Image Repeat Analysis in Conventional Radiography in Mobile Clinics: A Retrospective Observational Study

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ABSTRACT

Background. Mobile clinics offer crucial healthcare services, including X-ray examinations, to underserved communities. Minimizing image repeats in this setting is vital due to radiation exposure, patient inconvenience, and cost implications.

Objectives. This study investigated the prevalence and causes of image repeat in conventional radiography performed within mobile clinics in the Philippines.

Methods. A retrospective review analyzed data from five mobile clinics located in two highly urbanized cities in the Philippines from July to December 2023). Radiology staff assessed image quality, with suboptimal images requiring retakes. Reasons for rejection were categorized.

Results. Out of 871 radiographs taken, 118 (13.55%) were repeated. Vertebrae and pelvic girdle images had the highest repeat rates (33.33%). Positioning errors were the most common cause (44.07%), followed by underexposure and overexposure.

Conclusion. This study identified a concerning repeat rate (13.55%) for mobile X-rays, primarily due to improper patient positioning, particularly for specific body parts. Targeted training programs and stricter protocols for mobile clinic staff are needed. Radiography education should also emphasize these skills, potentially through collaboration with mobile clinic operators to ensure graduates are prepared for the unique challenges of this environment.

Keywords: mobile health units, patient positioning, radiography, X-ray film

INTRODUCTION

Mobile clinics have emerged as a crucial tool in delivering essential healthcare services to the underserved communities.[1] Particularly in geographically isolated and disadvantaged areas, these clinics bridge the gap by bringing critical health services directly to those lacking access to traditional healthcare facilities.[2] One valuable service often offered by mobile clinics is diagnostic imaging, including X-ray examinations. Due to the high cost of purchasing and installing digital radiography systems, mobile clinics in the Philippines primarily rely on conventional cassette-based radiography systems. This method relies on X-rays capturing information on film cassettes, which are then chemically processed to generate images.[3]

However, despite its affordability, conventional X-ray in mobile clinics faces a significant challenge: image repeat.

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Image repeat occurs when an X-ray examination needs to be repeated because the quality of image produced is suboptimal. Some common reasons for image repeat include improper patient positioning, anatomy cut-off, under or over exposure, patient motion or artifact.[4] These repeats translate to several disadvantages. First, patients are exposed to additional radiation with each repeat, raising concerns about cumulative dose and potential health risks.[5,6] Second, repeats cause inconvenience to both patients and healthcare professionals, disrupting workflows and delaying diagnoses.[7] These inconveniences are particularly pronounced in the mobile clinic setting, where time is valuable and resources are limited.

Several studies in various countries have documented concerningly high rates of image repeat, highlighting its widespread impact. For instance, the overall repeat rate was 11.0% in some Norwegian hospitals with positioning errors as the main reason for repeat.[8] The same main reason for repeat was found in Saudi Arabian hospitals but with a higher overall repeat rate of 14.7%.[9] An image repeat rate of at most 8% is considered acceptable in radiography.[10]

Interestingly, the Philippines has only one published study investigating image repeat rates, specifically focusing on tertiary hospitals equipped with general digital radiography and Picture Archiving and Communications System (PACS).[11] This study found a very high and unacceptable image retake rate of 54.07%, with non-sthenic, non-ambulatory, young/middle-aged, and male patients demonstrating a higher propensity for retake. While the study provides valuable insights, it did not analyze images obtained from hospitals equipped with mobile clinics for potential repeats.

To our knowledge, no research has specifically analyzed image repeat in the unique context of mobile clinics. Addressing this gap is crucial. Considering the additional challenges mobile clinics face, minimizing image repeat is paramount. Besides increased patient dose and inconvenience, repeats burden mobile clinics with the cost of additional film and processing chemicals.[12] Therefore, understanding the extent and causes of image repeat within this specific setting is vital for developing targeted interventions and guidelines to reduce their occurrence. Such measures will optimize healthcare delivery, minimize radiation exposure, and ensure efficient resource utilization in mobile clinics throughout the Philippines.

Driven by this critical need, this study investigated the prevalence and causes of image repeat in conventional radiography performed within mobile clinics in the Philippines. Ultimately, the findings will provide valuable evidence to policymakers to develop strategies to effectively reduce image repeats, thereby improving patient care, radiation safety, and resource allocation in mobile clinics across the country.

MATERIALS AND METHODS

Data Collection

A retrospective review of data collected from July to December 2023 was conducted in five mobile clinics located in two highly urbanized cities in the Philippines: Iligan and Cagayan de Oro. These clinics were chosen due to the availability of functioning X-ray machines (minimum 100 mA), darkroom processing capabilities, and a valid license to operate issued by the Center for Device Regulation, Radiation Health, and Research (CDRRHR) of the Food and Drug Administration (FDA). Each mobile clinic utilized a variety of vehicle types, including retrofitted vans and buses, to ensure accessibility in different urban and rural settings.

Radiation protection measures were in place, including the use of lead aprons, thyroid collars, and upright gonadal shielding. The clinics also adhered to dose optimization protocols to minimize patient exposure. Licensing requirements for radiation-emitting devices were regularly updated and compliant with CDRRHR standards. The X-ray machines installed in these clinics were portable units capable of handling general radiographic procedures, with cassette sizes ranging from 8 x 10 in to 14 x 17 in, tailored to specific body parts. Adjustments in exposure parameters were routinely performed to accommodate variations in patient body build, including height and thickness, to ensure high-quality radiographs for non-average patients.

Standard operating procedures (SOPs) were established to guide all clinical processes, from patient registration to image acquisition, darkroom processing, and result dissemination. The radiographers on duty were board-certified, with a minimum of five years of clinical experience. Each clinic was staffed with one to two radiographers. Radiographers underwent continuous training in quality control and radiation safety, focusing on both imaging techniques and adherence to safety standards.

Radiologists, who interpreted the radiographs, had specific preferences for image quality and positioning, which were communicated to the radiographers through regular consultations and case discussions. The clinics served a diverse patient population, including pre-employment clients, well patients requiring routine check-ups, and sick patients referred from hospitals, health centers, and private physicians. These clinics were instrumental in providing essential diagnostic services, particularly to underserved populations, while maintaining high standards of patient care and safety.

Image Quality Assessment

An experienced radiographer supervised by a certified radiologist per clinic assessed the image quality of the radiographs. Radiographs were repeated when their quality was suboptimal. To avoid image repetition, a radiograph must meet specific technical criteria, including adequate density, contrast, spatial resolution, and minimal artifacts, to provide sufficient detail and clarity for accurate diagnosis.[13]

Unacceptable radiographs were stored in separate boxes and categorized based on the reasons for rejection and body part. Any patient identifying information was removed from these discarded images before storage. Data collectors were trained and were given predefined data collection sheets for numbers and factors responsible for repeat examinations.

Radiological Procedures

A total of 871 radiographs were produced during the study period. The breakdown of radiographs produced by five different clinics is shown in Table 1. To avoid potential interference with the analysis, patients undergoing simultaneous examinations of multiple body parts were excluded. Radiographs were included in the study if they were obtained during the study period from the five mobile clinics and met minimum diagnostic quality standards, including adequate exposure, spatial resolution, and minimal artifacts. Both initial and repeated radiographs were included, provided the repeats were necessitated by technical deficiencies in the original images, such as improper exposure or positioning.

Radiographs were excluded if they showed excessive artifacts or distortions that rendered them non-diagnostic, even after repeat attempts. Images were also excluded if they were improperly positioned or exposed in ways that could not be corrected in subsequent repeats. Additionally, original radiographs with incomplete information—such as missing patient name, birthdate, date of examination, or the body part being examined—prior to deidentification were not included in the analysis.

All radiologic procedures were performed only upon written request from clinicians, and radiation exposure was strictly limited to clinically justified cases. Standard radiation protection protocols were followed for all patients.

Data Analysis

The collected data were entered into Microsoft Excel, and descriptive statistics such as frequency and percentage were used for analysis. The image repeat rate was determined using the formula of Owusu-Banahene et al.[14]:

$$\text{Image repeat rate (\%)} = \frac{\text{number of repeated radiographs}}{\text{number of radiographs taken}} \times 100$$

Ethical Considerations

The Institutional Ethics Research Committee of Iligan Medical Center College granted an ethical exemption for this study.

RESULTS

The research investigated the rate of repeat radiographs across various body parts (Table 2). A total of 871 radiographs were taken, with 118 needing to be retaken, resulting in an overall repeat rate of 13.55%. Looking at specific body regions, the repeat rate ranged from 11.11% for the abdomen to 33.33% for both the vertebrae and pelvic girdle. Interestingly, extremities, both upper and lower, had a higher repeat rate (25.00%) compared to the torso (abdomen and chest at 11.11% and 12.33%, respectively). The skull and shoulder girdle also showed a moderate repeat rate around 23% to 25%.

The analysis of reasons for repeat radiographs revealed that positioning errors, underexposure, and overexposure—classified as radiographers' errors—were the most common causes, collectively accounting for the majority of repeated radiographs (Table 3). Positioning errors alone contributed 44.07% (52 out of 118), followed by underexposure (19.49%) and overexposure (11.86%). Artifacts, which were mainly caused by patients wearing jewelry, and patient motion were categorized under patients' causes and constituted a smaller

Table 1. Distribution of Radiographs per Clinic

Clinic Code Name	Location	Number of Radiographs
CO1	Cagayan de Oro	185
CO2	Cagayan de Oro	170
CO3	Cagayan de Oro	178
I1	Iligan	175
I2	Iligan	163

Table 2. Repeat Rate per Body Part

Body Part	Number of Radiographs Taken	Number of Repeated Radiographs	Repeat Rate
Abdomen	18	2	11.11
Chest	787	97	12.33
Lower Extremities	4	1	25.00
Pelvic Girdle	12	4	33.33
Shoulder Girdle	13	3	23.08
Skull	8	2	25.00
Upper Extremities	8	2	25.00
Vertebrae	21	7	33.33
Total	871	118	13.55

Table 3. Reasons for Repeat Radiographs

Reasons for Repeat	Number of Repeated Radiographs	%
Positioning	52	44.07
Underexposure	23	19.49
Overexposure	14	11.86
Artifact	12	10.17
Patient motion	8	6.78
Darkroom processing	7	5.93
Others	2	1.69

proportion of the repeats. Darkroom processing errors and other minor factors also contributed to the remaining cases, albeit to a lesser extent.

DISCUSSION

This study examined the repeat rate of radiographs performed in mobile clinics that utilize conventional cassette-based systems in the Philippines. The concerningly high overall repeat rate of 13.55% indicates potential shortcomings in the quality assurance practices within these mobile clinics. This rate is higher than that found in Norway,[8] but lower than those found in Saudi Arabia and the Southern Philippine.[9,11] Despite the observed differences, the retake rate obtained in this study undeniably exceeds the 8% limit established by a previous study.[10] This statistic represents not only wasted resources but also delays in diagnosis and unnecessary additional radiation exposure for patients.

A closer look at the specific body regions reveals some interesting patterns. Notably, the vertebrae and pelvic girdle showed the highest repeat rates (over 33%), suggesting potential challenges in acquiring optimal initial radiographs for these complex anatomical structures. This aligns with a previous work,[15] who identified challenges in positioning for these areas. Conversely, the torso (abdomen and chest) displayed the lowest repeat rates (around 11%), potentially due to their simpler and more standardized positioning techniques. Interestingly, extremities, despite their relatively straightforward anatomy, exhibited a higher repeat rate (25%) compared to the torso.

Digging deeper, the analysis of reasons for repeat radiographs reveals valuable insights. Radiographers' errors, including positioning errors, underexposure, and overexposure, emerged as the primary causes, collectively accounting for the majority of repeat radiographs. Positioning errors emerged as the most prevalent cause, accounting for nearly half (44.07%) of all retakes. This highlights a critical area for improvement in mobile clinic staff training. Consistent with previous studies,[5,8,16] positioning errors were found to be a major contributor to image repeats. Finally, the study identified underexposure (19.49%) and overexposure (11.86%) as contributing factors to a significant portion of repeat radiographs. This suggests potential deficiencies in exposure verification protocols.

The findings of this study have significant implications within mobile X-ray clinics in the Philippines. To address the high repeat rate, several key areas require improvement. Firstly, targeted training programs for mobile clinic staff are crucial. These programs should emphasize proper patient positioning techniques, with a particular focus on extremities, vertebrae, and the pelvic girdle, which were identified as problem areas. Secondly, stricter protocols for exposure verification are essential to minimize retakes due to underexposure and overexposure. Implementing automatic exposure control systems or investing in portable densitometers for on-site image quality assessment could significantly improve this aspect.

Meanwhile, the findings hold significant implications for educational institutions offering radiography courses in the Philippines. Firstly, the high repeat rate associated with positioning errors underscores the need for robust training in this area. Curricula should dedicate ample time to proper patient positioning techniques for various body parts, including extremities, vertebrae, and the pelvic girdle, which exhibited the highest repeat rates in this study. This training should go beyond theoretical knowledge and incorporate extensive hands-on practice with simulations or phantoms to ensure graduates are well-equipped for real-world scenarios, particularly in mobile clinic settings. Secondly, the research highlights the importance of emphasizing proper exposure control techniques during radiography education. Incorporating training on using automatic exposure control systems and portable densitometers would prepare graduates for the realities of mobile clinics where resources might be limited. Additionally, educators should instill a strong understanding of exposure factors and quality control procedures to minimize the occurrence of underexposure and overexposure, thereby reducing repeat rates. Finally, fostering collaboration between educational institutions and mobile clinic operators could prove beneficial. Joint efforts could lead to the development of practical training programs that simulate the mobile clinic environment and expose students to the specific challenges encountered in these settings. This collaboration could ensure graduates are not only theoretically knowledgeable but also possess the practical skills necessary to excel in mobile X-ray clinics.

By focusing on these areas, mobile clinics can achieve a dramatic reduction in repeat radiographs. This translates to improved patient care by ensuring accurate diagnoses without delay, reduced costs associated with wasted resources and retakes, and minimized radiation exposure for patients and staff.

This study encountered some limitations worth consideration. The study only included data from five mobile clinics in two Philippine cities, potentially limiting the generalizability of the findings to other settings. Furthermore, the exclusion of patients undergoing examinations of multiple body parts may affect the applicability of the results to real-world clinical practice where such examinations are sometimes necessary. Additionally, the study assumes that all radiographers consistently adhered to established imaging protocols and quality assurance procedures across all clinics, which may not account for individual variations in practice. It also assumes that the documentation of radiographic procedures and patient data was accurate and complete. Limitations related to data quality include the exclusion of radiographs with incomplete information, such as missing patient names, birthdates, dates of examination, or the body parts being examined before deidentification, which may have led to the omission of otherwise relevant cases. Furthermore, the study assumes that the equipment and environmental conditions in all mobile clinics remained stable throughout the study period, which may not reflect the operational challenges faced in day-to-day practice. Despite these limitations, this study offers valuable baseline data on the repeat rate based on body part and reasons for repeat in mobile clinics. This information can serve as a foundation for future research and inform quality improvement initiatives in mobile X-ray services.

CONCLUSION AND RECOMMENDATIONS

This study found a high repeat rate (13.55%) for conventional radiographs in mobile clinics in the Philippines. Radiographer errors, primarily involving improper patient positioning, particularly for extremities, vertebrae, and the pelvic girdle, and suboptimal exposure techniques (both underexposure and overexposure), were the most frequent cause of image repeats. The findings suggest key areas for improvement. Targeted training programs for mobile clinic staff on proper positioning techniques, alongside stricter protocols and potentially new equipment for exposure control, could significantly reduce these repeat rates. There is a need for radiography education to emphasize these skills as well, potentially through collaboration with mobile clinic operators to create training programs that simulate real-world scenarios and ensure graduates are well-equipped for the specific challenges of mobile X-ray clinics.

Acknowledgments

The authors gratefully acknowledge the Research and Publication Center of Iligan Medical Center College for their financial support that made this study possible. Sincere gratitude is also extended to the data collectors for their invaluable assistance in the data collection process.

Statement of Authorship

All authors certified fulfillment of ICMJE authorship criteria.

Author Disclosure

All authors declared no conflicts of interest.

Funding Source

This study was funded by the 2023 Research Development Grant of Iligan Medical Center College.

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