management from the onset of trauma, via appropriate transport through to definitive care (27). The RFDS is an important part of the trauma system across Australia and, as demonstrated in this study, was the most common clinical diagnosis and patients were mostly transported direct to major tertiary hospitals (28). This is consistent with US data demonstrating direct transfer to a major center with appropriate facilities for definitive care results in improved outcomes when compared with an intermediate stop at a less equipped hospital (29). RFDS (Qld) is able to achieve this by having aircraft with the capacity to land on remote airfields with limited facilities and fly the extreme distances required to reach cities with major health facilities, with appropriate flight staff and equipment to provide intensive-care-level treatment while en route.

The retrievals considered in this study had an experienced aeromedical retrieval doctor and nurse attending the patient, as detailed earlier. This is in line with the published literature, which suggests that providing an inexperienced doctor in the retrieval environment seems to provide no benefit, whereas the presence of a physician who can significantly improve pre-hospital stabilization will result in better outcomes even if the pre-hospital time is extended (30,31). In particular, RFDS doctors are able to provide advanced airway skills and the ability to independently perform rapid sequence intubation and intubation, skills considered mandatory by some authors for the conduct of safe aeromedical retrieval (1). This is particularly important in the context of the extreme distances and prolonged travel times to definitive care, especially in the context where longer pre-hospital times can lead to improved outcomes if the time is spent by an experienced physician in preference to a paramedic stabilizing the patient (31,32).

This study found that the death rate in transport for critically ill patients was 1%, compared to 2.5% in South Australia, and 4% in the UK and Canada (33–35). This low rate may be a direct reflection of the quality of in-transit care provided as described above, notwithstanding the self-selection bias inherent in any service that has prolonged response times due to the geography and logistics surrounding the extensive distances involved and the use of fixed-wing aircraft, which require linking road transport.

In this study, Indigenous Australians were disproportionately represented, accounting for 20% of all retrievals for critical conditions, even though their total population in Queensland was 3.1% (36). This high rate reflects both the over-representation of Indigenous Australians living in rural and remote Queensland as well as highlighting the higher levels of morbidity and mortality they experience in comparison with other Australians (37). The noted younger average age was consistent with statewide Indigenous population demographics, whereas the higher female-to-male ratio was consistent with remote Indigenous population demographics (36).

**CONCLUSION**

In summary, this study details an Australian experience in providing aeromedical retrieval services for critical
clinical cases using fixed-wing aircraft. The RFDS, Queensland is an effective provider of fixed-wing aero-
medical retrieval services, operating in an unusual envi-
ronment with vast distances, low population density, and
a high number of Indigenous people.

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