A Study of Factors Affecting on Patients' Length of Stay in a Surgical Ward: Toward Optimization by Technology-based Solutions

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Abstract

Background: Understanding each of the factors affecting the length of hospitalization especially in surgery wards can play a major role in planning for the optimal use of hospital resources. This study aims to determine factors affecting the length of stay (LOS) in a surgical ward and then provide technology-based solutions .

Methods: In this cross-sectional study, 310 records were selected by systematic random sampling from hospitalized patients in surgery ward of a general teaching hospital in Bandar Abbas, situated in south of Iran. In order to determine the association of 26 variables (demographic, clinical, and non-clinical) with LOS, analytical and descriptive statistics were used. Then, the researchers reviewed relevant literature in PubMed, Scopus, and Google Scholar to introduce solutions based on health information technology (HIT) toward LOS optimization.

Results: Mean and median of patients' LOS in surgery ward were 3.30 ± 3.71 and 2 days respectively. According to multivariate regression model, factors that exerted higher influence on length of stay includes number of para-clinical tests, surgeries, and consultation as well as type of referral and months of admission ($p < 0.05$). Regarding HIT-based intervention, eleven general categories of suggestions were provided. Based on the findings, more accessible technologies such as hospital information system, picture archiving and communication system, telemedicine especially tele-consultation or tele-visit as well as electronic consultation and discharge planning tools alongside smart dashboards for institutions like the center under study in order to expedite the process of diagnosis and treatment, then optimizing LOS seem appropriate.

Conclusions: It is important to move toward optimized LOS through understanding and control influential factors; standardize LOS along with continuous monitoring of performance indicators may help to utilize hospital resources more efficiently. HIT-based interventions may support health care providers and administrators to manage patients' admission, hospitalization, transfer, and discharge processes more properly. **Keywords:** Index; length of Stay; Hospital; Health Information Technology; Surgery_ward

Introduction

The increasing cost of healthcare has forced politicians and planners to seek new solutions for cost control and proper usage of limited resources[1].

In hospitals, certain indicators such as bed occupancy rate, average length of stay, bed turnover rate, bed turnover interval, and mortality rate are among the most significant performance indicators which should be calculated and monitored[2, 3].

length of stay (LOS) is one of the most important hospital indicators which is required to be checked regularly. It is defined as interval between admission and discharge of a hospitalized patient is an indicator which is commonly used for purposes such as management and planning of hospital care, quality control, and demand of using hospital services. Also, it is an indirect indicator of resource consumption and efficient management of hospital beds; hence, it is an efficiency indicator of hospital performance [4, 5].

The patients' longer or shorter than necessary length of stay will influence cost and quality of provided care. In the first case, longer LOS may cause limited resources usages, lower level of service provision to higher number of people, higher pressure for more investment in new treatment centers, lower efficiency and higher depreciation of hospital facilities and more specifically exposure to hospital infection, complications of re-admission and reduction of available resources for patients with critical conditions. On the other hand, shorter-than-necessary length of stay will affect quality of service subversively and contribute to undesirable consequences [4, 6-8].

Limitation in treatment centers, personnel, equipment, and increasing costs of healthcare services, may cause more attention to optimize length of stay and related influential factors [9]. Previous studies suggest that a lot of factors influence length of stay. Depending on main goal and studied population, these factors will be different [6, 10].

Each of previous studies points to a set of variables as influential upon prediction of prolonged LOS[11, 12]. There is no consensus regarding factors affecting patients' length of stay[11], particularly in surgery ward. It is important to study the length of stay and its associated factors in each treatment center individually. Moreover, no study has provided technology-based solutions comprehensively in line with optimizing the patient's length of stay. Thus, this study addresses patients' length of stay and associated factors in general surgery ward as representative of surgical wards of Shahid_Mohammadi teaching hospital in Bandar Abbas; furthermore, it is aimed to provide solutions based on health information technology (HIT) toward LOS optimization.

Methods

This study was conducted in two main steps as follows:

The first step was a descriptive-analytical study with a cross-sectional design. The statistical population consists of patients hospitalized in general surgery ward of Shahid_Mohammadi teaching general hospital in Bandar Abbas situated in southern of Iran from March 2016 to March 2017. 310 records were selected from list of hospitalized patients by adopting systematic random sampling. The required information was collected through a checklist that was prepared after review of literature; then, were filled in department of medical records based on Hospital Information System (HIS) fields. In order to determine the association of 26 variables with patients' length of stay, one-way *ANOVA* (followed by Least Significant Difference (LSD) post-hoc test), independent sample t-test, Pearson correlation and linear regression were used. The significance level of tests was presumed to be less than 0.05. We used the SPSS software (IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp; 2015) for data analysis.

In the second step, the researcher reviewed HIT-based solutions to optimize patients' length of stay through a targeted search of available papers in Persian and English languages. To do so, combination of main terms of patient length of stay and information and communication technology (along with their synonyms) were searched in PubMed, Scopus databases as well as Google Scholar without presuming time limits based on a defined search query.

The ethical consideration was approved by the Research Ethics Committee of Hormozgan University of Medical Sciences. Accordingly, the confidentiality of information in patients' records was taken into account and the checklists also filled without mentioning patients' names, then the information remained confidential.

Results

The studied general surgical ward had 29 active beds in average during 2016 to 2017; the bed occupancy rate was 74 percent. Based on the results, mean $\pm$ SD and median of patients' length of stay in this department were 3.30 $\pm$ 3.71 and 2 days respectively. The shortest and longest lengths of stays were 1 and 30 days respectively. The patients' mean age was 33.94 $\pm$ 21.48 years and respective minimum and maximum ages of 1 and 91 years. In general, 80% of patients underwent surgery that considering the nature of the department, most cases were related to general surgery service. Other patients included three groups 1) according to more clinical examination, they didn't need to surgery, 2) canceled operation

for any reason, and 3) re-admission due to surgical complications such as surgical site infection. The results of association between study variables and average length of stay are represented in tables 1-4.

Table 1. Relationship between patient's length of stay and demographic variables

Variables		n (%)	Length of stay Mean±SD	P-value (<0.05)
Gender	Male	201(64.8)	3.60±4.21	0.025*
	Female	109(35.2)	2.74±2.50	
Urban Residence	Urban	194(62.6)	3.39±3.98	0.575
	Rural	116(37.4)	3.15±3.23	
Ethnicity	Native(residents of Bandar Abbas)	165(53.2)	3.34±4.01	0.842
	Non-native	145(46.8)	3.26±3.36	
Age/Elderly(yrs)	<=60	266(85.8)	3.16±3.75	0.098
	>60	44(14.2)	4.16±3.39	
Marital Status	Married	185(59.7)	3.39±3.87	0.190
	Single	105(33.9)	2.91±3.10	
	Unknown	20(6.4)	4.50±4.89	

SD= Standard Deviation, *Independent t-test

As shown in table 1, among demographic variables only average length of stay showed a significant difference between groups of gender since men had a longer LOS.

Table 2. Relationship between patient's length of stay and non-clinical variables

Variables		n (%)	Length of stay Mean±SD	P-value (<0.05)
Admitted Time	Day Shift	110(35.5)	2.50±2.70	<0.001*
	Evening and night shifts	200(64.5)	3.74±4.11	
Admitted Day/ Admitted on holiday	Holiday	42(13.5)	3.43±3.57	0.810
	Regular days	268(86.5)	3.28±3.74	
Patient Companion	Hasn't Companion	17(5.5)	3.65±3.06	0.641
	Has Companion	293(94.5)	3.28±3.75	
Admitted Day/ Week's days	Saturday	50(16.1)	3.58±3.89	0.089
	Sunday	74(23.9)	2.38±1.87	
	Monday	40(12.9)	3.00±2.72	
	Tuesday	45(14.5)	3.58±4.60	
	Wednesday	34(11.0)	3.00±2.79	
	Thursday	33(10.6)	4.70±6.01	
	Friday	34(11.0)	3.82±3.82	
Admitted months/ Solar Hijri calendar	<i>Farvardin</i>	26(8.4)	2.73±2.55	0.191
	<i>Ordibehesht</i>	25(8.1)	2.56±2.55	
	<i>Khordad</i>	25(8.1)	2.80±1.98	
	<i>Tir</i>	26(8.4)	2.73±2.38	
	<i>Mordad</i>	26(8.4)	2.38±2.55	
	<i>Shahrivar</i>	26(8.4)	2.50±1.98	
	<i>Mehr</i>	26(8.4)	4.81±3.95	
	<i>Aban</i>	26(8.4)	4.42±4.49	
	<i>Azar</i>	26(8.4)	4.35±6.19	
	<i>Dey</i>	26(8.4)	3.00±2.23	
	<i>Bahman</i>	26(8.4)	3.69±6.02	
	<i>Esfand</i>	26(8.4)	3.58±3.81	
Insurance Type	Social Security Organization	72(23.2)	2.42±2.13	<0.001**
	Medical Services Insurance	155(50.0)	2.87±3.29	
	<i>Imam Khomeini Relief Foundation</i>	8(2.6)	5.50±3.63	

	Armed Forces Medical Services Insurance	13(4.2)	2.69±2.50	
	Road traffic accidents	25(8.1)	7.72±7.00	
	Iranian Health	20(6.5)	3.50±2.67	
	Other	17(5.5)	3.65±3.32	
Referral Type	From physician's office	29(9.4)	3.34±2.53	<0.001**
	From hospital clinic	67(21.6)	2.09±2.02	
	From emergency unit	149(48.1)	4.54±4.67	
	Other	65(21.0)	1.69±1.22	

*Independent t-test, **Analysis of variance test (ANOVA)

The average length of stay shows significant difference in terms of time of admission, type of insurance and different levels of referrals ($P<0.001$). The patients who visited the hospital in afternoon shift to be admitted in surgery ward had longer average LOS. In regard to the variable "type of insurance", patients' average length of stay was longer when they used Traffic Accident insurance rather than other insurances ($P<0.001$).

In cases of referral from emergency department, average length of stay was longer than cases of referral from hospital clinic and other places ($P<0.001$).

Table 2. Relationship between patient's length of stay and non-clinical variables(continued)

Variables		n (%)	Length of stay Mean±SD	P-value <0.05
Attending Physician Degree	Specialist	291(93.9)	3.29±3.73	0.784
	sub-specialist	19(6.1)	3.53±3.55	
Admitting Physician Specialty	Emergency medicine	101(32.6)	4.37±4.68	<0.001**
	General Surgeon	132(42.6)	3.16±3.51	
	Urologist	43(13.9)	1.86±0.94	
	Otorhinolaryngologist (ENT)	7(2.2)	1.00±.00	
	Plastic & Cosmetic Surgeon	9(2.9)	3.33±2.45	
	Other surgeries(Neurosurgeon, Ophthalmologist, Orthopedist)	13(4.2)	1.62±0.76	
	Internist(Internist, Digestive-Liver Disease, infectiousDisease)	5(1.6)	5.40±3.97	
Attending Physician Specialty	Internist(Internist, Digestive-Liver Disease, infectiousDisease)	17(5.4)	4.76±3.78	0.018**
	General Surgeon	204(65.8)	3.67±4.19	
	Urologist	56(18.1)	2.14±1.41	
	Neurosurgeon	4(1.3)	4.5±5.07	
	Otorhinolaryngologist (ENT)	7(2.3)	1.00±.00	
	Ophthalmologist	6(1.9)	1.33±0.52	
	Orthopedist	7(2.3)	1.43±0.79	
	Plastic & Cosmetic Surgeon	9(2.9)	3.33±2.45	

**Analysis of variance test (ANOVA)

The cases in which admitting physician was emergency medicine specialist were accompanied by longer patient length of stay than cases in which patients were admitted by ENT specialist, general surgeon, urology or other surgeons(P<0.01).

According to post-hoc test, internal medicine specialties as attending physician were followed by patients' longer length of stay than orthopedics, urology, and ENT specialists as well as eye surgeon(P<0.05).

Table 3. Relationship between patient's length of stay and clinical variables

Variables		n (%)	Length of stay Mean±SD	P-value
Type of admission	Elective	161(51.9)	2.16±1.94	<0.001*
	Emergency	149(48.1)	4.54±4.67	
Hospitalization History	Has	223(71.9)	3.14±3.28	0.236
	Hasn't	87(28.1)	3.70±4.65	
Encounter Reason	Disease	228(73.5)	2.82±2.70	<0.001**
	Road traffic accidents	25(8.1)	7.24±6.88	
	Other events (Non-disease)	57(18.4)	3.51±4.29	
Hospitalization Cause/final diagnosis; categories of ICD-10	Neoplasms	11(3.5)	5.64±3.80	<0.001**
	Diseases of the digestive system	98(31.6)	3.14±2.96	
	Diseases of the skin and subcutaneous tissue	25(8.1)	2.08±2.56	
	Diseases of the genitourinary system	53(17.1)	2.09±1.20	
	Congenital malformations, deformations and chromosomal abnormalities	12(3.9)	2.25±1.42	
	Injury, poisoning, and certain other consequences of external causes	76(24.5)	4.84±5.58	
	Factors influencing health status and contact with health services	10(3.2)	1.80±0.92	
	Other	25(8.1)	3.08±3.42	
Patients' status at discharge	Recovery & Relative recovery	177(57.1)	3.01±3.64	0.032**
	Discharge without physician order/	25(8.1)	4.04±3.27	
	Discharge with personal desire			
	Death	4(1.3)	8.50±5.07	
	Need to Follow up	95(30.6)	3.49±3.78	
	Other	9(2.9)	2.67±3.61	

As a result, emergency admitted cases were accompanied by longer length of stay than non-emergency cases. In regard to the variable of reason of encounter, cases of accident-caused admission were followed by longer length of stay than cases of disease and other events($P<0.001$).

The LSD test showed that the difference between the LOS and "cause of hospitalization" related to longer LOS in cases of "neoplasm" and "injury, poisoning and certain other consequences of external causes" compared with those who had other cause ($p < 0.05$).

About patient's condition at time of discharge, in average, death cases had longer length of stay compared with other condition. ($P < 0.01$).

Table 4. Relationship between patient's length of stay and quantitative variables

Variables	Mean $\pm$ SD	Pearson Correlation Coefficient	P-value
Age	33.94 $\pm$ 21.48	0.146	0.01
Number of previous hospitalizations	0.53 $\pm$ 1.16	-0.019	0.737
The number of clinical consultations requested during hospitalization	0.53 $\pm$ 1.08	0.632	<0.001
Number of visits	2.82 $\pm$ 3.20	0.914	<0.001
Number of Surgery	0.94 $\pm$ 0.75	0.348	<0.001
Number of Para-clinical Services	8.11 $\pm$ 13.15	0.660	<0.001

Correlation is significant at the 0.01 level

As shown in table 4, increase of age, number of consultation, doctor visit, surgery, and para-clinical services (laboratory tests, pathologies, radiography, imaging and other diagnostic services) was followed by longer length of stay and this association was statistically significant.

As correlation coefficients in table 4 suggest, association of visits and number of para-clinical services with length of stay was stronger.

Table 5. Factors associated with patients' LOS in Multiple Linear Regression analysis

Variables	Unstandardized Coefficients	Standardized Coefficients	Confidence Interval		P-value
			Lower	Upper	
Admitted Months	0.052	0.048	0.006	0.098	0.028
Referral Type	-0.201	-0.047	-0.380	-0.022	0.028
Number of Consultations	0.283	0.094	0.098	0.467	0.003
Number of Visits	0.874	0.752	0.806	0.941	<0.001
Number of Surgery	0.482	0.097	0.265	0.698	<0.001
Number of Para-clinical Services	0.038	0.135	0.023	0.053	<0.001

All qualitative and quantitative factors which satisfied $P < 0.2$ in univariate analysis were added to multiple linear regression model. In this model, the variables with highest p-value were excluded until all of remaining variables of the model satisfied the condition $P < 0.05$. Finally, multivariate regression model of factors with highest association with LOS was reported in table 5.

Discussion

In this study, the length of stay was found to have a direct and significant association with number of para-clinical services, requested clinical consultations, surgeries, and doctor visit during hospitalization. Also, gender, insurance, type of referral, months and time of admission, as well as hospitalization followed neoplasms and injury, poisoning and certain other consequences of external causes were significantly correlated with LOS ($P < 0.05$). These results are in line with other studies including 13, 14, and 15 [13-15].

Furthermore, results showed that the patients admitted from 2p.m. to 7a.m. had higher length of stay. This might be due to absence of senior specialists during these hours. Lack of non-emergency admission during evening and night hours, modification of caring processes, provision of specialized medical and diagnostic services in 24-7 (24 hours a day-7 days a week) manner could prevent from increase of patients' average length of stay to a large extent. Farhadi Hassankiadeh et al revealed that the type of surgery significantly associated with LOS. In patients with appendicitis, hemorrhoids, and skin surgery was a shorter stay [14]. Ravangard et al [15] similarly found out stay due to neoplastic diseases add to patient length of stay. Also in regard to attending physician, they stated that engagement of internal medicine increases length of stay. Current study's results are in line with these investigations.

It is worth noting, in some cases the cancellation of surgery that leads to longer waiting time in the hospital, was due to lack of patient readiness or failure to perform physician orders, which is mainly due to inadequate training during hospitalization.

Information and communications technologies (ICTs) is one of the interventional tools which are discussed as follows, could be considered as solutions to the optimization of patients' length of stay. Based on related literature review results and available evidence, some of the technologies that are useful will be addressed in table 6. (figure 1)

According to table 6, These eleven technology-based categories might be involved in the pre-diagnosis, diagnosis, treatment, and post-care processes in the workflow of admission, hospitalization, transfer, discharge phases, and even the post-discharge period.

Table 6. HIT-facilitated Interventions for Optimize LOS

Categories	Capabilities(References)	More Effective in Processes Related to		
		Admission	Stay	Discharge
Hospital Information System (HIS)	- The integrated HIS improves the processes of admission, hospitalization, and discharge of patients due to better communication, integration of clinical, management, and hospital data as well as removing repetitive and unnecessary procedures[16, 17]	√	√	√
Electronic Health Records (EHR)/ Electronic Medical Record (EMR)	- Integrity of clinical and health-related data, improve clinical workflow and safety. - Observation of patient's medical records with more complete and readable documentation in real-time[18] - Provide alarms and reminders by embedded rule based CDSS: - Prevent from repetition of diagnostic tests. - Detection of drug interventions, drug side-effects or sensitivities, and clinical deterioration[19, 20]	√	√	√
Computerized Provider Order Entry (CPOE)/ Electronic Prescription	- Quicker reception of physician's orders, then quicker implementation of the orders[21]. - Timely and correct prescription of drugs, identification of problems related to drugs side-effects and interventions, reduction of medication error, and better consideration of clinical instructions[22]		√	√
Clinical Decision Support System (CDSS)	- CDSS based on treatment instructions, protocols. and caring standards could improve and facilitate diagnosis and treatment processes by recommending a series of care-related processes such as doing tests or prescribing drugs to patients with typical and uncomplicated diagnoses (for example administration of antibiotics and heparin in surgical patients[23]). - Admission scheduling[24] and discharge planning based on individual patients.	√	√	√
Radio-frequency Identification (RFID) and Barcode Technology	- Tracing of patients' location and monitoring of patient turnover [25]. - Exact monitoring of discharging time and facilitated identification of empty beds[26]. - Drug safety and facilitation of drug therapy by confidence in targeting correct patients, correct dose of intended drug by cross-checking[27]. - Identification and warning related to mismatch, drug-related errors, and overdose by comparison of patient's identity and intended drug dose. - Improve the quality of caring, prevent from medical errors and enable more efficient use of proper resources. - Reduce the workload of nurses and eliminate unnecessary processes and steps of caring patients[28]	√	√	√
Monitoring Systems, Wireless Sensors, and Wearable Tools	- Timely and early detecting of the clinical condition and vital signs changes and abnormalities[29, 30], especially in high-risk patients. - Peri/intra-operative management, analysis of post-surgical undesirable infections and side-effects. - Prevents from reinforcement of unpredicted consequences related to treatment activities or surgery.		√	√

Table 6. HIT-facilitated Interventions for Optimize LOS (continued)

Categories	Capabilities(References)	More Effective in Processes Related to		
		Admission	Stay	Discharge
Telemedicine	<ul style="list-style-type: none"> - A lot of potentials for reducing patients' length of stay by this technology[31]. - Remote consultation [32] along with electronic planning of consultation[33]. - Tele-pathology[34], tele-radiology[35] and picture archiving and communication system (PACS) for forwarding pathologic and radiologic images to specialists and reception of their viewpoints will help in shortening diagnostic and therapeutic process[35, 36]. 		√	√
Robotic Surgery	<ul style="list-style-type: none"> - Reduced surgical complications, infections, pain, and bleeding. - Post-operation recovery quality and reduce patients' LOS [37-39] 		√	√
Smart Management and Clinical Dashboards	<ul style="list-style-type: none"> - Continuous monitoring of significant indicators for managers' decision-making as well as identification of procedural problems[27, 40] - Show the patients' monitoring results in hospital wards and determine waiting (e.g. waiting to enter operation room or exit delays, transfer or reception of blood, and clinical consultation) - Use of artificial intelligence and machine learning in dashboard analyses will contribute to estimation of patients' LOS and better planning of patient discharging [41] 	√	√	√
Electronic Discharge Planning Tools	<ul style="list-style-type: none"> - Better management of processes related to discharge and reduce patients' LOS[42, 43] 			√
Electronic Post-Discharge Follow-up System	<ul style="list-style-type: none"> - Reduced re-hospitalization of patients by post-discharge follow-up through ICT, mobile health, wearable monitoring tools, or smart houses based on internet of things (IoT) - Remote monitoring and post-discharge follow-up of surgical patients[44, 45] based on patients' condition (especially high-risk groups such as diabetic or elderly patients, also people with immunodeficiency) - Early identification of post-discharge surgical complications, quicker treatment in outpatient centers and reduced re-hospitalization and undergoing additional financial expenses. - Timely detection of unwanted changes in patients clinical conditions can lead to a reduction in LOS of patients who have been re-admitted[46] 	√	√	

Actually at health care institutions, more accessible technologies for LOS optimization are recommended. Among which HIS (by increasing the focus on recording more clinical data), PACS, telemedicine especially tele-consultation or tele-visit as well as electronic consultation and discharge planning tools alongside smart dashboards in order to expedite the process of diagnosis and treatment

then optimize the LOS seems appropriate. The role and relationship of the ICT oriented solutions for LOS optimization are presented in figure 1.

Figure 1: The Role of ICT in Optimizing LOS

In this research, there is a limitation of difficulty of generalization related to the collected data from a specific training hospital in particular time. Although purposeful selection of intended variables was done by review of variables, those variables was used in which they had already been addressed in HIS. Certain issues such as co-morbidities, surgical complications, and infections as clinical variables weren't registered in the system. In some cases, low data quality results in exclusion of some variables. Thus, more comprehensive study with more comprehensive variables and bigger data collected from various hospitals in different time duration may be required.

Conclusions

In general, planned and timely admission and discharge of patients and offering necessary training at time of discharge along with management of stay in hospital may prevent prolonged LOS and re-admission. As a result, applying guidelines of medical care management by hospitals managers and attention to standardization of patients' length of stay for dealing with different diseases and surgeries are critical. Available HIT-based interventions may facilitate length of stay reduction through optimization of processes of patient's admission, stay, and discharge.

Declarations

Abbreviations

LOS: length of stay; SD: standard deviation; LSD: least significant difference; ICTs: information and communications technologies; HIT: health information technology; HIS: hospital information system; EHR: Electronic Health Records; EMR: Electronic Medical Record; CPOE: Computerized Provider Order Entry; CDSS: Clinical Decision Support System; RFID: Radio-frequency Identification; IoT: internet of things; PACS: picture archiving and communication system

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Author's contributions

TB, MH and MSH contributed for the research design, data acquisition and analysis. TB, ShRNK and MGH contributed for the manuscript writing. ShRNK also contributed in editing of the manuscript. All authors gave approval for the final version of the manuscript.

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Availability of data and materials

The dataset used and analysed during the current study are available from the corresponding author on request.

Ethics approval and consent to participate

The ethical consideration was approved by the Research Ethics Committee of Hormozgan University of Medical Sciences, Bandar Abbas, Iran (ethical code: HUMS.REC.1395.56).

We just extracted information from HIS, then confidentiality was maintained based on the rules and policies of the center under study and this was approved by the ethics committee as stated above. So, didn't need to patients' written consent.

Consent for publication

As our manuscript does not include any individual data or sensitive personal information, therefore consent for publication is "Not Applicable" in this case.

Declaration of conflicting interests

The authors declare that there is no conflict of interest.

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Figures

Figure 1

The Role of ICT in Optimizing LOS