



The first picture archiving and communication system in Lao People's Democratic Republic: Changes in the utilization rate of imaging tests in the first year after implementation



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ABSTRACT

Background: Implementation of the Picture Archiving and Communication System (PACS) is more challenging in developing countries than in developed countries. Given that the first PACS in Lao People's Democratic Republic (PDR) was successfully installed at the Children's Hospital of Lao PDR, we aimed to investigate whether the utilization rate of imaging tests increased after PACS implementation.

Methods: PACS was implemented at the Children's Hospital of Lao PDR in December 2014. We compared the utilization rates of imaging tests including X-ray and ultrasound examinations between the pre-PACS period (from December 2013 to November 2014) and the post-PACS period (from December 2014 to November 2015). The utilization rate was defined as the number of imaging tests divided by the number of patients per month.

Results: The average number of total imaging tests was 225.8/month (standard deviation [SD], 37.7) during the 1-year pre-PACS period and was 269.4/month (SD, 38.5) during the 1-year post-PACS period ($P=0.0103$). The utilization rate of total imaging tests significantly increased after PACS implementation (pre-PACS, 2.47%/month; post-PACS, 4.23%/month; $P<0.0001$). Increased utilization rates were observed for both X-rays (pre-PACS, 1.65%/month; post-PACS, 2.38%/month; $P=0.0004$) and ultrasound examinations (pre-PACS, 0.82%/month; post-PACS, 1.85%/month; $P=0.0001$).

Conclusions: The implementation of PACS at the Children's Hospital of Lao PDR resulted in a significant increase in the utilization rate of imaging tests, suggesting the indirect benefit of improved quality of care. Our findings showed that the benefits of PACS can be realized even in a resource-limited country such as Lao PDR.

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Abbreviations: Lao PDR, Lao People's Democratic Republic; PACS, picture archiving and communication system; KOICA, Korea International Cooperation Agency; OPD, outpatient department; ER, emergency room; ICU, intensive care unit; OR, operation room; MDG, millennium development goal; ODA, official development assistance; HIS, hospital information systems.

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1. Introduction

Picture archiving and communication system (PACS) refers to an electronic medical imaging technology in which images acquired from multiple modalities are digitalized and stored [1]. Based on the merits of PACS, such as economic storage of medical images, rapid retrieval, and simultaneous access at multiple sites, the PACS has accomplished a tremendous achievement during the past three decades [2]. The implementation of PACS led to increased numbers of patients visiting hospitals, reduced lengths of hospital stay and improved work flow of the department of radiology [3]. Hospitals with PACS have realized reduced film-related costs, and the cost-effectiveness of PACS would be greater in large hospitals and in hospitals with full PACS [4,5]. PACS also achieves several important indirect benefits, such as improved quality of care and enhanced education and research [6–12].

Developed countries have been on the cutting edge of radiologic technology and have benefited from the growth of PACS. However, most developing countries could have not been able to benefit from this growth [13,14]. The disparities in the use of PACS between developed and developing countries are mainly attributable to the low levels of human development, limited infrastructure, lack of experience with imaging technology, and low expected level of user acceptance [15]. More importantly, whether these potential benefits of PACS could be accomplished in resource-limited setting has not been fully investigated. There have been several reports on experiences in PACS implementation in developing countries, but their impacts on local healthcare service were not evaluated in a quantitative manner.

Lao People's Democratic Republic (Lao PDR), also known as Laos, is a land-locked country located on the central Indochinese Peninsula. Most of the public health indicators in Lao PDR demonstrate the poor medical environment of this developing country [16,17], and especially, the children's healthcare is one of the most urgent medical issues in this country [18,19]. According to World Bank statistics, the under-five mortality rate in Lao PDR is 67 per 1000 live births, infant mortality is 51 per 1000 live births, and neonatal mortality was 30 per 1000 live births [5,16,20].

Similar to other developing countries with limited resources, Lao PDR has not achieved distribution or implementation of PACS. The infrastructure for computer technology and network systems in Lao PDR is also inadequate: in Lao PDR, there are 1.7 computers and 1.77 internet users per 100 inhabitants [17,21]. Limited knowledge and experience with radiology among physicians also influence the low utilization rate of imaging tests in Lao PDR, which contributes to low quality care [22,23]. Therefore, the implementation of PACS in Lao PDR was expected to be challenging.

In 2014, we implemented a partial PACS at the Children's Hospital of Lao PDR, the only national pediatric referral hospital [24,25]. We aimed to evaluate whether the PACS implementation affected the utilization of imaging tests in the Children's Hospital by examining the utilization rate of imaging tests in the 1 year following PACS implementation.

2. Methods

As an evaluation study of health informatics, our study followed the currently recommended guidelines: the Statement on Reporting of Evaluation Studies in Health Informatics (STARE-HI) [26].

2.1. Children's Hospital of Lao PDR

Children's Hospital of Lao PDR is a primary, secondary, and tertiary care teaching hospital located in Vientiane Prefecture (18.0037552 N, 102.626456 E). It is the only national pediatric refer-

ral hospital in Lao PDR. This 70-bed hospital was built in 2011 (Fig. 1) [24], and was equipped with a radiographic and fluoroscopic X-ray system (WSRF-50, R/F X-ray System, WONSOLUTION, Korea), a trans-thoracic echocardiography machines (ACCUVIX V10 ultrasound system, Samsung Medison, Korea), and a portable ultrasound system (Toshiba Viamo. TOSHIBA, Japan). The Ministry of Health (MOH) of Lao PDR has had management authority of the Children's Hospital since its opening on November 11, 2011; the Korea International Cooperation Agency (KOICA) has provided volunteer doctors, nurses, radiographic technicians and specialists in computer technology to the hospital [27].

2.2. Implementation of the PACS

Before the implementation of the PACS at the Children's Hospital of Lao PDR, the results of medical imaging tests were distributed to patients but not stored at the hospital. Patient information was written in ledgers simply to count the number of patients but not to identify patients (Fig. 2A). Therefore, damage to and loss of imaging test results were inevitable (Fig. 2B), and follow-up of patients' clinical courses were not possible. Adding to the difficulty of the utilization of imaging tests was the fact that inexperienced radiography technicians often produced poor-quality X-ray films that were not adequate for interpretation because of radiation exposures that were too low or high (Fig. 2C).

In order to enable the systematic utilization of imaging test results and to improve the capabilities of hospital staff members in radiology, we introduced PACS at the Children's Hospital of Lao PDR. Considering that other hospitals in Lao PDR were using film-based practices and that the PACS at the Children's Hospital was the first in the nation, we installed a partial PACS program (ZEROPACS, DIMEDI Co., Ltd., Korea) with a film scanner (DMD D-2000, DIMEDI Co., Ltd., Korea). The main server room and work station were configured separately in the radiology department, and the gateways for the conversion of images to the Digital Imaging and Communication in Medicine (DICOM) standard were placed in the X-ray room and the ultrasound room (Fig. 3). The ultrasound machines were directly connected to the main server. Twenty PACS viewer programs were installed at every unit throughout the hospital: the outpatient department (OPD), medical ward, the emergency room (ER), the intensive care unit (ICU), the operation room (OR), the conference room, the cardiovascular unit, the allergy clinic, the Childhood Cancer Center, the Thalassemia clinic, the international clinic and the library.

The field project for PACS implementation had a total budget of \$53,397 USD. The equipment and network were prepared, and then the PACS was installed in December 2014. To enhance the user acceptance, we provided maintenance and education for 5 months after its installation [25].

2.3. Study outcomes

In the present study, we aimed to compare the utilization rates of imaging tests between the 1 year before the implementation of PACS (pre-PACS) and the 1 year after the implementation of PACS (post-PACS) at the Children's Hospital of Lao PDR. We hypothesized that the installation of PACS increased the utilization rate of imaging tests. To investigate the change in utilization rates, we counted the number of imaging tests performed during the study period and the number of patients who visited the hospital, including the OPD, ward, ER, ICU, cardiovascular unit, allergy clinic, OR, Thalassemia clinic, Childhood Cancer Center and international clinic. The utilization rate of imaging tests was defined by following equation: utilization rate of imaging tests = (total number of imaging tests performed per month) ÷ (total number of patients who visited the hospital per month) × 100 (%). We compared the utilization rates of

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