Original Article

Healthc Inform Res. 2019 October;25(4):324-331.
https://doi.org/10.4258/hir.2019.25.4.324
pISSN 2093-3681 • eISSN 2093-369X

HIR
Healthcare Informatics Research

PACS Implementation Challenges in a Public Healthcare Institution: A South African Vendor Perspective

Romain Abbas, Yashik Singh
Department of Telehealth, Nelson R. Mandela School of Medicine, University of KwaZulu-Natal, Durban, South Africa

Objectives: Conventional radiological processes have been replaced by digital images and information technology systems within South Africa and other developing countries. Picture Archiving and Communication Systems (PACS) technology offers many benefits to institutions, medical personnel and patients; however, the implementation of such systems can be a challenging task. It has been documented that South Africa has been using PACS for more than a decade in public hospitals with moderate success. The aim of this study was to identify and describe the PACS challenges endured by PACS vendors during implementation in the South African public healthcare sector. **Methods:** This was achieved by engaging in a methodological approach that was qualitative in nature collecting data through semi structured interviews from 10 PACS experts/participants which were later analysed qualitatively. **Results:** The findings show that PACS vendors have countless challenges, some of which include space, insufficient infrastructure, image storage capacity, system maturity and vendor related concerns. It was clear that the PACS experts readily offered contextually appropriate descriptions of their encounters during PACS implementations in South African public healthcare institutions. **Conclusions:** PACS vendors anticipate these challenges when facing a public healthcare institution and it is recommended that the hospital management and potential PACS stakeholders be made aware of these challenges to mitigate their effects and aid in a successful implementation.

Keywords: Radiology Information Systems, Medical Informatics, Medical Informatics Computing, Information Storage and Retrieval, Radiography

I. Introduction

Over the past few decades, there have been some major changes in radiology practice and in medical imaging technology worldwide leading up to the changeover of medical imaging machines to a digital format replacing the commonly used X-ray film [1]. These revolutionary changes include the introduction and broad use of Picture Archiving and Communication Systems (PACS), a sub-division of healthcare information systems (also called medical information systems or clinical information systems), which has modified workflows in hospitals and increased clinical efficiency between healthcare practitioners and patients [2]. A simple PACS workflow is shown in Figure 1.

PACS forms an integral part of medical imaging informat-

Submitted: August 7, 2019
Revised: October 23, 2019
Accepted: October 23, 2019

Corresponding Author
Yashik Singh
Department of Telehealth, Nelson R. Mandela School of Medicine, University of KwaZulu-Natal, 5th Floor, Main Building, Umbilo, Durban 4001, South Africa. Tel: +27-312604543, E-mail: singhyashik@gmail.com (https://orcid.org/0000-0001-9676-8169)

ics, which concerns itself with the development and adaptation of techniques from medicine, engineering, computer science and other fields to create and manage medical data and knowledge and improve clinical care [3]. During the last few years, PACS technology has been adopted by many radiology departments within South Africa, particularly in the private sector [4]. The South African Department of Health recognized the potential benefit of PACS and consequently endorsed its implementation in the South African public health sector to benefit the wider population [5]. The public helath sector is massive compared to the private sector and treats almost 90% of the population. Table 1 lists the number of public and private clinics and hospitals there are in South Africa and the number of beds per provance.

After all this time, even with several deployment efforts for PACS combined with the support of the Department of Health, the systems were not operating successfully and only a small number of PACS were fully operational [6]. The success of PACS implementation is based on the vendor's ability to meet a list of requirements such as desirable features, system uptime, ease of use and professional training programs defined by the stakeholders such as radiologists, PACS administrators, radiographers and others [7]. A PACS vendor represents the company that sells, installs and implements the healthcare information systems.

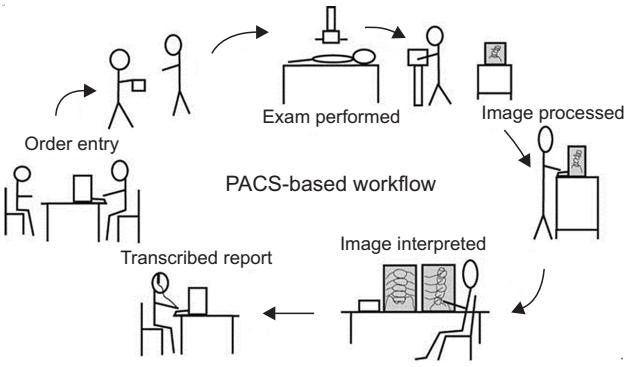

Figure 1. A Picture Archiving and Communication Systems (PACS)–based workflow.

The current situation in South Africa is one such where medical equipment vendors (PACS vendors) become exclusively responsible for the appropriate implementation of the equipment and its accompanying software; their expertise and skills are heavily relied upon by the Department of Health and its users. PACS implementation projects are typically handled by vendors until the project is handed over, and even after the handover, external expertise is available until the system is classified as a success [8]. With almost 60%–70% of all software implementation projects failing in healthcare, it is agreed that healthcare information technology is difficult to implement, and the manner of implementation is best left to the actual vendor [8,9]. Supporting the PACS vendor is deemed crucial at the primary implementation stages to achieve a successful project [8]. This can be achieved by persuading vendors to be held more responsible for their involvement in the PACS project [10].

A number of PACS related studies conducted internationally have included participants such as radiologists, technologists and referring doctors, but few have gathered data based on vendor and expert reviews from a developing country [2,11,12]. Most investigations have considered a single, or at best, a small number of factors that contribute to a fragmented view of PACS success. PACS implementation from an institutional perspective is also generally reported [13]

Table 1. The number of public and private clinics and hospitals and the number of private and public healthcare facility beds available in 2014

Province	Public			Private		
	Clinic	Hospital	Beds	Clinic	Hospital	Beds
Eastern Cape	731	91	13,200	44	17	1,723
Free State	212	34	4,798	22	13	2,337
Gauteng	333	39	16,656	286	83	14,278
KwaZulu-Natal	592	77	22,048	95	12	4,514
Limpopo	456	42	7,745	14	10	600
Mpumalanga	242	33	4,745	23	13	1,252
North West	273	22	5,132	17	14	1,685
Northern Cape	131	16	1,523	10	2	293
Western Cape	212	53	12,241	170	39	4,385
Total	3,863	407	85,362	610	203	31,067

rather than at the vendor level. To summarize, past empirical and evaluative studies have provided limited discussion on the conceptual frameworks for holistic or comprehensive understanding of PACS success or systematic and practical descriptions of challenges endured in a developing country. The outcome would enable healthcare management and users and vendors to anticipate possible challenges during implementation that would later mitigate their downside effects.

Thus, the aim of this study was to identify and describe PACS challenges endured by PACS vendors during implementations in South African public healthcare institutions. This was achieved by engaging in a methodological approach that was qualitative in nature and collected data through semi-structured interviews from 10 PACS experts/participants.

II. Methods

This study used an interpretive qualitative research approach. It enabled an information rich narration of a population of PACS vendor employees with the aim to capture data of their live experiences and to report on their meanings and understandings in context [14]. Ethics permission was sought and granted, by the University of KwaZulu-Natal (UKZN) Humanities and Social Sciences Research Ethics Committee as this study (No. HSS/1582/016M) was completed in partial fulfilment for a Masters of Medical Science in medical informatics. Permission to perform the study was also obtained from the UKZN Registrar's Office and was conducted with the participants' consent.

The study population consisted of PACS experts currently employed by a PACS vendor with a minimum of 2 years implementation experience within a South African public healthcare institution. Convenience sampling was used, and participant selection was based on both the judgement of the researcher and the availability of participants. Ten participants were selected for this study, and the cohort consisted of PACS managers, application specialists and technicians.

The data were collected by a qualitative approach utilizing semi structured interviews. Participant interviews were audio recorded, numbered and transcribed for detailed thematic analysis. The analysis aimed to capture and narrate the subjective experiences and understandings of the participants. Reading and re-reading of the transcribed information steered the author into classifying key themes which were subsequently used to establish connections and associations with the aims of this study. After identifying the themes, the authors re-interviewed the participants asking about their opinions on the emerging themes.

III. Results

1. Biographic Details

Table 2 provides a summary of the demographic details of the respondents including age, years of experience, current designation and prior work experience. The vast majority of the respondents (7 of 10) were between the ages of 25–40 years old with predominantly prior medical and IT experience.

2. PACS Implementation Challenges

From the ten individual interviews conducted with the specialists who have implemented PACS in a South African public healthcare institution, 12 sub-themes emerged as related to the above-mentioned main research question. These themes and key themes are listed in Table 3. The direct narratives of the respondents are italicized and indented. A PACS vendor's customer refers to radiologists, radiographers and referring doctors specifically.

1) Space & inappropriate furniture

The respondents noted that space is a great challenge because space is needed for the deployment of PACS worksta-

Table 2. Summary of demographic details of the respondents

	n
Age of respondents (yr)	
25–35	4
35–40	3
≥40	3
Years of experience	
2–4	3
4–8	3
≥8	4
Current designation	
Application specialist	4
Technicians	4
Managers	2
Prior work experience	
Medical	4
IT	4
Engineering	2

https://doi.org/10.4258/hir.2019.25.4.324

tions and ancillary devices, for working in the PACS server room and for users to operate the PACS. The narratives supporting these statements are noted below:

Space is always an issue;
Space for your switch cabinets and running the cables;
They don't have a dedicated server room;
The server room is also very small;
There is no space to work on the computer.

In addition to needing space, the respondents noted that the correct furniture is needed for the placement of workstations in an ergonomic manner.

There were no desks;
The correct furniture for radiographer's desks and workstations;
Ergonomically challenging.

Third, the respondents noted that space could be made available by removing old equipment which is a laborious task.

Vendors are tasked with finding a place to put all this equipment;
Getting rid of old equipment to make space for new ones can take some time.

2) Insufficient infrastructure

Respondents in this study described power cuts, the lack of stable power and insufficient networks installed by the healthcare institution as some of their major infrastructure related challenges during PACS implementations. The above statements are supported by the narratives below:

The biggest issue in this country is the power cuts;
Power cuts blow your power supply and your hard drives;
No physical infrastructure like network, power;
Hospitals need to take on the costs of networking in order to reap the full benefits from the system so no skimming here;
In certain buildings, old ones, it becomes difficult to run network and cables.

3) Protection of equipment

Protection of IT equipment was noted as a challenge by a few respondents who stated that the old X-ray dark rooms were converted to server rooms which are still not safe enough to store patient image archives evident by the following responses.

Someone can drill through the wall, puncture a pipe and spray your IT equipment;
The fact that there can be drains in these rooms mean there can be flooding.

One respondent noted that there is a need to train users on proper downtime procedures for when there is a power failure to minimize damage to equipment.

Users don't switch off the PC's when there is a power cut.

One respondent mentioned that theft of equipment was a concerning factor.

Theft is also an issue.

4) Hospital financial constraints

Budget is an important factor in PACS projects, and this is one of the challenges noted by the respondents. Respondents mentioned that the reduction in the healthcare budget

Table 3. Summary of all key themes

Challenge	Possible solution
Space and inappropriate furniture	Proper situational and needs assessment
Insufficient infrastructure	Government and private sector support
Protection of equipment	Government and private sector support
Hospital financial constraints	Government and private sector support
Lack of IT knowledge	Training
Resistance to change	Proper change management processes
Image storage capacity	Adequate needs assessment
System maturity	Regular maintenance and evaluation
Software and hardware encounters	Regular maintenance and evaluation
Maintaining the radiology workflow	Regular maintenance and evaluation
Vendor related concerns	Regular maintenance and evaluation

means that the best solution for the institution is not often purchased as demonstrated below:

There's never enough money to purchase the best equipment for the hospital;
It's always too low for what you need to put in;
Its cut down so much… the correct solution does not get installed.

Additionally, the extra costs of buildings and construction, which are desired for the supporting infrastructure, are not factored in to budgets. Hospitals do not prepare a budget for future upgrades and the maintenance of a system or budget for theft of equipment. The narratives which supported the above statements are noted below:

They don't ever factor in the building works, infrastructure, etc.;
They don't see a need to upgrade the equipment during the years;
Always additional costs incurred due to theft and not enough PCs to be allocated to all wards;
These costs cannot be skimmed since it affects the running of the PACS long term;
Budget needs to be allocated to PACS maintenance every year.

5) Lack of information technology knowledge

Respondents noted that computer literacy and a general lack of IT knowledge are contributing factors to the challenges of implementing PACS in South African public health institutions. The supporting statements are given below:

Their lack of IT knowledge makes implementation difficult;
In this country in the public sector, computer literacy is one of our biggest problems;
Lack of IT knowledge is a major issue.

6) Resistance to change

The respondents noted that a general resistance from all staff members is perceived during a PACS implementation in the public healthcare sector. Fear of technological change and its accompanying lack of leadership are some of the factors noted. The supporting narratives are noted below:

People who are not familiar with technology… they were very scared;
They're also a bit reluctant to learn about the new software;
Change is always difficult especially in the medical arena since it is a highly stressful environment;
Nobody wants to take the lead and learn about this system.

7) Image storage capacity

Image storage capacity refers to the amount of images the PACS can store until no new patients can be archived. Respondents noted that healthcare institutions do not project their storage needs accurately, and radiological image storage space is depleted in the coming years which are noted in the below narratives:

They need to budget for additional storage going forward;
Not enough storage space and customers don't project their storage needs accurately;
The PACS archives are always running out of space.

8) System maturity

System maturity deals with the actual ageing of the PACS and the ongoing support and upgrades needed to keep the system operational for a longer period than initially anticipated. Respondents noted that customers do not know the system's life expectancy, and they do not plan for service level agreements (SLA) after the initial warranties expire. Furthermore respondents recommend a SLAs or extended warranties be pursued for ongoing support. The associated statements are noted below:

They feel like once the PACS is installed it must run for its life expectancy;
Recommended that the public sector has an SLA to manage that;
If it's out of warranty then it becomes an issue because we can't attend to their problems.

9) Software and hardware encounters

A few respondents noted that there are clearly visible hardware and software challenges that vendors endure during PACS implementations as noted below:

There could be quite a lot of issues regarding hardware;
Software usability issues and challenges will always be present.

These challenges seemed to have come from the use of maintenance contracts or SLAs. Vendors believe that software has bugs and those bugs can be eliminated with software upgrades; however, these upgrades become costly if there is no service contract in place. The supporting statements are noted below:

https://doi.org/10.4258/hir.2019.25.4.324

Software upgrades are expensive if no SLAs are in place;
Constant upgrades of both hardware and software and customers need to be aware of this;
Sometimes new versions need to be bought to eliminate bugs and this is costly for the consumer.

Moreover, the non-conformity of certain DICOM (Digital Imaging and Communication in Medicine) protocols that exist whilst integrating modalities to the PACS can be time consuming as seen below:

Sometimes the DICOM doesn't conform and you end up spending a lot of time working your way around that.

10) Maintaining the radiology workflow

The PACS radiology workflow has many advantages for the department; however, maintaining the correct workflow is a challenge in the South African public healthcare sector. The below responses state that there are always workflow issues, and there is difficulty in maintaining it:

There are workflow issues all the time;
Sticking to it is probably the most difficult part.

It is well-known by the respondents of this study that workflow related issues are the responsibility of the vendor and proper workflow training, and those improvements in the workflow operations process can only be visualized once the entire implementation is complete. The supporting narratives are listed below:

Users need to be trained on workflow changes between analogue and digital;
Users need to be shown how these new work processes will impact their daily lives;
Workflow improvements can only be seen once the entire implementation process is complete.

11) Vendor related concerns

PACS vendors operating in South Africa also have their own set of challenges that are merely vendor related having a token impact on PACS implementation challenges and are worth noting. Lack of specialist training for all staff, lack of man power on large projects and timely professional support from international manufacturers are deemed the most noteworthy challenges as described by PACS vendor employees. The narratives supporting the above discussion can be seen below:

Manpower is not enough;
Lack of specialist training;
Professional support from international manufacturers.

12) The single greatest challenge

The single greatest challenge identified by the study respondents is operator related. Respondents were tasked to name the greatest challenge anticipated during the implementation, and it was the healthcare user (operator) of PACS that was mentioned for varying reasons. These reasons point to a lack of training supported by the following narratives:

90% of the time it is always the medical staff doing something wrong;
Not capturing the patient in the correct format in the correct places;
There is a clear lack of IT and PACS training.

Furthermore, respondents mentioned that a reluctance to attend meetings, unmet customer expectations, resistance to change and employee interactions are all user related causes of PACS implementation failure. The narratives supporting the claims are noted below:

They do not attend meetings;
They just don't want to adapt; People within the department do not help each other;
There is a big gap in understanding as to what the system can do and what it is meant to do.

IV. Discussion

A summary of the challenges that vendors face is shown in Table 1. A general lack of space to position the PACS workstations and its accompanying peripheral devices was intensified with the absence of proper furniture limiting the potential for their use. Triegaardt [6] concurred by noting that the resistance from users during a PACS implementation in the Eastern Cape, South Africa was generally due to minor system changes such as uncomfortable ergonomic positioning of equipment. The current situation leaves the PACS vendor responsible for the positioning of these workstations and the removal of the older equipment which is said to be a laborious task. Moreover respondents noted that old X-ray darkrooms are often converted to unsafe server rooms with the possibility of damage to the equipment. In South Africa, there is a lack of physical infrastructure like rooms, offices and general space [15]. This has been identified as a problem

by the vendors as well.

The most important elements of a sufficient infrastructure needed for PACS deployment are power and networking as noted by the respondents. Similarly, the failure of Limpopo's health system in 1999 had comparable examples of infrastructure problems that included difficulties identifying the appropriate computer rooms with air conditioning, reliable power and installed local networks which was delayed by a concurrent plan to upgrade hospitals [16]. South Africa has a general problem with power and electricity that affects all sectors, including business and healthcare [17]. This clearly also poses a challenge to PACS implementation as the entire system depends on stable power.

The lack of financial support was the most significant barrier to successfully implementing information technology in healthcare from both the clients' and vendors' perspective [18]. Moreover, funds are available, but vendor contracts limit system adjustability, and governmental systems limit the options that hospitals can purchase [6]. Other barriers include the additional costs of space modifications, budgets for future upgrades, maintenance of the system and replacement for theft of equipment. Respondents noted that theft is a concerning factor in the South African healthcare sector.

A general lack of IT knowledge was noted as a challenge that impaired the implementation of PACS systems because PACS software training is reliant on a basic understanding of IT. This has been also reported in the healthcare domain. In a recent study that determined the perceptions of healthcare workers in Africa on IT, only 40% had seen a computer in their lifetime, and only a meager 29% had received basic computer literacy training [19]. This is a major challenge to vendors during PACS implementation. If the users are not even computer literate, there will be major issues with using the PACS systems.

A general resistance to change was reported with PACS users lacking IT experience said to be the most reluctant. In addition, there is a lack of leadership and change management which creates challenges during implementation and training phases of the project. Lorenzi and Riley [20] advocated that organizational resistance always occurs during the implementation of new healthcare information systems. Along similar lines, the PACS workflow was reiterated by the respondents suggesting that operators do not follow the guidelines set out at the planning stages. In addition, it was noted that the workflow related issues are the responsibility of the vendor, and proper workflow training along with process improvements can only be visualized once the entire implementation is successfully accomplished.

Respondents noted that healthcare institutions do not project their storage needs accurately, and hospitals often have their storage space depleted meaning they will not be able to archive any more patients. Moreover, customers are unaware of the system's life expectancy, and they do not plan for SLAs after the initial warranties expire. System maturity was stressed as a challenge. Because South Africa has been implementing PACS for over 10 years, there are many systems operating without possible service contracts in place translating into higher costs and system instability. PACS vendors endure many software and hardware encounters, some of which are expected such as software bugs that can easily be eliminated with system upgrades. It was generally advocated by the respondents that all these matters are of no concern when the customer has an active SLA but can become costly when there is no service contract in place. PACS vendors endure some of their own challenges that have a token impact on PACS implementations. Lack of specialist training, lack of man power on large projects and timely professional support from international manufacturers are the most salient points because these can lead to implementation delays and dissatisfied customers contributing to the resistance mentioned earlier.

The study respondents were tasked to name the greatest challenge anticipated during the implementation, and it was the healthcare user (operator) of the PACS that was mentioned for varying reasons. A lack of training was noted with either the current PACS, basic IT or an interconnected system that transmits data to the PACS. It is well-known that users have unfounded expectations of the system, and this has proven to be challenging for the PACS vendors. Furthermore, respondents noted that users are reluctant to attend PACS meetings aimed at solving some of these challenges. As a final point, users were observed not helping each other with PACS related queries during implementation which if achieved can reduce the constant training liability of the PACS vendor.

Understanding and evaluating PACS implementation challenges are paramount in developing countries where many unforeseen encounters can take center stage by triggering a system to fail. The results of this paper indicate that space, insufficient infrastructure, image storage capacity, system maturity and vendor related concerns are the more pertinent challenges noted by the study respondents among others. PACS vendors anticipate these challenges when facing a public healthcare institution, and it is recommended that the hospital management and potential PACS stakeholders be made aware of these challenges to mitigate their effects and

 https://doi.org/10.4258/hir.2019.25.4.324

to aid in a successful implementation.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Acknowledgments

This study was part of the MMedSci-MI degree of Romain Abbas at the University of KwaZulu-Natal.

ORCID

Romain Abbas (http://orcid.org/0000-0002-5908-8452)
Yashik Singh (http://orcid.org/0000-0001-9676-8169)

References

1. Liu Y, Wang J. PACS and digital medicine: essential principles and modern practice. Boca Raton (FL): CRC Press; 2011.
2. Pare G, Trudel MC. Knowledge barriers to PACS adoption and implementation in hospitals. Int J Med Inform 2007;76(1):22-33.
3. Bui AA, Taira RK. Medical imaging informatics. New York (NY): Springer Science & Business Media; 2010.
4. Mulla FA. The experiences of radiographers working with PACS and RIS in Gauteng [dissertation]. Johannesburg, South Africa: University of Johannesburg; 2012.
5. Department of Health. Minister of Health calls for national telemedicine strategy [Internet]. Gauteng, South Africa: Sabinet; 2010 [cited at 2019 Oct 25]. Available from: https://legal.sabinet.co.za/articles/minister-of-health-calls-for-national-telemedicine-strategy/.
6. Triegaardt M. Picture Archiving and Communication Systems in the South African public healthcare environment: a suitable structure and guidelines to assist implementation and optimisation [dissertation]. Stellenbosch, South Africa: Stellenbosch University; 2013.
7. Jorritsma W, Cnossen F, van Ooijen PM. Merits of usability testing for PACS selection. Int J Med Inform 2014;83(1):27-36.
8. Abdullah ZS. Hospital information systems implementation framework: critical success factors for Malaysian public hospitals [dissertation]. Perth, Australia: Curtin University; 2013.
9. Ammenwerth E, Iller C, Mahler C. IT-adoption and the interaction of task, technology and individuals: a fit framework and a case study. BMC Med Inform Decis Mak 2006;6:3.
10. Reddy AS, Loh S, Kane RA. Budget variance analysis of a departmentwide implementation of a PACS at a major academic medical center. J Digit Imaging 2006;19(1):66-77.
11. Aldosari B. User acceptance of a picture archiving and communication system (PACS) in a Saudi Arabian hospital radiology department. BMC Med Inform Decis Mak 2012;12:44.
12. Carlin L, Smith H, Henwood F, Flowers S, Jones A, Prentice R, et al. Double vision: an exploration of radiologists' and general practitioners' views on using picture archiving and communication systems (PACS). Health Informatics J 2010;16(2):75-86.
13. Inamura K, Kim JH. History of PACS in Asia. Eur J Radiol 2011;78(2):184-9.
14. Wynekoop JL, Russo NL. Studying system development methodologies: an examination of research methods. Inf Syst J 1997;7(1):47-65.
15. Manyisa ZM, van Aswegen EJ. Factors affecting working conditions in public hospitals: a literature review. Int J Afr Nurs Sci 2017;6:28-38.
16. Health Systems Trust. Evaluation of hospital information system in the Northern Province in South Africa [Internet]. Durban, South Africa: Health Systems Trust; 2002 [cited at 2019 Oct 20]. Available from: http://www.samrc.ac.za/sites/default/files/files/2017-07-03/nothern.pdf.
17. Benatar SR. Health care reform and the crisis of HIV and AIDS in South Africa. N Engl J Med 2004;351(1):81-92.
18. Health Information and Management Systems Society. Enabling healthcare reform using information technology. Chicago (IL): Health Information and Management Systems Society; 2008 [cited at 2019 Oct 20]. Available from: https://www.himss.org/sites/himssorg/files/HIMSSorg/2009CalltoAction/HIMSSCallToAction-Dec2008.pdf.
19. Sukums F, Mensah N, Mpembeni R, Kaltschmidt J, Haefeli WE, Blank A. Health workers' knowledge of and attitudes towards computer applications in rural African health facilities. Glob Health Action 2014;7:24534.
20. Lorenzi NM, Riley RT. Organizational issues = change. Int J Med Inform 2003;69(2-3):197-203.