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Clinical utility of out of hours chest radiographs
ABSTRACT

Purpose:
In Australia, radiology services are provided as full 24 hour services, 24 hour urgent out of hours (on call) services and business hours only service. The primary purpose of this study was to determine whether out of hours (11pm to 7am) chest x-ray referrals are consistent with out of hours service expectations associated with the cost and inconvenience of calling in staff from home. A secondary objective was to determine whether the mobile chest plain film examinations are consistent with expectations of a patients increased degree of infirmary.

Method:
A retrospective analysis was undertaken over six contiguous months for patients referred from the emergency department for chest x-ray out of hours and within standard hours. The study population included 436 out of hours patients recruited into the investigation cohort and a matched cohort of 438 within hours chest x-ray examinations. The key information gleaned from the study was concordance or discordance between the clinical details relating to the actual referral and the findings of the chest x-ray.

Results:
The total sample comprised 414 female (47.4%) and 460 male (52.6%). The mean age was 55.3 years, a median of 56.5 years and a range of 0-97 years. The examination type performed was 8.9% mobile compared to 91.1% departmental for the sample. It was found that there was 43.5% prevalence of abnormalities, 27.0% significant abnormalities and 8.7% clinically significant abnormality. The predictors found for clinically significant abnormalities where increasing patient age ($p < 0.001$) and the need for mobile examination ($p < 0.001$). Performing the examination out of hours did not predict a clinically significant abnormality ($p = 0.491$) and similarly, gender did not predict clinically significant abnormality ($p = 0.152$).

Conclusion:
The results suggest that similar approaches to referrals for chest x-ray are applied within hours and during the out of hours period which are inconsistent with the ‘urgent’ philosophy that should accompany an out of hours service. Only increasing
patient age and the need for a mobile chest x-ray offered predictors of a clinical significant abnormality and this offers an insight into the potential approach to the development of referral guidelines for out of hours procedures.
INTRODUCTION
In Australia, there are a variety of radiology services provided including, without being limited to, full 24 hour service, 24 hour urgent out of hours (on-call) service and business hours only service. The 24 hour on-call service is designed to avoid the costs of staffing a radiology department 24 hours per day and 7 days per week, particularly when there are quiet blocks during paid shifts. Nonetheless, the on-call service can be disruptive to staff, expensive, a strain on resources and have a negative effect on the individuals’ productivity post on-call responsibilities. The most important issue, however, is whether the urgent out of hours (on-call) service is utilised appropriately for ‘urgent’ cases.

Current trends in medical imaging suggest there is an increase in patients being imaged. This trend is increasingly prevalent during the out of hours period with as many as 30% of imaging procedures performed out of hours [1-3]. While a large proportion of out of hours services relate to highly technical modalities, [for example computed tomography (CT) and magnetic resonance imaging (MRI) at 40% and 50% respectively], 38% of radiographs are performed out of hours [1]. On-call hours are typically defined as being between 11pm and 7am, 7 days a week.

The culture of modern medicine practice may not provide a logical distinction between routine and emergency cases, rather the patient’s situation defines the emergency. Apart from cost and resource implications, non-urgent out of hours requests for x-ray procedures increases radiographer fatigue and result in decreased productivity during normal shifts (eg. tardiness or absence), particularly after a difficult night on-call [4]. These factors are compounded for mobile radiology procedures. The flow on effects put additional strain on, costs, resources, culture and the entire medical imaging team. There is a need for balance to ensure that a radiological procedure that is performed after hours has a reasonable probability of influencing or changing the patients management, whether the findings are positive or negative [1,3,5-8]. Furthermore, the changes in patient management should also occur after hours or within 8 hours of the findings to justify the radiographer call out [3]. If out of hours radiological procedures are being performed to find certain conditions and the findings are consistently negative, requests for these procedures should be closely examined [1,3,9-12]. While this is not to imply that negative findings are not
useful in patient management, but rather if findings for specific radiological procedures for specific conditions are mainly negative, the probability of a positive finding in this procedure is low [1,3,9-12].

Chest radiography (CXR) is a common tool used to evaluate patients in the Emergency Department (ED), however, this modality has been described as expensive (due to the number of examinations requested and performed), time consuming, and potentially unnecessary in a large number of ED patients [13]. Still, plain film chest examinations are the most frequently requested out of hours examination, as they evaluate the airways, pulmonary parenchyma and vessels, mediastinum, heart, pleura and chest wall. The large range of pathologies presenting, for example chronic cardiac failure (CCF), pneumonia, pneumothorax, acute pulmonary oedema (APO), chronic obstructive pulmonary disease (COPD), chronic airflow limitation (CAL) and lower respiratory tract infection (LRTI), and the need for immediate treatment if significant pathology is discovered, are all reasons for the high volume of chest x-rays requested [11,14,15].
METHODOLOGY
The primary aim of this study was to evaluate the relationship between plain film chest examinations being performed out of hours on the prevalence of clinically significant abnormality. A secondary aim was to evaluate the relationship between plain film chest examinations being performed mobile on the prevalence of clinically significant abnormality. More specifically, the primary objective was to determine whether out of hours chest x-ray referrals are consistent with out of hours service expectations. A secondary specific objective was to determine whether the mobile chest plain film examinations are consistent with expectations of patients increased infirmary.

The investigation was a retrospective matched cohort study of all chest x-rays referred from a hospital emergency department over a 6 month period. Inclusion criteria included referral from the emergency department for a chest x-ray with availability of reliable follow-up patient notes. Each chest x-ray included was performed during either the ‘on-call’ period of 11pm to 7am (experimental group) or during ‘normal hours’ of 9am to 5pm (control group). Exclusion criteria included chest rays performed outside the above mentioned time frames and chest x-ray requests generated external to the emergency department. The investigation was approved by institutional ethics committees.

Participant data was retrieved from the radiology information system (RIS) including:
- Gender,
- Age,
- Time of x-ray,
- Mobile or departmental x-ray,
- Details of request (reason for x-ray),
- Outcome of x-ray (report),
- Patient management (from medical records).
The data was then evaluated with respect to three criteria:

1. Was there an abnormality? Based on the radiologists report, if there was any deviation from normal, then the study was considered abnormal regardless of whether the abnormality correlated with presenting symptoms or the reason for the referral.

2. Was there a significant abnormality? If the abnormality was considered to be associated with the patients presenting symptoms, it was considered a significant abnormality.

3. Was there a clinically significant abnormality? Where the chest x-ray influenced patient management or treatment as a direct result of the abnormal findings, it was considered to be a clinically significant abnormality.

The statistical significance was calculated using Chi-Square analysis for nominal data and Student’s t test for continuous data. A p-value less than 0.05 was considered significant. The differences between independent means and proportions were calculated with a 95% confidence interval (CI). Confidence intervals without an overlap and/or those that did not include zero were considered to support a statistically significant difference while confidence intervals with an overlap and/or those that included zero represented differences for which chance could not be excluded as the cause. Correlation was evaluated with Chi-Square analysis and reliability measured using Cohen’s Kappa coefficient. Matched pairs t test were used to assess agreement between paired data. Normality of distribution was assessed using the Shapiro-Wilk W test where a p-value less than 0.05 indicating a statistically significant variation from the normal distribution.
RESULTS
During the period June 1st to November 30th 2009 there were 436 plain film chest examinations referred to and performed by the medical imaging department during the on-call period and 1589 referred and performed during the in-hours period. One on-call examination was eliminated because the data could not be retrieved from the RIS. Thus, the study population included 435 chest x-ray patients. After randomisation, a representative sample of 438 in-hour chest x-ray examinations was included as a matched control group.

The entire sample (experimental and control groups) included 47.4% (n = 414) female and 52.6% (n = 460) males with no statistically significant variation in gender distribution being noted (p = 0.1197). The mean age of was 55.3 years with a 95% CI of the mean age of 53.7-56.8 years, a median of 56.5 years and a range of 0-97 years. Mobile chest x-ray procedures represented 8.9% (n = 78) of studies with the remaining 91.1% (n = 796) being performed within the department. Female examinations were 7.7% of mobile x-rays as opposed to 10.0% for males (p = 0.240).

There was no statistical significant difference between the prevalence of an abnormality (p = 0.547), a significant abnormality (p = 0.310) and a clinically significant abnormality (p = 0.152) when a mobile was performed on either gender. There were 18 patients on-call that had multiple examinations, 8 males and 10 females with only one female having three examinations, compared to 10 in-hours (4 males and 6 females).

Mobile chest examinations demonstrated a statistically significant increase in prevalence of abnormality when compared to departmental examinations (p < 0.001), a significant abnormality (p < 0.001) and a clinically significant abnormality (p < 0.001) for the entire cohort (combined data). The entire sample demonstrated 43.5% (n = 380) of patients with an abnormal finding, 27.0% (n = 236) a significant abnormality and 8.7% (n = 76) a clinically significant abnormality.

There was a statistically significant variance between the ages of patients undergoing mobile examinations compared to departmental (p < 0.01), with statistically significant variance occurring between the patient’s age when a significant abnormality (p < 0.01) or a clinically significant abnormality (p < 0.01) was
demonstrated. Patients were found to be older when mobile examinations were performed and when significant or clinically significant abnormalities were detected.

When the cohort was reduced to a sub group (45 – 70 year old patients), it was found that the mean age for mobile exams was 57.6 years compared to 56.8 years for departmental \( (p = 0.624) \). This delineation demonstrates that, correcting for age, there remains a statistically significant variance for clinically significant abnormalities between examinations performed mobile versus within the departmental (table 1).

The 435 on-call examinations were comprised of 54.8\% \( (n = 239) \) males and 45.2\% \( (n = 196) \) females which showed no statistically significant variation from the 50.5\% \( (n = 221) \) males and 49.5\% \( (n = 217) \) females representative of the 438 in-hours examinations \( (p = 0.071) \) (table 2). The mean age of patients performed ‘on-call’ was 53.1 years with a 95\% CI of the mean of 50.8 -55.4 years, a median of 54.0 years and a range of 0-96 years. The mean age of patients performed ‘in-hours’ was 57.4 years with a 95\% CI of the mean of 55.2 – 59.6 years, a median of 59.0 years and a range of 1-97 years. While the ‘on-call’ patient was typically older than the ‘in-hours’ patient and there was a statistically significant difference in the age distribution of the two groups \( (p = 0.009) \), the overlap of the 95\% CI’s suggests chance can not be excluded as the cause of this observation. The procedure types were found to be 9.4\% mobile and 90.6\% departmental for on-call patients which did not show a statistically significant variation from the 8.4\% mobile and 91.6\% departmental demonstrated for in-hours patients \( (p = 0.998) \). The cohort subgroup for patients aged 45-70 years, when comparing ‘on-call’ to ‘in-hours’, found there to be no significant statistical variation for the mean age \( (p = 0.100) \). The percentages for abnormality, significant abnormality and clinically significant abnormality are demonstrated in table 3 below.

The cohort subgroup analysis revealed the following predictors of a clinically significant abnormality:

- age \( (p < 0.001) \) especially if patient over 60, and
- mobile examination \( (p < 0.001) \) corrected for age.

It was found that on-call \( (p = 0.491) \) and gender \( (p = 0.152) \) were not predictors for a clinically significant abnormality. This is further highlighted in table 4 where it is
shown that there is no significant statistical variance between the time the procedure was performed (urgency of ‘on-call’ examinations) and a number of parameters.

Table 5 provides a summary of the reason for referral against the relevance of an abnormality, a significant abnormality and a clinically significant abnormality. With respect to reasons for an abnormality being classified as clinically significant, there were similarities between the on-call and in-hours cohorts:

- Admission (11 on-call, 29 in-hours)
- Anti-biotic (12 on-call, 15 in-hours)
- Bi-level positive airway pressure (BIPAP) (4 on-call, 1 in-hours)

Other classifications included chest tubes (3 in-hours), generalised tendomyopathy (GTN) (3 on-call), unspecified medication (4 on-call), central or peripherally inserted central catheter (PICC) line (4 on-call), surgical intervention (1 on-call), infusion (1 on-call) and pastoral care (1 in-hours). Interestingly, there is a statistically significant increase ($p < 0.01$) in the proportion of patients with a significant abnormality who are subsequently admitted within hours (30.5%) versus out of hours (8.9%).

There were four classifications found for abnormalities not being considered clinically significant:

- No treatment recorded post examination (39 on-call, 34 in-hours)
- No data recorded (16 on-call, 11 in-hours)
- Discharged (11 on-call, 17 in-hours)
- No change in patient treatment post examination (13 on-call, 5 in-hours)

One might consider an abnormality on chest x-ray that resulted in the patient being subsequently discharged as a change in management. Inclusion of the above discharge group would see the conversion rate from significant abnormality to clinically significant abnormality increase from 28.2% to 37.2% of out of hours chest x-rays and 43.2% to 61.1% for in hours chest x-rays; in both cases an indication that in hours chest x-rays have a greater propensity to detect clinically significant abnormalities. This might simply reflect the greater likelihood that appropriate medical staff are on duty to effect appropriate patient management.
DISCUSSION

Of the 436 patients referred to medical imaging during the on-call period, 7.8% were considered clinically significant. This refers to a change in management post chest x-ray that was initiated during the on-call period. This investigation also showed that during the in-hours period, 9.4% of patients returned clinically significant abnormalities. These results are concordant with a Norwegian study that reported 8% of all admitted emergency patients required surgical or invasive medical treatment within 8 hours of arrival [12]. These results suggest that the time of day referrals are made bears no statistical significant correlation with the likelihood that a clinically significant abnormality would be detected. Indeed, increased age ($p < 0.001$) and the study performed mobile ($p < 0.001$) were the only predictors of a clinically significant abnormality. Furthermore, abnormalities and significant abnormalities were detected at higher rates in the within hours cohort. This observation is likely to reflect several co-existing factors. Firstly, it supports the previously cited anecdotal evidence that on-call referrals do not adopt a different referral pattern to reflect an urgent nature. Further, chest x-ray screening may well reflect a strategy to address ‘bed block’. Secondly, the detection of significant abnormalities may require a period of time for resource and expertise availability for suitable intervention. That is, a chest x-ray finding may require intervention by expert clinicians not available until the subsequent within hours period. Nonetheless, those patients requiring such intervention were likely to be admitted to hospital and captured within the data collection; although admission may not have occurred within the define on-call period.

Increasing age as a predictor of clinical significant abnormalities is not entirely surprising and reflects increase infirmary, morbidity, co-existing pathology. These same factors, combined with the increased age of the cohort having mobile chest x-rays, explain the increased rate (almost 3 fold) of clinical significant abnormalities in the mobile group over those where the chest x-ray was performed within the x-ray department. These factors could be used to inform a referral guideline to be used for justifying an on-call request for a chest x-ray. The absence of other predictors of abnormality, significant abnormality and clinically significant abnormality, in relation to the detection rates for in-hours procedures, suggests that there is no significant variation in the referral patterns on-call and within hours. Similarly, Nayek and
Lindsay [8] reported that some after hours chest x-rays could have been performed the following day within hours and, indeed, some were considered not justified during any shift. Those chest x-rays performed unnecessarily risk diversion of resources from those that genuinely require them while adding a cost and risk (radiation) burden.

There was sufficient power in these results to guide the development of referral guidelines for after hours. Table 5, for example, provides an insight into the specific reasons for referral provide in the urgent clinical setting. While referrals for chest pain, LRTI, infection, sepsis and consolidation represented the bulk of on-call referrals, they also returned both the lowest rate of detection of pathology and the least specific outcomes (in relation to the original reason for referral. Conversely, suspicion of CCF, COPD or CAL provided the strongest likelihood of detection of an abnormality and for that outcome to impact on patient management; particularly compared to referrals within normal work hours. These findings further support the proposition that chest x-ray examinations are used as a non urgent screening tool during the on-call period. The high rate of normal findings in chest pain referrals is consistent with that reported in the literature [7]. An argument in favour of referral guidelines for on-call chest x-rays is further supported by the findings of Heckerling et al. [16] who reported that the chance of radiographic appearance indicating pneumonia increased if any of the following symptoms existed: increased temperature, increased respiratory rate, decreased breath sounds and an absence of asthma. A decrease in chest x-ray referrals of 11% and decrease by 9% in inappropriate referrals might be expected following implementation of referral guidelines [5].

Several related observations require discussion. Chest x-rays performed within normal hours had a higher rate of admission following a clinically significant finding than those performed on-call (30.5% to 8.9%). This may simply reflect more efficient pathways for admission within normal hours. Increased levels of medical, allied health, nursing and administrative staff during normal hours may simply allow prioritisation of the admission process; a luxury that may not always be afforded the after hours working environment. Similarly, the observation that on-call hours patients have a lower rate of conversion of significant abnormalities to clinically
significant abnormalities than those performed within normal hours (28.2% versus 43.2%) may simply reflect the decreased access to specialist staff after hours required for some acute interventions (eg. surgery, specialist consultations). While this may be seen as a bias or confounder, it highlights the need for referral guidelines that match the therapeutic capabilities. That is, if the outcome cannot effect the appropriate change in patient management, then an on-call referral is somewhat more difficult to justify.

**Limitations**

This investigation was accompanied by a number of limitations that warrant discussion. Firstly, there were a number of limitations associated with retrieving patient histories form medical records (eg. incomplete or vague notes). Secondly, the time stamp in the RIS reflected the time the entry was tracked to completion and may not reflect the precise time the examination was completed or, indeed, the time the images were made available on the picture archival and communication system (PACS) for the emergency physicians. Thirdly, the cohort may have been contaminated by patients in whom an upper abdomen x-ray was requested and in whom the practice of also performing a chest x-ray was performed. While the probability of chest pathology was reduced, this practice was thought to equally impact the on-call and within hours cohorts. Fourthly, the variation in skill and experience of clinicians between within hours and on-call, particularly in relation to access to consultants, was not able to be controlled within the study design.

Perhaps the most important limitation was the classification of a patient discharge following a referred chest x-ray as not being included as a significant change in patient management. Although patient discharge might be viewed as a change in management (n = 28), it was not considered clinically significant on the basis that the practice of patient discharge normal chest x-ray does not justify an ‘urgent’ referral or, indeed, adequate justification for the ionising radiation. While patient discharge can be considered a significant finding following a negative chest x-ray, it should be considered that on-call procedure should have a reasonable chance of positive findings [3]. Nonetheless, a normal chest x-ray resulting in patient discharge could be seen as a prudent use of resources. Furthermore, this classification approach was also applied to the within hours cohort.
RECOMMENDATIONS
A number of recommendations can be made from these findings:

1. For on-call services, a referral guideline should be developed.
2. Feasibility assessment should be undertaken for a full 24 hours service.
3. The investigation provides a baseline for which comparison could be made to assess effectiveness of referral guidelines post implementation.

CONCLUSION
The results suggest that similar approaches to referrals for chest x-ray are applied within hours and during the on-call period which are inconsistent with the ‘urgent’ philosophy that should accompany an on-call service. Only increasing patient age and the need for a mobile chest x-ray offered predictors of a clinical significant abnormality and this offers an insight into the potential approach to the development of referral guidelines for on-call procedures. Furthermore, some specific clinical indicators provide strong justification for an on-call referral (eg. CCF and COPD) while others where poorly justified (eg. chest pain); further fodder for guideline development.
REFERENCES


