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Research article

The Development of Web Application and Projection System for Assisting Patients with Chest X-Ray Positioning

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Abstract: Chest X-ray imaging helps doctors assess the severity of infectious diseases. Radiologic technologists directly involved in chest X-rays are at risk of exposure while preparing patients for imaging. To address these issues, we developed the XBOT web Application and projection system to assist patients with chest X-ray positioning. The XBOT web application and projection systems have been developed to provide bilingual guidance for chest X-ray positioning, posteroanterior, and lateral view. The systems use Thai and English instructions and video demonstrations. We produce engaging videos for projection systems that effectively demonstrate the proper positioning on a bucky wall stand. User experience and satisfaction with the positioning systems were evaluated. In this study involving 13 volunteers, the average time for chest X-ray positioning was 11.52 seconds for the right lateral, 15.22 seconds for the left lateral, and 22.90 seconds for the PA view. The study demonstrated the effectiveness of the XBOT system in chest X-ray positioning. The right lateral view achieved the highest average score of 5.00 ± 0.00 points, followed by the left lateral view at 4.77 ± 0.42 points and the PA view at 4.23 ± 0.42 points. Satisfaction with the XBOT Web Application and Projection System resulted in an overall score of 4.25 ± 0.67, indicating general satisfaction with its performance. The results indicate precise positioning, suggesting that the XBOT web application and projection systems may reduce staff workload. Minimizing contact between patients and radiologic technologists may also lower the risk of infection within the hospital.

Keywords: Position; Chest X-ray; Assisting; Web application; Projection system

1. Introduction

In the last two decades, three major viral infectious diseases have emerged: severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS), and coronavirus disease (COVID-19) [1]. Microbial diseases are common worldwide, mainly caused by bacteria, fungi, parasites, and viruses. These illnesses are primarily transmitted from person to person and from animals to humans [2]. Radiological technologists have been at the frontline of the fight against the pandemic. They actively participate in the pandemic response and must wear personal protective equipment before entering X-ray rooms [3]. However, most of them have limited expertise in working with patients. Additionally, nonstandard preventative practices used during imaging procedures increase the risk of hospital cross-infection in radiology departments [4]. Radiology teams are in close contact with suspected and confirmed patients, placing them at high risk of occupational exposure to the disease [5]. The pandemic's spread among healthcare workers has significantly impacted the community, directly affecting healthcare services. Radiological examinations are crucial in diagnosing and managing pandemic cases. Chest X-rays are routine for patients in intensive care units, necessitating radiation protection and adherence to 'as low as reasonably achievable' (ALARA) procedures, minimizing exposure time, and ensuring proper shielding [6-7].

The world's population is aging, which is affecting a variety of industries. According to the World Health Organization, 22% of the global population will be over 60 by 2050 [8]. The demographic shift will significantly impact many aspects of the healthcare sector, with the primary outcome for radiology being a continued growth in demand for medical imaging services, as the elderly population requires more frequent screening examinations [9]. Radiological technologists must interact with patients regularly in cohort wards and during severe outbreaks, posing significant risks. Consequently, many radiology professionals contract infections from patients and coworkers while working. Significant benefits have been provided by technology in disease control, logistics, telecommuting, and healthcare by continuously disinfecting areas, reducing human involvement, and saving healthcare workers [10].

The aging population increases the demand for radiological services, especially for elderly patients who require more frequent imaging procedures. These patients often need extra care during positioning, raising the risk of infection exposure [11]. With many radiological technologists lacking comprehensive training in infection control and safe handling, the need for standardized, efficient solutions to manage patient positioning and minimize risks is urgent [12]. The development of the XBOT web application addresses this gap, offering a practical tool to help technologists safely position patients and reduce exposure during chest X-rays.

The study developed an XBOT web application and projection system to assist with patient positioning for chest X-rays in PA and lateral views. It provides instructions for positioning posteroanterior (PA) and lateral chest X-rays in Thai and English.

2. Methods

The institution has approved this study for ethical human research under the Certificate of Approval (COA) IRB No. P1-0066/2566. This research focuses on producing an application for guiding chest X-rays. The XBOT web application includes preparation for clothing changes, positioning, and breathing during a chest X-ray. When the patient changes into the hospital gown and stands in the room for the X-ray, there will be a projection system that displays a video onto the bucky wall stand. The projection system will show an example of the positioning to guide the patient in following the instructions.

This study employs a quasi-experimental research design to evaluate the effectiveness of the XBOT web application and the projection system for guiding chest X-ray positioning. Participants were asked to perform chest X-ray positioning in three views—PA (Posteroanterior), left lateral, and right lateral—using both the XBOT web application and the projection system. The independent variables in this study include the type of guidance system (XBOT web application vs. projection system) and the language option (Thai vs. English). The dependent variables include the time taken for positioning in each view, the accuracy of the positioning as assessed by radiologic technologists, and participant satisfaction, which was measured using a Likert scale. To control for confounding variables, the study employed standardized instructions, ensured the use of the same patient pool, and maintained consistency in the evaluation process by having the same radiologic technologists assess all participants.

2.1 Feature and Design of an XBOT web application

The web application named XBOT was developed using Glide web-based application, a mobile app-based learning media design platform. Glide was chosen for the XBOT web application due to its user-friendly interface, quick deployment, and ability to support multimedia features like images and audio. Its ease of adding multi-language support and customizing made it ideal for guiding patients through X-ray positioning. Additionally, the application is compatible with both Android and iOS devices, allowing for broad accessibility and ensuring that users can access the system on various platforms with ease. It is utilized to guide patients to the X-ray positioning and can display illustrations and emitting sound to assist patients in preparing for a chest X-ray. It also provides guidance on posture and breathing management. The positions for chest X-ray imaging are PA, left, and right lateral views.

The XBOT web application includes several key components that guide patients through chest X-ray preparation and positioning. The application provides features such as language selection, which supports Thai and English, and detailed instructions for positioning in three views: PA (Posterior-Anterior) and two lateral views. Additionally, the system guides patients through preparation steps like clothing removal and proper posture during the procedure. These functionalities, as outlined in **Table 1**, are crucial for improving the user experience. The table provides a detailed breakdown of the sections within the web application, including the various languages and the specific guidance provided for each chest X-ray position. By offering comprehensive, step-by-step instructions, the XBOT application ensures that patients can follow the necessary procedures with ease and accuracy.

Table 1. Key Components and Features of the XBOT Web Application

No.	Description
1	Home
2	Thai Language
3	English Language
4	Pre-Chest X-ray Preparation (Thai)
5	PA (Posterior-Anterior) Position (Thai)
6	Lateral Position (Thai)
7	Left Lateral Position (Thai)
8	Right Lateral Position (Thai)
9	Pre-Chest X-ray Preparation (English)
10	PA (Posterior-Anterior) Position (English)
11	Lateral Position (English)
12	Left Lateral Position (English)
13	Right Lateral Position (English)

The web application design for the chest X-ray positioning guide video was developed using the Glide platform. In the initial phase of the design process, a storyboard was created for the web application. Following this, information regarding patient preparation and positioning instructions for chest X-ray imaging was compiled and added to a Google Sheet. This data served as the basis for defining the option buttons in the web application. The information from the Google Sheet was then imported into Glide Apps by selecting the "NEW APP" option, clicking on Google Sheet, and selecting "Continue." After choosing the desired data, another click on "Continue" created the web application. The next step involved refining the web application for user functionality. Modifications were made to the web application’s interface, including adding a HOME screen and language selection options for both Thai and English.

Radiologic technologists can use the language selection button to communicate with Thai and foreign patients. The XBOT web application can guide patients regarding preparation before X-ray procedures. It advises patients on positioning for X-rays. Guiding the Patient to chest x-ray positioning, the XBOT web application provided a web-based application interface for guiding the posteroanterior (PA) and lateral chest view. XBOT's application setup, comprising display monitoring and a projector-based system, consists of: Guideline 1: Prepare for a chest X-ray by removing any clothing, jewelry, or other objects that may obstruct the X-ray area, and wear a gown. Guideline 2: Position the body erect, facing the forward image receptor, with the chin lifted, shoulders turned anteriorly, hands on the posterior aspect of the hips, and then take a breath and hold it—the conceptual framework for designing, as shown in Figure 1.

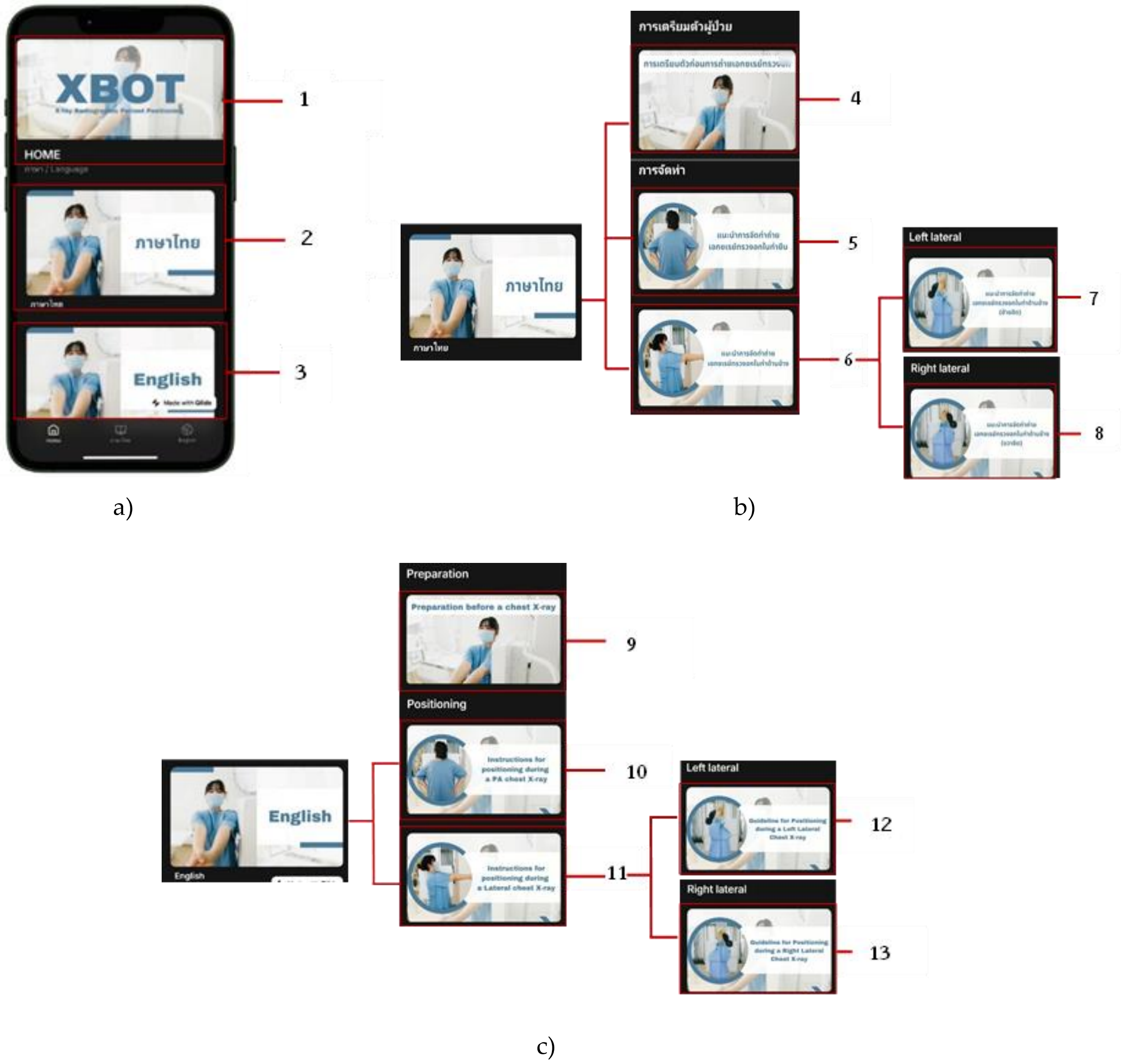

Figure 1. a) Users can choose between Thai and English. The system provides instructions for patient preparation and positioning for X-ray imaging in three views: PA, right lateral, and left lateral. b) Thai is chosen, and c) English is chosen.

2.2 Feature and Design of the projection system

The projector system, with a 1080P resolution and 150 American National Standards Institute (ANSI) Lumens, is designed for business and educational use. It features a portable, compact design with an LED lamp a 1.2:1 throw ratio, and is ideal for short-distance projections of less than 24 cm. The model C1000 offers a resolution of 854x480 pixels, providing clear and sharp images for various applications.

The video development for the projector system, which demonstrates chest X-ray positioning for display on the standing X-ray positioning setup (Bucky Wall Stand), involved filming and editing the content. Initially, the video was edited using the CapCut program to prepare it for projection. The video demonstrates various X-ray positions, such as the standing and left and right lateral positions.

The videos were created explicitly for the projection system to visually guide patients through the proper chest X-ray positioning, as depicted in Figure 2. For the posteroanterior (PA) chest X-ray positioning, the patient is instructed to stand with their chest against the Bucky Wall Stand, placing their hands on their hips while rolling their elbows forward to move the scapulae out of the lung field. The radiologic technologist guides the patient on breathing, asking them to take a deep breath and hold it during exposure. For the lateral chest X-ray positioning, the patient is asked to turn sideways with their side against the Bucky Wall Stand. They are then instructed to either raise their arms above their head or cross them in front to ensure the arms are out of the X-ray exposure area. The technologist ensures proper alignment by centering the X-ray beam on the midline of the chest, as shown in Figure 2.

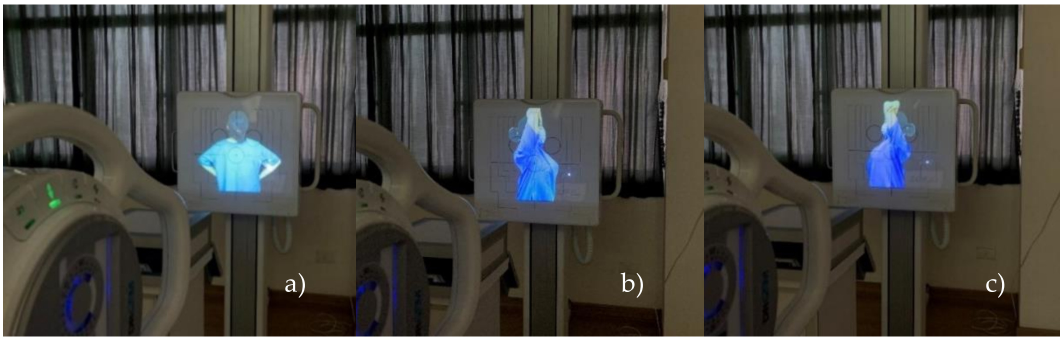

Figure 2. Illustrates the projection system designed to demonstrate chest X-ray positioning. It includes videos that guide patients in adopting the correct positions for the chest X-ray procedure on the Bucky Wall Stand. The figure displays three views: a) Posteroanterior (PA) position, b) left lateral position, and c) right lateral position. These videos provide step-by-step visual instructions for each positioning, ensuring clear and practical guidance for patients to achieve proper alignment during the chest X-ray procedure.

2.3 Evaluation of the Effectiveness of XBOT Web Application and Projection System

The evaluation of the web application and projection system involved 13 volunteers. Data was collected from July to August 2024. Participants watched the XBOT web application and then positioned themselves according to the projection system for all three views: PA, left lateral, and right lateral. The timing for each position was recorded, and the average time for each was calculated.

The sample size for this study was determined using statistical software based on a single-group design. The full score was set at 5 points, with an expected mean score of 3.00 points per prior experience. The standard deviation was assumed to be 2.00. A significance level (α) of 0.05 and a test power (1- β) of 0.80 were applied. Based on these parameters, the required sample size for evaluating the web application and video projection system was calculated to be a minimum of 8 participants. However, this study involved 13 participants who voluntarily consented to participate, exceeding the minimum sample size requirement.

The evaluation of the effectiveness of the XBOT Web Application and Projection System was based on a scoring criterion that assessed the ability of volunteers to position themselves accurately for chest X-rays. The scoring system was determined by the number of explanations needed from the researcher. Volunteers who could position themselves independently without any explanation received 5 points. Those requiring one explanation scored 4 points, two explanations earned 3 points, three explanations received 2 points, and four explanations resulted in 1 point. Volunteers who could not position themselves without assistance from the researcher were scored 0 points.

2.4 XBOT Web Application and Projection System Satisfaction Assessment

We evaluated the satisfaction of radiological technologists by presenting examples of chest X-ray photography poses for both systems through the XBOT web application and a projection system approach. The sample selection for this study was conducted using purposive sampling, where participants were chosen based on the researcher's judgment to align with the study's objectives. The inclusion criteria specified that participants must be radiologic technologists working in the diagnostic radiology department, aged between

25 and 60 years, and capable of communicating in Thai and English. A total of 5 participants were selected, all of whom voluntarily consented to participate by signing the informed consent form. Data was collected from July to August 2024. The exclusion criteria were radiologic technologists without experience in diagnostic radiology or those who did not consent to participate in the research. This purposive sampling approach ensured that the participants had the necessary expertise and competence to evaluate the effectiveness and satisfaction with the web application and video projection system.

The Likert scale was chosen for its simplicity and effectiveness in quantifying and evaluating the technologists' perceptions and satisfaction across various aspects of the web application. The Likert scale was used to rate each item on a 1 5- 5-point scale. A score of 1 indicated 'very unsatisfied,' 2 represented 'unsatisfied,' 3 was 'neutral,' 4 signified 'satisfied,' and five denoted 'very satisfied'. Evaluation of the XBOT web application includes assessing the positioning accuracy ensuring that the video images are clear and appropriately sized. The audio must be suitable and audible. Additionally, the web application should be convenient and user-friendly, with appropriate time allocated for each demonstration. The English content in the video should be accurate and easy to understand, and the necessity of the web application in assisting with positioning will be considered. Overall, these factors will be combined to assess the effectiveness of the web application. The evaluation of the video demonstration for X-ray positioning from the projection system will assess how effectively the projector-based video facilitates the positioning process. This includes evaluating the clarity and appropriateness of the video image and ensuring that the time allocated for demonstrations of both PA and lateral positions is suitable. It is anticipated that, with further development, the projection system will significantly reduce the time required for chest X-ray imaging, improving overall efficiency.

3. Results and Discussion

Before evaluating the effectiveness satisfaction assessment, the XBOT web application was assessed by verifying its functions to ensure stability and ease of use. The video intended for the projection system was also evaluated, focusing on the size of the images and video when projected onto the Bucky Wall Stand and confirming the stability of the connection.

3.1 Evaluation of the Effectiveness of XBOT Web Application and Projection System

The evaluation of the web application involved 13 volunteers who viewed video instructions for chest X-ray positioning in the PA, left lateral, and right lateral views. The video was projected onto the Bucky Wall Stand. After watching the video, the volunteers positioned themselves for the chest X-ray according to both the web application and the projection system. The results indicated that, among the 13 participants, the average score for positioning in the right lateral view was the highest at 5.00 ± 0.00 points, followed by the left lateral view with an average score of 4.77 ± 0.42 points, and the PA view with an average score of 4.23 ± 0.42 points. The average time for chest X-ray positioning was 11.52 seconds for the right lateral, 15.22 seconds for the left lateral, and 22.90 seconds for the PA view.

3.2 XBOT Web Application and Projection System Satisfaction Assessment

The research analyzed a questionnaire that tested the usability and satisfaction evaluation of web applications and projector systems, utilizing a 5-point Likert Scale. The scale was as follows: an average score of 4.51–5.00 indicated "Very Satisfied," 3.51–4.50 indicated "Satisfied," 2.51–3.50 indicated "Neutral," 1.51–2.50 indicated "Unsatisfied," and 1.00–1.50 indicated "Very Unsatisfied."

The results of the satisfaction evaluation for the XBOT web application and projection system are shown in Table 2. The satisfaction with the accuracy of the video demonstration for X-ray positioning from the web application had an average score of 4.80 ± 0.45, indicating ‘very Satisfied’. The necessity of the web application for assisting with positioning had the lowest average score of 4.00 ± 0.71, but still rated as ‘Satisfied’ with the accuracy of the video demonstration for X-ray positioning from the projector system had an average score of 4.40 ± 0.55, reflecting ‘Very Satisfied.’ The lowest-rated aspect was the facilitation provided by the projector-based video system, with an average score of 3.80 ± 0.45, still considered ‘Satisfied.’

Table 2. Results of the satisfaction evaluation for assisting patients with X-ray positioning demonstrations using the XBOT web application and the projection system.

Item	Average Score	Descriptive rating
1. Web Application		
Accuracy of the positioning	4.80 ± 0.45	Very satisfied
Appropriateness and clarity of the video image	4.60 ± 0.55	Very satisfied
Suitability and clarity of the audio in the video	4.40 ± 0.89	Satisfied
Convenience and ease of use	4.20 ± 0.84	Satisfied
Appropriateness of the time allocated	4.40 ± 0.84	Satisfied
Accuracy and ease of understanding of the English content in the video	4.20 ± 0.89	Satisfied
Necessity of the web application in assisting with positioning	4.00 ± 0.71	Satisfied
2. Projection system		
Convenience	3.80 ± 0.45	Satisfied
Appropriateness and clarity of the video image	4.00 ± 0.71	Satisfied
Appropriateness of the time allocated for PA and lateral views	4.00 ± 0.00	Satisfied
Anticipated future reduction in X-ray imaging time with improved projection system	4.40 ± 0.55	Satisfied
Overall	4.25 ± 0.67	Satisfied

The overall result, with a score of 4.25 ± 0.67, was collective 'satisfied' satisfaction with various aspects of the XBOT web application and projection system performance. This score encompasses feedback on factors such as image display quality and potential future benefits within diagnostic radiology departments.

Implementing effective protocols and technologies can play a crucial role in infection prevention, reducing human error and enabling front-line staff to focus on higher-priority tasks, thereby minimizing direct exposure to infection. Radiological technologists frequently interact with suspect and confirmed patients and are particularly vulnerable to occupational disease exposure [13]. The widespread transmission of the pandemic among healthcare personnel has significantly impacted communities, leading to immediate consequences for healthcare services.

In response, we have developed prototypes of the XBOT web application and projection system for assisting patients with X-ray positioning, designed to guide chest X-ray procedures. XBOT web application and projection system for assisting patients with X-ray positioning offer recommendations for postures and guide patients in preparation for chest X-rays and positioning. These systems are accessible via QR code scanning or through a provided link, enhancing user convenience. The videos were edited, and their backgrounds were removed to ensure seamless projection. The evaluation consisted of two parts: the effectiveness and satisfaction assessment with the XBOT web application and projector system.

Volunteers were assessed based on how accurately they could position themselves for the X-ray. The highest scores observed were in the right lateral position, followed by the left lateral and PA positions, respectively. The right lateral received the highest score, possibly due to its simplicity and ease of execution, and may have been influenced by familiarity. Since the right lateral was the third position tested, volunteers may have gained confidence from the earlier trials. In contrast, the PA position had the lowest score, potentially because it involves more steps and is more complex than the lateral positions. Additionally, the PA was the first position volunteers attempted, so they may not have been as familiar with the process, aligning with Kolb's experiential learning theory, which emphasizes learning through experience [14, 15].

Overall, the satisfaction level with the XBOT web application and the projection system was satisfied. The video demonstrations provided through the XBOT web application were clear and appropriate, with accurate explanations and content, making the application easy and convenient. The projection system was suitable, easy to understand, and correct in its presentation. However, there were additional suggestions from radiologic technologists who participated in the satisfaction evaluation. Improve the projector video by adding a more varied background color, as the different colors of bucky wall stands could affect the projected video's clarity.

Yasmeena Akhter et al.'s research on AI-based radiodiagnosis using chest X-rays provides a structured review of CXR-based analysis for various tasks, lung diseases, and the challenges faced by Artificial Intelligence / Machine Learning-based systems in diagnosis [12]. Our research, which focuses on technology for patient positioning during X-ray imaging, contributes to this by addressing how improvements in X-ray imaging and diagnostic accuracy can be achieved. This represents a development in the technology related to X-ray imaging.

In addition, there has been research in radiology focused on developing software and web applications for X-ray procedures. These innovations aim to enhance the accuracy, efficiency, and accessibility of radiographic imaging, improving diagnostic workflows and supporting radiologists in making informed decisions. Such applications incorporate advanced technologies like machine learning, artificial intelligence, and cloud-based solutions, streamlining the X-ray process from patient positioning to image analysis. These developments have the potential to significantly reduce errors, increase diagnostic consistency, and improve patient care. Cristian Sosa Vera et al. developed a web-based application for structural shielding calculations in medical X-ray imaging facilities [16]. The application, available in English and Spanish, ensures accurate results while offering a user-friendly interface to assist physicists with shielding computations. Kousuke Usui et al. developed software that evaluates CXR images to assess whether a retake is necessary, utilizing deep learning (DL) techniques [17]. Their findings demonstrate that the software can promptly and accurately determine if a chest X-ray requires re-scanning.

The small sample size of participants limits this study. Future studies should aim to include a more extensive and more diverse sample of radiological technologists from various institutions to ensure broader applicability. Additionally, the analysis could be improved by incorporating greater statistical depth, such as comparative methods or advanced modeling, to support further development.

4. Conclusions

The XBOT web application and projection system development provides bilingual guidance for chest X-ray positioning in the PA, left lateral, and right lateral views. The system provides volunteers with preparation instruction for Thai and English chest X-rays and video demonstrations projected onto the bucky wall stand. Results showed that volunteers accurately followed the positioning instructions, with the right lateral position achieving the best results in accuracy and setup time. The system effectively aids in X-ray positioning. Radiologic technologists also reported high satisfaction ratings for the XBOT web application and projector system. This solution may reduce staff workload, minimize contact, and assist patients in preparing for X-rays, improving overall workflow efficiency. Moreover, future iterations could focus on integrating AI-based posture correction for real-time adjustments and expanding multilingual capabilities to improve accessibility for a broader range of users. These enhancements would enhance the efficiency and global applicability of XBOT in radiology settings.

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