Mobile X-ray service for nursing homes

BACKGROUND Transport to a radiology department can be a strain on nursing home patients, leading to less use of diagnostic imaging. The purpose of this study was to examine the use and benefit of a mobile X-ray service that enables imaging at nursing homes.

MATERIAL AND METHOD In connection with 300 of a total of 326 referrals to a mobile X-ray service in Vestfold County in the period March to September 2015, 66 doctors at 33 nursing homes completed a questionnaire on the options patients would have had in the absence of the mobile service. A hundred of these referrals were followed up one to two weeks later with a further questionnaire on the implications of the X-ray scan for diagnosis, treatment and nursing. Eighty-seven questionnaires were completed.

RESULTS In 219 cases (73 %), the patients would have been sent to a hospital radiology department if the mobile X-ray service had not been available. In 60 cases (20 %) the patients would not have had an X-ray examination. In the follow-up, doctors answered that the X-rays had yielded new diagnostic information in 81 cases (95 %), that 71 (83 %) of the X-ray results had had implications for further treatment and that 29 (34 %) had helped patients avoid hospitalisation. In 77 cases (89 %), the X-rays enabled important information to be given to patients and their families.

CONCLUSION A mobile X-ray service makes it possible to avoid transports that place a strain on patients and to provide necessary diagnoses for patients who would not otherwise have been examined.

Einar Vigeland
einar.vigeland@siv.no
Radiology Department
Vestfold Hospital Trust

Ragnhild Eikaas Bøhm
Nygård Residential and Treatment Centre
Development Centre for Nursing Homes and Home Care Services, Vestfold County
Sandefjord

Alfred Rostad
Radiology Department
Vestfold Hospital Trust

Kristin Bakke Lysdahl
Faculty of Health Subjects
Oslo and Akershus University College of Applied Sciences

The questionnaires are available at tidsskriftet.no/vigelandengappendiks

MAIN POINTS

A mobile X-ray service can save nursing home patients a trip to a radiology department

In one of five cases, the mobile service provided X-ray imaging for patients who would otherwise not have been examined. The X-ray results had implications for the diagnosis and treatment of a majority of patients

The Norwegian Coordination Reform widens municipal responsibility for institution-based care services (1). Nursing homes must be able to quickly accept patients who are defined as ready for discharge from hospitals, and with effect from 2016, municipalities are required to have organised emergency admission services (2). Nursing homes make up the largest institutional sector in Norway, with close to 40 000 beds, and have a demanding patient population characterised by advanced age and multi-morbidity (3). Forty-eight per cent of all deaths in Norway take place in nursing homes, and many municipalities have organised palliative care units that specialise in the treatment and care of the terminally ill (4).

Nursing home doctors and other medical professionals are constantly having to decide whether treatment should be given at municipal level or whether patients must be transferred to hospital. Nursing home doctors have little help in making this assessment other than clinical examinations and blood tests. Acute admissions from nursing homes occur frequently, and pulmonary diseases, fall-related injuries and cardiovascular disease are common causes (5).

In 2004, a prospective study was performed of acute medical incidents at nursing homes (6). About a quarter resulted in contact with the specialist health service, and around 50 % of these in turn to referral for X-rays. The authors found nonetheless that the use of X-rays was low, in view of the high morbidity of the nursing home population.

For elderly patients, transport to a radiology department can be a considerable strain that may result in delirium and exacerbate their medical condition (7, 8). An alternative diagnostic service in the form of a mobile X-ray service was therefore established for nursing home patients in Oslo in 2004. A radiographer brings a lightweight, digital radiography device to the nursing home, and X-rays can be taken in the patient's own room. The images are then transferred to a radiology department, for interpretation and reporting by a radiologist. Studies comparing images acquired with this type of mobile apparatus with images from stationary X-ray laboratories have shown the technical quality to be good enough for adequate diagnostics (9–11).

A mobile X-ray service modelled on that of Oslo University Hospital has been established as either a trial project or a permanent service in lower the Romerike area (Akershus University Hospital), in the Fredrikstad area (Østfold Hospital Trust), in Vestfold County (Vestfold Hospital Trust), in Bærum/lower Buskerud County (Vestre Viken Hospital Trust) and in Bergen (Haraldsplass Deaconess Hospital).

The pilot project for the mobile service in Oslo was evaluated in 2004–2005. Skeletal scans were found to be performed most often, particularly of the pelvis and hips (12). Approximately 10 % of nursing home

patients would not have been offered an X-ray examination if this had required transport to a radiology department. A mobile X-ray service based on a similar model has been established in Lund, in southern Sweden, and the results of early operations were published by Eklund et al. in 2011 (10). They found that the safety and comfort of the mobile service resulted in less confusion for patients, particularly those with dementia, and that unnecessary transfers to hospital were avoided.

The goal of our study was to define clinical situations in which patients were referred to a mobile X-ray service and to survey the options open to patients if the service had not been available. We surveyed the types of X-ray examinations that were ordered, whether these had consequences for diagnosis, treatment and nursing, and any cases of hospitalisations or outpatient treatment.

Method

The study forms part of the evaluation of a three-year pilot project for a mobile X-ray service in Vestfold County. The pilot project, which started on 1 January 2014, is being financed in its entirety by Vestfold Hospital Trust. The service is available from Monday to Friday from 8 a.m. to 3 p.m. at 42 nursing and assisted living homes in ten of the county's municipalities. The X-ray examination is conducted in the patient's room, and the radiographer is assisted by institutional personnel as needed.

Referrals are made on paper-based forms by post or fax. Alternatively, the mobile X-ray service is called by phoning a radiographer, who collects the paper-based referral when taking the X-rays. The images are transferred to the hospital's radiology system by means of a USB flash drive and described by the hospital radiologists in the same way as other X-ray examinations. In cases of high priority emergency examinations, the radiologist informs the referring doctor of the results by telephone.

We developed two questionnaires for use in the study. They are available in the *Vigeland Appendix*. These questionnaires were tested by four doctors at one of the nursing homes and then modified. The questionnaires had multiple choice questions, but also a free-text option.

Data collection took place in the period March–September 2015, in two stages. Stage 1 At the time of referral, the doctor was presented with four questions printed on the reverse of the paper referral form (questionnaire 1). The questions are shown in Table 1. Referrals on which questionnaire 1 was completed were included continuously in the study until the planned number of 300 was attained.

Table 1 Questions to referring doctor in connection with referrals for mobile X-ray service at Vestfold nursing homes regarding alternative treatment of patients if this service had not been available. Based on 300 referrals in the period March–September 2015.

Multiple choice questions	Number of responses	Per cent
Who makes referrals for mobile X-rays?		
Nursing home doctor	292	(97)
GP	5	(2)
A&E doctor	1	(0)
Other	2	(1)
What would have happened if the mobile X-ray service had not been available?		
The patient would have been sent to the radiology department at a hospital	219	(73)
The patient would have been transferred to hospital for assessment/admission	18	(6)
Local clinical assessment in the nursing home without the use of X-rays	60	(20)
How would transportation to hospital probably have taken place?[1]		
By ambulance	114	(48)
By taxi	90	(38)
With the assistance of patient's family (private transport)	21	(9)
Other	10	(5)
Would the patient have needed accompanying, and if so, who would have accompanied the patient?[1, 2]		
No accompanying person, would have gone alone	9	(4)
Nursing home personnel	151	(64)
Ambulance personnel	46	(19)
Family	56	(24)
Others	2	(1)

[1] Only cases where it is indicated that the patient would have been sent to a radiology department or transferred to hospital (n = 237)

[2] More than one accompanying person was indicated for some patients

Stage 2 As follow-up, the doctors were presented with a new questionnaire 1–2 weeks after the X-ray examination had been conducted (questionnaire 2). For reasons of capacity, these were limited to 100, in accordance with the research protocol. Every third patient examination from stage 1 was selected, in chronological order. Questionnaire 2 was sent to the doctors by post together with a copy of the X-ray results, and one reminder sent as needed. The questions with multiple choice answers are shown in Table 2.

Data from both stages of the study were analysed using a simple descriptive method (frequencies, cross-tabulation, pivot tables). In stage 2 we specifically analysed the 22 X-ray examinations where the doctor had said at the time of the referral that the patient would not have been examined if the mobile X-ray service had not been available. Fisher's test (R for Windows FAQ, version R-3.2.2.) was used to compare these with the cases where the patient would have been sent to a radiology department or hospitalised.

The Regional Ethics Committee categorised the project as health service research and thus not within the scope of the Health Research Act. However, the committee

granted the necessary dispensation from the duty of confidentiality. The study was also reported to the Norwegian Centre for Research Data, which acts as the Data Protection Officer for Vestfold Hospital.

Results

Stage 1

During the study period, we received a total of 326 referrals for the mobile X-ray service from 66 doctors at 33 municipal institutions. The number of referrals per doctor varied from one to 22. The referrals concerned 280 patients: 181 women and 99 men. The patients' average age was 83.8 years. Questionnaire 1 had been answered in 300 cases (92 %) (Table 1).

Nursing home doctors accounted for 292 (97 %) of the completed questionnaires. Had there not been a mobile X-ray service, 219 of the patients (73 %) would have been transported to a hospital radiology department, while 18 (6 %) would have been transferred to hospital for acute assessment and/or admission. In 60 cases (20 %) the patient would not have been sent, and only a local clinical assessment would have been made, without an X-ray examination.

In the 237 cases where patients would have been sent to hospital, 114 of the transports (48 %) would have been by ambulance, and 90 (38 %) by taxi. Nursing home personnel would have accompanied the patient in 151 of these transports (64 %).

In 153 of the cases (51 %), some type of skeletal examination was ordered. X-rays of the lungs were taken in 144 cases (48 %). The distribution of the X-rays conducted is shown in Table 3.

Stage 2

In the case of questionnaire 2, 87 (87 %) completed questionnaires were returned by 42 different doctors. Examinations were conducted on 83 patients, 47 women and 36 men, at 27 institutions. Their average age was 82 years. One form was excluded because of conflicting responses to some of the questions. The complete results are shown in Table 2.

Of these patients, 54 (63 %) were on long-term stays at the nursing home, while 19 (22 %) were there on short-term or rehabilitation stays. A small percentage, six patients (7 %), were in the palliative care unit, and five (6 %) had municipal emergency places. In 60 cases (70 %) the patient was stated to have some degree of mental impairment.

The indications given for the examination were acute de novo conditions for 44 (51 %) and undetermined condition/assessment for 29 (34 %). The radiology reports were considered adequate and unambiguous in 79 (92 %) of the cases. In 28 (33 %) of the

Table 2 Follow-up questionnaire after an examination performed with a mobile X-ray device in nursing homes in Vestfold, answered by referring doctor 1–2 weeks after receipt of X-ray results. Questions concerning the type of institutional stay, the patient's mental status, characterisation of the problem and assessed usefulness and efficacy (n = 86, period March–September 2015)

Multiple choice questions	Number of responses	Percentage
What type of department was the patient in when the survey was conducted?		
Long-term stay	54	(63)
Short-term stay/rehabilitation	19	(22)
Palliative unit	6	(7)
Municipal emergency place	5	(6)
Assisted living apartment	2	(2)
Problem/indication for examination:		
Acute de novo condition	44	(51)
Undetermined condition/assessment (subacute/chronic)	29	(34)
Follow-up of known condition	13	(15)
What was the patient's mental state at the time of the examination?		
Severe dementia	30	(35)
Slight mental impairment/dementia	27	(31)
Alert and oriented	26	(30)
Acute delirium/confusion/psychosis	3	(4)
To what extent did the radiology results provide answers to questions put in the referral?		
Questions were adequately and unambiguously answered	79	(92)
Questions were partly answered	6	(7)
Questions were not answered	1	(1)
How and to what extent did the examination provide new diagnostic information?[1]		
Disproved possible tentative diagnosis	28	(33)
Increased certainty about assumed clinical diagnosis (tentative diagnosis)	25	(29)
Provided diagnostic knowledge of previously unknown condition	21	(24)
Information about developments (improvement or exacerbation) in known condition	14	(16)
Of no significance for clinical diagnosis	4	(5)
[Not completed]	1	(1)

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How did the X-ray examination affect a decision regarding further treatment at a hospital (admission or outpatient treatment)?		
Led to the avoidance of hospital treatment	29	(34)
No effect	23	(27)
Referral to outpatients clinic avoided	20	(23)
Led to patient being admitted to hospital	6	(7)
Led to patient being referred to a hospital outpatients clinic	5	(6)
[Not completed]	3	(3)
What implications did the X-rays have for the continued medical treatment of the patient?[1]		
Prevented new unnecessary treatment	26	(30)
New treatment initiated	24	(28)
No implications for treatment	13	(15)
Current treatment was terminated or changed	12	(14)
Other	12	(14)
Empty	2	(2)
What implications did the X-rays have for the nursing of the patient?[1]		
No implications for nursing	41	(49)
Palliative measures (e.g. cautious moving in fracture cases, raising of bed-head in cases of fluid accumulation etc.)	17	(20)
Increased mobilisation/exercise	13	(15)
Immobilisation/support (bedrest, wheelchair, walker etc.)	5	(6)
Other	9	(9)
Empty	3	(3)
To what extent did the X-rays enable important information to be given to patients and their families:		
To a large extent	50	(58)
To some extent	27	(31)
To a limited extent	6	(7)
Empty	3	(3)

[1] Where more than one option is indicated, they are added together. Percentage of number of patient referrals, i.e. 86

cases, the X-ray results disproved the existing tentative diagnosis. In 25 cases (29 %), the X-rays increased the certainty of the presumed clinical diagnosis, while in 21 (24 %) they revealed a previously unknown condition. Only four of the X-rays (5 %) were regarded as having no implications for the clinical diagnosis.

The responses regarding the implications of the X-rays for further treatment indicated that new, unnecessary treatment had been avoided for 26 patients (30 %). For 24 (28 %) it led to the start of new treatment, while the current treatment of 12 (14 %) was terminated or changed. The view that the examination had no implications for treatment applied to only 13 (15 %) of the patients.

In 29 cases (34 %) the doctor indicated that the examination led to hospitalisation being avoided, and in 20 cases (23 %) referral to an outpatients clinic was avoided. In six cases (7 %) the X-ray examination also led to patients being hospitalised, and in five (6 %) to patients being referred to an outpatients clinic. The doctors were of the view that 41 of the X-ray examinations (49 %) had no implications for further nursing. In 17 cases (20 %) they led to palliative measures, in 13 (15 %) to increased mobilisation/exercise and in five (6 %) to immobilisation/bracing. The doctors were also asked whether the X-rays had contributed important information that could be given to patients and their families. In fifty of the cases (58 %) this was very much the case, in 27 (31 %) to some extent, and in just six (7 %) to only a limited extent.

In twenty-two of the cases covered by the follow-up stage 2, the doctor had indicated at the time of making the referral that without the mobile service, the patient would not have had X-rays taken. A far larger proportion of these patients were on long-term stays (81 % compared with 56 %, $p = 0.04$). The implications of the X-rays for diagnosis, treatment and nursing were very much the same as the others, but the X-ray examination was regarded for a larger proportion as having no implications for transfer to hospital for treatment (45 % versus 20 %, $p = 0.03$).

Discussion

Of the patients in our study, 219 (73 %) would have been sent to hospital for an outpatients X-ray examination if the mobile service had not been available. Although X-rays at a stationary laboratory often only take a few minutes, waiting and complicated transport logistics often result in a long period of absence from the nursing home. Figures from Oslo and Lund show that the time spent is typically between 3.5 and 5 hours (6, 10). This places a severe strain on frail, elderly individuals, and there is a risk of a negative effect on their medical condition (7, 8).

Delirium may occur, and patients with dementia are particularly susceptible (13). Patients were perceived by the doctor as being without mental impairment in only 26 (30 %) of the cases in our study. An Italian study in which mobile X-ray examinations were performed in the patients' homes revealed significantly fewer cases of delirium than in a control group who were transported to a radiology department (11). A similar favourable effect was also reported from Lund – less confusion in patients with dementia – when scans were conducted locally in nursing homes (10).

The study confirms that mobile X-ray services make diagnostic imaging possible in situations where patients would not otherwise have been examined. Sixty of the patient examinations performed (20 %) would not have been carried out if the ambulant service had not been available. This percentage is twice as high as previously reported from Oslo (12). We have no information regarding the reasons that these patients would not have been sent, but there is reason

Table 3 Examinations performed with mobile X-ray device at Vestfold nursing homes – 300 referrals in the period March – September 2015. Referrals that contained individual examinations from several categories are added together

X-ray examinations	Number	(%)
Skeletal X-rays, total	153	(51)
Pelvis/hip	60	(20)
Other lower extremity	39	(13)
Upper extremity	40	(13)
Spinal column	33	(11)
Thorax	144	(48)
Abdomen	27	(9)
N/a	2	(1)

to believe that high morbidity and frailty played a part. There were relatively more patients on long-term stays in this group. We saw that three of a total of six X-ray examinations of patients in a palliative unit would not have been carried out in the absence of a mobile service.

The study indicates that the availability of a mobile X-ray service would lead to increased use of diagnostic imaging at nursing homes. In view of the high utility value reported by nursing home doctors, we believe there is reason to maintain that this is desirable from a medical perspective.

Our respondents were also asked about the effect of the X-rays in terms of decisions to transfer patients to hospital for treatment. At the time of making the referral, they were of the view that 18 of the patients (6 %) would have been transferred directly to hospital for acute assessment or admission if the mobile X-ray service had not been available. Their view after X-rays had been taken was that they allowed hospitalisation to be avoided in 29 cases (34 %), and referral to an outpatients clinic to be avoided in 20 (23 %).

There are reports from Australia of a significant reduction in acute hospitalisations from nursing homes where mobile X-ray services are used frequently (14). Our study did not have such hard endpoints, but gives an indication of similar effects. Hospitalisation of nursing home patients may be necessary in certain cases, but this has been shown to be associated with a risk of increased morbidity and a subsequent reduction in functional status (15). Mortality in connection with hospitalisations is also very high, with the consequence that many patients end their lives in a busy hospital department instead of in their accustomed surroundings in the nursing home (5). Thus a mobile X-ray service could reduce the number of these undesirable situations.

On the other hand, there is a certain risk that a mobile X-ray service might lead to patients with complex disease pictures, who ought to be treated in hospital, remaining in municipal institutions without access to specialised diagnostic services, including sophisticated diagnostic imaging such as CT, MRI and ultrasound scans. Although our experience indicates that images acquired with a mobile X-ray apparatus are of a high diagnostic standard in the great majority of cases, in some cases better images will be achieved with a stationary laboratory. This applies, for example, to trunk photography of large patients. A mobile X-ray service also places great demands on the radiographer, who must make preparations and improvise when performing X-rays in nursing homes.

A mobile X-ray service has clear consequences for personnel and health economics resources. The equipment is relatively costly, and the unit must be manned by a qualified radiographer. On the other hand, one avoids costly transport by ambulance or taxi, often entailing prolonged absences by accompanying nursing home personnel.

A Norwegian socioeconomic analysis from 2005 that compared the costs of stationary and mobile X-ray services for nursing home patients concluded that a mobile X-ray service turns out to be cheaper per examination than similar examinations performed at hospitals (16). A recently published prospective comparative study from southern Sweden also documents lower costs (17). However, the finances are complicated by the fact that the mobile X-ray service lies in the borderline territory between the spheres of responsibility of the municipal and the specialist health services. Furthermore, there is currently no special reimbursement scheme for mobile X-ray examinations.

In our study, it is the nursing home doctors and their subjective views on patients and treatment that are being investigated. The option of a mobile X-ray service has been very well received, with great enthusiasm, as demonstrated by the very high response rate. The nursing home doctors were well acquainted with the mobile X-ray service as a pilot project for a limited period, and aware that the results of the study could affect the decision to continue the service. This may have caused a certain positive skewing of the responses.

The weakness of the study is the lack of hard endpoints. We have no exact figures for the use of diagnostic imaging at municipal care institutions before and after the introduction of the mobile X-ray service, nor comparable figures for hospitalisations and treatment at outpatient clinics. The number of responses in the follow-up stage 2 is relatively low, and thus does not really provide a basis for a statistical analysis.

In our view, it would be particularly interesting to conduct a closer analysis of the group of patients who would not have been offered diagnostic imaging if it had not been possible to offer a mobile X-ray service. A cost-benefit analysis that includes potentially saved hospitalisations would be of great interest. Thus the study points the way for new research projects in this area.

Einar Vigeland (born 1961)
Specialist in radiology and senior consultant.
The author has completed the ICMJE form and reports no conflicts of interest.

Ragnhild Eikaas Bøhm (born 1978)
GP at Kvelde Medical Office, Larvik. She was formerly a nursing home doctor at Nygård Residential and Treatment Centre/Development Centre for Nursing Homes and Home Care Services, Vestfold County.
The author has completed the ICMJE form and reports no conflicts of interest.

Alfred Rostad (born 1981)
Radiographer and employee at Curato Røntgen X-ray Centre. Previously employed at the Radiology Department, Vestfold Hospital Trust, as project manager for Ambulant Radiology in Vestfold.
The author has completed the ICMJE form and reports no conflicts of interest.

Kristin Bakke Lysdahl (born 1959)
Senior lecturer.
The author has completed the ICMJE form and reports no conflicts of interest.

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