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Evaluation of a mobile X-ray service for elderly residents of residential aged care facilities

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Abstract

Objective. The Royal Melbourne Hospital established a mobile X-ray service (MXS) in 2013. The goal of the MXS is to address the radiology needs of frail, elderly or demented residents of residential aged care facilities (RACFs) who would otherwise require transportation to attend for X-ray. The present study describes the activity of the MXS, and the impact of the MXS on emergency department (ED) attendances by residents of RACFs.

Methods. The study is a descriptive study and uses a before-and-after cohort approach. Activity for the first year of operation was collected and described. At the end of the first year of operation, the top 30 RACF users of the MXS were identified. The hospital Department of Radiology database was examined to find all plain X-rays performed on any patient presenting from the same 30 RACFs for the 1 year before commencement of the MXS (1 July 2012–30 June 2013) and for the 1 year period after the commencement of the MXS (1 July 2013–30 June 2014). Attendances were compared.

Results. The MXS delivered 1532 service attendances to 109 different RACFs. The mean age of patients receiving MXS services was 86 years (range 16–107 years). In all, 1124 services (73.4%) were delivered to patients in high-care RACFs. Most patients ($n = 634$; 41.4%) were bed or wheelchair bound, followed by those who required assistance to ambulate ($n = 457$; 29.8%). The most common X-ray examinations performed were chest, hip and pelvis, spine and abdomen. There were 919 service attendances to the top 30 RACFs using the MXS (60.0% of all attendances). There was an 11.5% reduction in ED presentations requiring plain X-ray in the year following the commencement of the MXS (95% confidence interval 0.62–3.98; $P = 0.019$).

Conclusion. The present study suggests a reduction in hospital ED attendances for high users of the MXS. This has benefits for hospitals, patients and nursing homes. It also allows the extension of other programs designed to treat patients in their RACFs. Special rebates for home-based radiology service provision should be considered.

What is already known about this subject? Digital processing has changed the way radiology delivers services. The Australian community is in the middle of a shift towards an aging population, with a greater numbers of residents in RACFs. It has been suggested in previous studies that mobile X-ray reduces the rate of delirium in patients who require X-ray.

What does this paper add? There is an unmet demand for MXS to residents of RACFs. MXS may reduce presentations by elderly residents of RACFs to hospital EDs for X-rays. MXS may assist general practitioners, and other innovative programs, such as Hospital in the Home and Inreach, to better manage care for patients in RACFs.

What are the implications for practitioners? Providers of radiology services should examine the opportunities and benefits of establishing MXS. Funders of services should examine ways of rebating MXS to encourage further development. Hospitals (Hospital in the Home and Inreach services), RACFs and general practitioners should use mobile X-ray and integrate these services into their management of aged care delivered in RACFs.

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Introduction

For a decade before 2012, there was no mobile X-ray service (MXS) in Melbourne, despite the transformative technology developments in radiology. Digitisation of image processing and transfer has streamlined the process of taking, processing, reporting and storing X-ray images. However, with no specific

reimbursement model for mobile X-ray through the Commonwealth or other sources, there is limited viability for this service.

At the same time, the number and proportion of the elderly living in residential aged care facilities (RACFs) is increasing, as is the length of time they spend there.[1] Residents of RACFs present to emergency departments (EDs) more often than community residents, and have higher hospital admission, re-admission and mortality rates.[2–4] Despite this, in most cases those hospital presentations and admissions are appropriate, lengths of stay are comparable and these patients return to their normal status on discharge.[5–7] There are no studies quantifying the need for X-ray as the main reason for hospital ED presentation in patients living in RACFs. In the only reported randomised trial of home-based mobile X-ray, Aimonino Ricauda *et al*. reported a reduction in episodes of acute confusional delirium in patients who received mobile X-ray compared with those transferred to hospital for X-rays.[8] No other reports of the use or impact of MXS were found on a search of the medical literature.

Part of the appropriate clinical response to many events in this group (e.g. simple falls, new pain or infection) often requires X-rays. In the frail elderly or immobile patients who live in RACFs, this otherwise simple investigation frequently requires assisted transfer to hospital (usually by ambulance). The presentation in hospital for an X-ray may then lead to a cascade resulting in traditional hospital admission. The Victorian health system has developed programs such as Hospital in the Home and Inreach to assist elderly, immobile residents of nursing homes to remain in their usual place of care in the event of acute changes in their health.[9–11] The roles of these programs could be expanded by access to radiology.

In 2012, a proposal was accepted by the Victorian Department of Health (DOH) to fund the establishment of an MXS at the Royal Melbourne Hospital (RMH). The service commenced on 1 July 2013 to service RACFs in the northern and western areas of Melbourne. The aim of the service is to address the radiology needs of frail, elderly or demented residents of RACFs who would otherwise require transportation to attend ED or community radiology facilities.

The study has two aims: (1) to describe the activity of the MXS, its recipients and the number and type of plain X-rays performed; and (2) to measure the impact of the MXS on ED attendances by residents of RACFs who require plain X-ray services.

Method

Service description

The service commenced on 1 July 2013.

The service uses a single vehicle, staffed by a radiographer. It accepts referrals by telephone and facsimile, and travels to nursing homes to deliver services. The vehicle contains a portable plain X-ray machine, a digital processor, a compact disc (CD) burner and a printer–scanner, as well as a computer with mobile broadband capable of processing images and sending digital images for reporting and storing.

The MXS has a relationship with a radiology service for reporting images, and is responsible for reporting, sending results and storing images.

Prior to commencement, the service met all required technical and professional standards, including insurance, accreditation and radiation safety requirements and legislation.

Hours of operation

The MXS operates during business hours 8 h each day, 5 days a week. It operates on weekends for urgent cases only.

Capacity

The aim for the MXS was to provide up to eight services per day.

Geographical area

The MXS operates in the northern and western regions of Melbourne.

Co-payment

Patients or RACFs would not be charged a co-payment for any service during the duration of the pilot trial.

Booking

A specific request form was created, printed and mailed to all nursing homes. The form was also available online. Services could be requested by nursing home staff on general practitioner (GP) or locum verbal or written request, GPs, GP locums, Inreach staff after consultation with Inreach medical staff and Hospital in the Home medical staff. Requests could be left at the nursing home, faxed to the MXS or emailed to the MXS.

Priority was given to requests for residents who were going to be transferred to hospital unless the X-ray could be performed that day.

Services provided

Plain X-ray services are provided, including chest, abdomen, limbs, joints, pelvis and skull X-rays. A CD with the images would be left at the RACF immediately following service attendance. The images would be sent to the radiology provider for reporting. Reporting urgent films would take place within 4 h. All other films would be reported within 24 h. Reports would be faxed or emailed to the referrer and the RACF.

Urgent requests

It was important that the MXS could respond appropriately and quickly to urgent requests that would otherwise require transfer to hospital.

Urgent requests would be attended within 2 h of receipt of the request, and reporting on urgent films would occur within 3 h of attendance.

Description of MXS activity

A database of activity was established by the study team before the commencement of the project and was maintained throughout the year by the MXS. The following information was collected for all attendances of the MXS during its first year of operation, from 1 July 2013 until 30 June 2014: number of episodes of service attendance; number of X-rays performed per attendance; day of the week service performed; number of services per month; urgency of referral, as marked on the request;

source of referral (GP, Inreach service, Hospital in the Home); the age and sex of the patient; the mobility of patient, as assessed by MXS staff on arrival (patients were categorised as either independently ambulant, ambulant with assistance, not mobile/immobile or wheelchair/bed bound); region of X-ray examination; specific RACF attended; and any X-ray abnormality as reported by the radiologist as an abnormality.

Effect of MXS on ED attendances

The second aim of the study was to examine whether the MXS had an impact on the presentation of residents from RACFs to hospital ED for plain X-ray. This part of the study was retrospective and used a before-and-after cohort approach. The outcome for this part of the study was the number of plain X-rays performed in the ED on residents from a sample of high-frequency RACF users of the MXS.

The MXS commenced on 1 July 2013 and the subsequent first year of operation formed the intervention.

No formal power or sample size could be determined before the commencement of the study because there was no ability to predetermine the baseline presentation of residents of RACFs to hospital for X-ray services, and no estimate of the likely activity or adoption of the MXS among RACFs.

Study population

It was necessary to select a cohort of RACFs, and their residents, for further analysis. It was determined that those RACFs who were high users of the MXS should be included in the study sample. Thus, at the conclusion of its first year of operation, the MXS database was analysed by RACF location of the patient service to elicit a frequency count for all RACFs as users of the MXS. It was determined that a sample of the highest-frequency RACF users of the MXS that included more than 50% of all services administered throughout the year should be further examined. Based on this approach, and the frequency count result, it was determined that the top 30 RACFs users of the MXS and their residents would be included in the study sample.

Study duration

A search of the hospital Department of Radiology database was made to identify all plain X-rays performed on any patient presenting from the above identified 30 RACFs for the 1 year before commencement of the MXS (1 July 2012–30 June 2013) and for the 1 year period after the commencement of the MXS (1 July 2013–30 June 2014).

Outcomes

All plain X-rays requested by and/or conducted by the RMH ED on residents of the identified 30 RACFs were included for analysis. In-patient X-ray services were excluded. Patients presenting for X-ray multiple times on the same day were counted only once, with the first presentation counted.

Ethics

Ethics approval for the study was obtained from RMH Office for Research.

Data analysis

Descriptive analysis of overall MXS activity was undertaken and results are reported as the mean ± s.d. for patient age and *n* (%) for all categorical data. Comparisons between pre- and post-MXS periods were made using the Chi-squared test for categorical data. The significance of differences in the number of emergency presentations before and after introduction of the MXS was determined using the Wilcoxon rank sum test. Two-sided $P < 0.05$ was considered significant.

Results

Overview of service activity

The MXS delivered 1532 service attendances to 109 different RACFs between 1 July 2013 and 30 June 2014; 85 of these services (5.5%) were requested as urgent, 1016 services (66.3%) were delivered to women and 516 services (23.7%) were delivered to men. The mean age of the patients receiving MXS was 86 years (range 16–107 years). In all, 1124 services were delivered to patients in high-care RACFs (73.4%) and 407 services were delivered to residents in low-care RACFs (26.6%). Most patients ($n = 634$; 41.4%) were not mobile, and were bed or wheelchair bound, followed by those who required assistance to ambulate ($n = 457$; 29.8%) and fully ambulant patients ($n = 441$, 28.8%). Few services were delivered on the weekend. There were no major differences in the day of the week services were delivered (Table 1).

The period covered in this evaluation includes the commencement and introduction of the service. Growth in service activity on a monthly basis is shown in Fig. 1. Three hundred and seventy-three different doctors referred to the program. Table 2 provides details of the source of referrals to the MXS.

In all, 2102 separate examinations were performed. One hundred and fifty-two patients (9.9%) required two examinations during their attendance, 32 (2.1%) had three examinations and 11 (0.7%) had four or more examinations. The most common X-ray examinations performed were chest, hip and pelvis, spine and abdomen (Table 3).

Results were reviewed for all examinations performed, and abnormalities were reported in 758 examinations (49.5% of attendances, 36.1% of all examinations).

Top 30 RACF

There were 919 service attendances to the top 30 RACFs using the MXS (60.0% of all attendances) during the first year. Table 4 details differences in ED presentations before and after the introduction of the service. There was an 11.5% reduction in

Table 1. Mobile X-ray service attendances by day of the week

Day	No. attendances (%)
Monday	262 (17.1)
Tuesday	302 (19.7)
Wednesday	277 (18.1)
Thursday	314 (20.5)
Friday	344 (22.5)
Saturday	22 (1.4)
Sunday	13 (0.8)

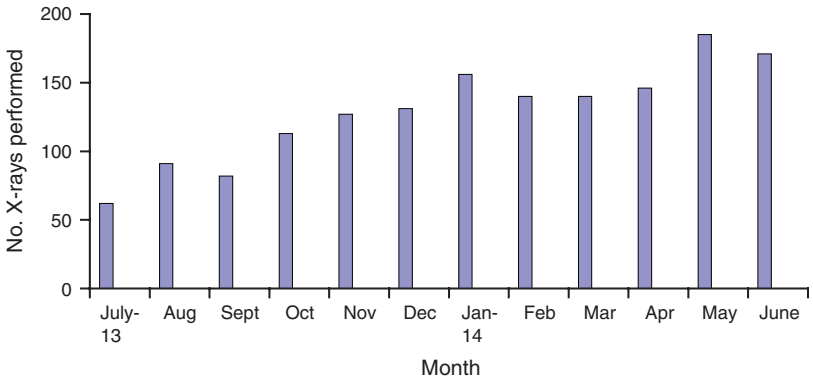

Fig. 1. Mobile X-ray service attendances by month July 2013–June 2014.

Table 2. Sources of referral to the mobile X-ray service

Referrer	No. referrals (%)
General practitioner	1317 (86.0)
Royal Melbourne Hospital in the Home	35 (2.3)
Royal Melbourne Hospital Inreach	117 (7.6)
Northern Hospital Inreach	25 (1.6)
St. Vincent's Inreach	3 (0.1)
Austin Hospital Inreach	19 (1.2)
Other	7 (0.4)

Table 3. Region of examination

Region	Number (%)
Chest	617 (29.4)
Hip joint	251 (11.9)
Pelvic girdle	251 (11.9)
Spine	160 (7.6)
Abdomen	141 (6.7)
Knee	134 (6.4)
Shoulder	113 (5.4)
Ribs	70 (3.3)
Wrist	68 (3.2)
Foot	67 (3.2)
Ankle	53 (2.5)
Hand	44 (2.1)
Femur	41 (2.0)
Clavicle	2 (0.0)
Elbow	31 (1.5)
Humerus	27 (1.3)
Forearm	13 (0.01)
Skull	8 (0.0)
Facial bones	6 (0.0)
Leg	4 (0.0)
Sternum	1 (0.0)

ED presentations requiring plain X-ray from 585 before introduction of the MXS to 516 after (2.3, 95%CI 0.62-3.98 $P<0.05$). In this analysis, three facilities (10.0%) showed no change in ED presentations, seven facilities (23.3%) were found to have an increased number of ED presentations and 20 facilities (66.7%) had a decreased number of ED presentations.

Table 4. Differences in emergency department presentation by nursing home residents involving plain X-ray before and after introduction of the mobile X-ray service

CI, confidence interval. 95% CI 0.62–3.98, $P=0.019$

Facility	No. presentations		
	2012–13 (Before)	2013–14 (After)	Difference
1	83	82	–1
2	42	40	–2
3	34	24	–10
4	47	46	–1
5	1	1	0
6	29	27	–2
7	47	29	–18
8	3	1	–2
9	14	16	2
10	27	27	0
11	18	17	–1
12	10	7	–3
13	27	19	–8
14	24	24	0
15	15	19	4
16	18	11	–7
17	26	15	–9
18	0	6	6
19	17	19	2
20	7	12	5
21	16	11	–5
22	34	29	–5
23	3	1	–2
24	7	6	–1
25	18	16	–2
26	1	0	–1
27	0	1	1
28	7	2	–5
29	7	1	–6
30	3	7	4
Total	585	516	–67
Mean	19.5	17.2	2.3

Discussion

There was a rapid uptake of the RMH MXS among elderly, immobile residents of RACFs. By the end of its first year, the service delivered an average of 8.8 visits per day. This is a high

level of awareness and uptake for a completely new clinical service, and suggests there was unmet demand. The present study was conducted during the introductory year of the MXS, which could underestimate service activity in the future.

The MXS was specifically targeted towards acute hospital substitution: 13.4% of all referrals were made from hospital-based acute substitution services (Hospital in the Home) or acute hospital clinical response services (Inreach).[9–11] In this subset of referrals, the MXS is likely to have substituted for other hospital-based providers of radiology services and may have extended the scope of Hospital in the Home and Inreach for residents of RACFs. Clinical impact could be achieved in two broad clinical circumstances. First, if the MXS demonstrated a normal X-ray result, the need for ED transfer may have been unnecessary. Second, a detected abnormality may have allowed the GP, Inreach or Hospital in the Home to manage the problem without the need for ED transfer.

The present study found a significant reduction in presentations of patients from RACFs to the ED involving a plain X-ray after introduction of the MXS. If valid, the impact of this outcome on the workload of the RACF, the hospital ED and downstream service departments is compelling. The direct cost benefit of reducing ED presentations by elderly RACF patients relates to saving the cost of the transfer to and from the ED, as well as the cost of treating the patient in the ED. There are also indirect cost benefits, along with reductions in adverse events and improvements in quality of life from avoiding such transfers in elderly institutionalised patients.[8]

However, there are several important shortcomings in the present simple descriptive study that limit its validity. This study was based on a single service and a single hospital. Some of the authors of the study were involved in service delivery. Because RACFs were not randomised to MXS access, there may be other variables explaining the reduction in ED X-rays in the cohort of 30 facilities studied. Possibilities include decreases in RACF population numbers, changes in X-ray-dependent disease incidence or the use of alternative EDs for X-ray needs. We do not believe there have been any decreases in the patient population in the 30 RACFs examined, nor have there been changes observed in the choice of ED in referral patterns or numbers. However, unknown variables may still have influenced this result.

The MXS was supported by a grant from the Victorian DOH. This means that no patient co-payment was required. The goals achieved by the service are dependent on broad support for the service, which may depend, in part, on the absence of a patient co-payment. The current Commonwealth rebate for radiology services does not differentiate between facility-based services and home-based services. Therefore, no home-based service could be viable without reliance on external sources of funds, either grants or patient co-payment. If further studies validate the findings of the present study, and if supported with costing studies, then the Commonwealth should review its schedule of benefits to allow increased rebates for home-based radiology service provision.

This intervention is an example of an attempt at the targeted use of health technology beyond its typical application, but not beyond its technical application, to meet evolving demographic trends, patient demand and to augment other health service innovations.

Competing interests

SS is a Director of Aged Care Imaging, which is the provider of the mobile X-ray service described in this paper, under contract with Melbourne Health.

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