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Article

A Comparative Study on Biomedical Equipment Inventory Management Practices in Delhi Government Hospitals and Institute of Liver and Biliary Sciences, Delhi

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Abstract: The present study examines biomedical equipment inventory management practices in Delhi Government Hospitals and the Institute of Liver and Biliary Sciences (ILBS), Delhi, addressing a critical research gap in the Indian public healthcare context. Using an empirical research design, primary data were collected through structured questionnaires and interviews from 600 employees across selected institutions, supported by secondary data from records and reports. The study compares inventory control, maintenance, utilization, challenges, and technology adoption using statistical tools such as t-test, ANOVA, and correlation analysis. The expected findings aim to assess impacts on patient care and propose a practical framework and policy recommendations for improving biomedical equipment inventory management in government hospitals.
Keywords: terminology:Biomedical,ILBS,Patient care,Government Hospital,Inventory Management

1. INTRODUCTION

Biomedical equipment plays a crucial role in modern healthcare delivery by supporting accurate diagnosis, effective treatment, and continuous patient monitoring. The efficient management of these assets through systematic inventory control, timely maintenance, and optimal utilization is essential for ensuring patient safety and operational efficiency in hospitals. In public healthcare institutions, particularly government hospitals in India, biomedical equipment inventory management often faces challenges such as limited resources, inadequate maintenance systems, lack of trained personnel, and insufficient use of technology. In contrast, specialized institutions like the Institute of Liver and Biliary Sciences (ILBS), Delhi, adopt relatively structured and technology-driven management practices. This study undertakes a comparative analysis of biomedical equipment inventory management practices in Delhi Government Hospitals and ILBS to identify gaps, assess challenges, evaluate their impact on patient care, and develop an effective framework for improving inventory management practices in public healthcare institutions.

2. RESEARCHGAP

From the thorough literature review on above title and the concept, it is observed by the researcher that many of the studies related to hospital management, hospital administration, inventory management in manufacturing, inventory management in super specialty hospitals, etc. There is no such kind of hospital equipment inventory management in Govt. hospitals, that too studies like comparison context not available. In particularly in Indian context very rare to relevant and find out.

STATEMENTOFTHEPROBLEM:

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From the research gap, and the complete discussion with research guide and hospital staff at the said area, the statement of the presentproblem has drawn. Inventory management practices and its comparison on various 'Government hospitals' and 'Institute of Liver and Biliary sciences' at Delhi. The title is worked out as ***"A comparative study on Biomedical Equipment Inventory Management Practices in Delhi Government Hospitals and Institute of Liver and Biliary Sciences, Delhi."***

OBJECTIVES OF THE STUDY:

The detailed objectives of the study are as follows:

1. To evaluate the impact of inventory management practices on the quality of patient care and safety in govt. hospitals and ILBS, including the role of biomedical equipment in diagnosis, treatment, and monitoring.
2. To compare the inventory management software and technologies used in Delhi govt. hospitals and ILBS, including their features, functionality, and effectiveness in managing biomedical equipment inventory.

HYPOTHESIS

H01- Inventory management practices have no significant impact on the quality of patient care and safety in government hospitals and ILBS, including the role of biomedical equipment in diagnosis, treatment, and monitoring.

H11- Inventory management practices have a significant impact on the quality of patient care and safety in government hospitals and ILBS, including the role of biomedical equipment in diagnosis, treatment, and monitoring.

H02- There is no significant difference in the inventory management software and technologies used by government hospitals and ILBS in terms of features, functionality, and effectiveness in managing biomedical equipment inventory.

H12- There is a significant difference in the inventory management software and technologies used by government hospitals and ILBS in terms of features, functionality, and effectiveness in managing biomedical equipment inventory.

SCOPEOFTHESTUDY:

Basically, the present study is to evaluate the "study of Biomedical equipment inventory management of Govt. hospitals and ILBS at Delhi, (***"A comparative study on Biomedical Equipment Inventory Management practices in Delhi Government Hospitals and Institute of liver and Biliary Sciences, Delhi."***) This study covers various inventory practices of both the organizations with their existing inventory management practices, and prepare a comparative analysis to offer findings and suggestions for the both organizations in the said area. It is the study of the existing practices individually and the comparison based on the information collected for research.

METHODOLOGY OF THE STUDY:

In pursuance of the above-mentioned objectives and hypotheses, the following methodology was adopted for the study. It is an empirical method based on both primary and secondary data.

Sources of data:

Primary data: The study is mainly based on primary data, obtained first-hand information through a well-designed questionnaire with qualitative questions and open discussion with selected employees of both Govt. hospitals employees and ILBS employees who are familiar with Inventory management in Delhi. For this purpose, a questionnaire has been prepared, covering all aspects of biomedical equipment inventory management.

Secondary data: The data collected from some Govt. hospitals and ILBS records and website which is useful to know and understand on various existing management practices of biomedical equipment inventory management.

Collection of Data:

Primary data were collected through a well-designed questionnaire and open discussion with selected employees in various categories of both organizations in Delhi. The responses of the employees through structured questionnaires which were prepared for this study. This session schedule was finalized after conducting a pilot study among a sample of fifty employees. Appointments had been made in advance by the respondents. Over a period of more than 200 days, various interviews were scheduled in both Govt. Hospitals and ILBS of selected employees separately. The researcher then executed the data as per the requirements of analysis. The questionnaire contained questions regarding the problems faced by employees of inventory management practices. The researcher conducted **pilot study** with a sample of 50 employees in both states in select banks. The result of the pilot study is majority of the employees of hospitals in Delhi are facing inventory management practices. Whereas ILBS is can able to manage its level best comparatively than Govt. hospitals. On the basis of their responses, some questions are modified and the modified questionnaire is finally canvassed among the 600 employees as represented in the table.

The schedule consists of different variables under the five main factors pertaining to inventory management. The researcher had developed a five-point rating scale namely 'strongly disagree', 'disagree', 'neutral', 'agree' and 'strongly agree' for rating the answers to the questions. The respondents were asked to give information on the five-point rating scale. Rating scale 5 point has given for strongly agreements, 1 point for strongly disagree and in between points 4,3 and 2 were given in the order of rating. Before the commencement of interview, a sample schedule is given to each respondent and a brief explanation (in English or Hindi) regarding the study was given to them. Each question/item in the schedule was asked by the researcher to the respondent. Proper care was taken to give enough time to the employees to think about answering the questions. The respondents were encouraged to express their opinions and suggestions openly and fairly. Before the interview, the researcher gave an assurance that it was an independent and unbiased study and their responses and opinions would be maintained confidentially, so as to enable them to be frank, lucid and fearless in expressing opinions without any interference of indeterminacy principle. The respondents were interviewed considering their time and availability and after obtaining permission from their employers. There was extensive use of secondary information in the form of books, articles published in magazines , journals ,newspaper, reports of hospitals, websites, circulars, pamphlets of the hospitals. etc.

Sample Size: The universe/total population of employees of selected branches from all hospitals is approximately 486. So, the researcher has selected around 10-15% of the sample respondents from each hospital. So, the selected sample is around from all hospitals is 250. And from the ILBS the population size is around 2510. So, the researcher has selected sample with 350 respondents in various designations. Out of the total population a sample of 600 was selected from each Govt. hospitals and from ILBS Delhi.

Sample Design

The sample is based on a simple and systematic random sampling method. A few executives are also taken. All designated employees were covered for the present study.

Selection of the Hospitals

The Investigator identified all the Govt. hospitals in Delhi, there are 30 hospitals are available in the Delhi. Out of them the investigator only picked up 10 hospitals on simple random basis with same size and approximation of their man power size. The selected hospitals number is 10. Each hospital employees' size is more or less around 300 to 350. The total population of all 15 hospitals is around 3500. The researcher wrote a letter to the authorities of selected hospitals and ILBS branches, to get the permission to collection of required research data. From ILBS there are 20 departments are available, the investigator has selected 350 respondents from all the departments of ILBS on stratifies random sample basis with covering all the designated employees of all the departments who are close associating with various levels of bio medical inventory management. The sample size of ILBS is 350. Altogether the overall sample is 600. Seeking permission is mere mandatory to collect the relevant information from the respondents. With lot of correspondence and efforts, the authorities of the following have accepted to permit the investigator to collect information. The sample institutes are selected on the following criteria.

In hospitals there are 10 hospitals were considered. In ILBS 20 departments were selected. From Each hospital 30 respondents were selected with systematic sampling procedure. Whereas from ILBS there are 20 departments were selected, and from each department 15-20 respondents were chosen systematically.

Sampling Technique

There searcher selected simple random sampling method for selection of hospitals at Delhi. and complex random sampling method for the selection of employees in selected hospitals, and the ILBS since the population is finite/known. The sample of employees consists of different designations like Biomedical engineers, hospital administrators, technicians and procurement officials at various levels. The sample is drawn on the basis of the experience of the employees in the selected institutes and minimum five years is considered as appropriate for the selection of the sample. The following is the category sample of employees.

2.1 Category of profile of respondents(Employees)

Category		**ILBS Hospital**	**Government Hospital Delhi**	**Total**
Respondents	**Employees**	350	250	600
Total		**350**	**250**	
Age	**Below 30**	70	50	600
	30-40	136	82	
	40-50	84	76	
	50-60	60	42	
Total		**350**	**250**	**600**
Gender	**Male**	**192**	**140**	600
	Female	**157**	**110**	
Total		**350**	**250**	**600**
Occupation Type	**Permanent**	**309**	**220**	600
	Ad hoc	**41**	**30**	
Total		**350**	**250**	**600**
Education	**Diploma**	66	35	600
	Inter	54	20	
	Graduation	175	125	
	Post-Graduation	55	70	
	Others	0	0	
Total		**350**	**250**	**600**

The category of profile of respondents (employees) is shown in table 2.2. From the total population the researcher has selected 600 sample respondents from both organizations and both the states. The above table 2.2 category of respondents (employees) is presented with the help of age, region, and education. In the age group, respondents of 40-50 years age are more in number when compared to other age groups. In case of education, the respondents who completed graduation are more in two types of organizations. The respondents who completed intermediate are more. In case of two organizations, the respondents who have graduated as their qualification are more. In case of occupation, employers dominated all the hospitals which are included in the study.

LIMITATIONSOFTHESTUDY:

1. This research study was taken in a limited area only (both organizations Govt. hospitals and ILBS) and findings may vary from both.

2. The study was limited to two types of institutions only. That too both are from Government sector.

3. Some of the respondents might have given bias in their responses as it depends on their experience gained by them during the working.

4. There might be indeterminacy principle involved as both are under govt related organizations.

5. Someoftheconclusionsalsodependuponsecondarydatawhicharereliabletothe extent.

REVIEW OF LITERATURE:

Effective biomedical equipment inventory management is crucial for ensuring the availability, functionality, and safety of medical devices in healthcare institutions. In the context of Delhi, two prominent healthcare entities—the Delhi Government Hospitals and the Institute of Liver and Biliary Sciences (ILBS)—serve as pivotal centres for medical care. While both institutions aim to provide high-quality healthcare services, their approaches to managing biomedical equipment inventory may differ due to variations in organizational structure, specialization, and resource allocation.

A review of existing literature reveals that inventory management practices in healthcare settings are multifaceted, encompassing aspects such as procurement, maintenance, utilization, and disposal of medical equipment.

HEALTHCARESYSTEMINGCCREGION

1. **Alnuman, 2023**, this research uses data envelopment analysis and financial performance indicators to examine the effectiveness of the financial performance and financial features of publicly traded firms in the healthcare industry in the GCC area from2011to2021.Thisnonparametrictechniquewaschosenforavarietyof reasons, including the fact that it pinpoints the causes of inefficiency and defines the directions and magnitudes of changes needed. Three input-oriented models—CCR (Charnes–Cooper–Rhodes) under a constant returns-to-scale assumption and BCC (Banker–Charnes–Cooper) under a variable returns-to-scale assumption—are used to assess the technical, pure technical, and scale efficiencies. Two assumptions are evaluated and experimentally confirmed: first, there is considerable business heterogeneity in financial performance, and second, investments are the principal cause of inefficiency among the observable indicators. These findings suggest that hospital enterprises' profitability, growth, and return on invested capital are represented in their financial performance when compared to pharmaceutical firms' higher efficiency and growth. The findings also show that healthcare organizations do not invest in or spend money on research and development (R & D) related to technological innovation. This outcome may represent the belief that future cash flow will have a greater impact on the profitability, growth, and leverage of healthcare organizations.

2. **Vakhteret al.,** 2022, this Article emphasized the necessity of security for the upcoming tiny wireless biomedical devices. MWBDs are a target for cybercriminals because to the mix of valuable assets belonging to several stake holders and numerous attack surfaces. Security should be included into MWBDs in a controlled and repeatable manner during the pre-market stage since MWBDs provide considerable risks for their stakeholders. Bio medical devices need trust and need to be at least minimally secure in order to withstand ever-evolving attacks. Despite the fact that they have limited resources (in terms of size, power, processing, and storage), These devices demand it. The first step in making MWBDs safe is to simulate potential threats. As a result, the researcher went through the material on threat modeling that was pertinent to MWBDs and summarized it. After that, they proposed a domain-specific qualitative-quantitative threat model with the intention of assisting the designers and manufacturers of MWBDs in the pre-market phase of the lifecycle of a MWBD in identifying threats and embedding security in their designs.

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3. **Xu et al.,** 2022, according to the author, the corrective accuracy is the most important factor in determining the clinical results of open-wedge hightail osteotomy (OWHTO)formed osteoarthritis. The purpose of this research was to evaluate the effectiveness of laser correction technology using a regular laser pen and a surgical equipment box as the experimental setup. Techniques were applied. A total of 71 patients participated in the prospective study that used a randomized split to assign them to either the laser group (n = 36) or the

conventional group (n = 35). The hip center, knee (Fujisawa point), and ankle center were determined preoperatively in the laser group by utilizing the lid of the surgical equipment box. With a regular laser pen, the leg was brought into proper alignment. A metal cable was used to adjust the alignment of the lower limbs in the group that followed the standard approach. Radiation exposure, operational duration, and the rate of outliers (defined as a lower limb force line that does not pass through 62–66% of the lateral tibial plateau)were assessed in this study. Scores on the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and the visual analogue scale (VAS) were recorded. Following a period of twenty-four months, measurements were taken to determine the femoral tibial angle (FTA), the medial proximal tibial angle (MPTA),and the posteriors lope angle(PSA).The survival time of afflicted knees was determined using the Kaplan-Meier technique, and surgical complications were kept a record of. The findings of this study indicate that the laser correction group had significantly reduced levels of radiation exposure, operational duration, and the rate of outliers (P<0.05). After a postoperative follow-up of six months, the VAS and WOMAC ratings of both groups showed statistically significant improvement (P<0.001). After 24months,there was a significant improvement in both groups' FTA, MPTA, and PSA (P<0.001). There was no significant difference between the groups in terms of post-operative knee survival time from OWHTO to knee arthroplasty (P = 0.53; P = 0.61), nor was there a difference in terms of postoperative complications.

4. **Rajannaet al**., 2022, the authors of the review reported the most cutting-edge existing AECG (Ambulatory Electrocardiogram) monitoring devices and their role of long-term ECG recording in patients who were suspected of having cardiac syncope and palpitations. This was done in order to understand the under lying arrhythmic cause of these symptoms, as well as for the diagnosis and treatment of atrial fibrillation(AF).In the beginning, a thorough analysis was performed on the usefulness and diagnostic yield of external cardiac recorders, also known as event loop recorders (ELRs), in capturing the symptom rhythm correlation,

This is an essential component of clinically useful recordings of the electrical activity of the heart during infrequent arrhythmic conditions. In addition, a short case study on the difficulties associated in clinical data gathering utilizing ambulatory external monitoring equipment has been given. The research was conducted at a cardiac care unit. In conclusion, proposals have been made for enhancements in design engineering and algorithmic innovations with the goals of increasing the diagnostic yield of ELRs and their applicability in clinical settings.

5. **Abbas et al**., 2022, a revolutionary ultra-miniaturized antenna with rectangular slots is devised for deep-tissue-implanted capsule endoscopes and leadless pacemakers in this particular research study. Theantennahasa very small volume and works in the ISM (Industrial Scientific and Medical) band at 2.45 GHz. Its dimensions are 6 by 6.5 by 0.2 mm3. In order to accomplish miniaturization of the antenna, they employ a radiating patch, a shorting pin, and rectangular slots in the ground plane. Simulating and testing than tennaina variety of situations ensures that it will function properly inside the banding all of the potential implantation locations. The suggested antenna has a gainof-16.5dBi(decibels relative to Isotropic) and a bandwidth of 480 MHz, according to simulations of the antenna's performance. The suggested antenna features an omni directional radiation pattern and a band width that is suitable for the applications that are needed to be supported by it. The SAR of the antenna does not exceed the thresholds that have been established by the IEEE (Institute of Electrical and Electronics Engineers) standards. In addition, there was no discernible difference eintheantenna' sperformance when it was put in a variety of devices and oriented in a variety of ways to test the influence on the antenna's operation. Therefore, the proposed antenna is thought to be appropriate for use with deep-tissue-implanted biomedical devices such as leadless pacemakers and capsule endoscopes.

6. **Grigatti and Gefen**, 2022, the author explored a novel approach to the prevention of device-related injuries by determining the face tissue loading state while wearing an oral-nasal mask and applying hydrogel-based dressing cuts for prophylaxis. They did this by comparing the compressive mask-skin contact pressures at the nasal bridge, cheeks, and chin with and without these dressing in cisions, and then feeding these data in to a finite element, adult head model. This was done in order to accomplish this goal. Model versions were created in order to examine the strain energy densities an defective stresses in skin and a cross the facial tissue depth when the dressing cuts were present as opposed to when they were absent. We discovered that the dry (fresh) dressing cuts decreased tissue exposures to loads (above the median loading threshold) by at least thirty percent at the nasal bridge and by as much as ninety-nine percent at the cheeks, all the way to the tissue depth. These dressing cuts were also able to keep atleast65%and89% of their protective capability under moisture at the nasal bridge and cheeks, respectively. This was achieved when the moisture was applied to the area. The hydrogel-based dressings showed protective efficiency at all of the facial locations that were

examined, but they per formed the best at then as abridge and cheeks, which are the areas of the face that are at the highest risk of damage.

7. **White et al.,** 2022, the author tested their FALCON emergency ventilator on a rabbit model and compared its safety and functionality to those of traditional mechanical ventilation. And suggested procedure in which New Zealand white rabbits (n = 5) were given mechanical ventilation for a total of one hour from both the FALCON and a traditional mechanical ventilator.The measures that were taken were blood oxygen saturation, end tidal CO2 levels, airflow and pressure, and arterial blood gas levels. In addition, macroscopic and histological lung samples were compared to rabbits (n = 3) who were allowed to breathe on their own in order to look for symptoms of ventilator-induced lung damage.In the results, it is noted that the FALCON was able to effectively ventilate all of the rabbits. Both ventilators were used with the same settings; however, the FALCON had a lower inspiratory to expiratory ratio than the other ventilator. Tidal volumes, pressures, and respiratory rates were all comparable across the two ventilators. The FALCON had a substantially higher end tidal CO2 concentration, and arterial blood gas tests revealed a lower arterial partial pressure of O2 at 30 minutes but a higher arterial partial pressure of CO2 at both 30 and 60 minutes when using the FALCÓN. Nonetheless, they found a stepwise drop in end tidal CO2 when ventilated at greater respiratory rates than normal. The investigation of Poincare plots showed that there were modest but substantial increases in the short-term and long-term variance of the FALCON's peak inspiratory pressure production. Both the wet to dry lung weight and the lung damage rating were comparable between the rabbits who were mechanically ventilated and those that breathed on their own.

8. **Piela et al.,** 2022, the purpose of the authors' research was to evaluate the efficiency of intra-oral suction devices that are often used for the reduction of aerosols. And the processes that are employed for this. For the purpose of producing aerosol particles, ultrasonic scaling and high-speed hand piece processes were carried out. A number of particle sensors were set up in close proximity to the mouth cavity. Single-board computers written in a bespoke Bash script were used within the company to retrieve the sensor data. Throughout the procedures, a variety of static and dynamic high volume and low volume suction devices, as well as a combination of the two, were tested to see how effective they were in preventing particle escape. According to the findings, the use of any of the tested suction devices in all of the aerosol-generating procedures (AGPs) led to a significantly lower number of particle counts as compared to the cases in which no suction was used. Suction devices with a low volume and a static suction created spikes in the particle count, indicating that certain particles were able to escape from the mouth cavity at certain points. Yet, high-volume dynamic suction devices were able to lower the particle count to background levels in a consistent manner, giving the appearance that particle escape was no longer an issue. In contrast to dynamic high-volume suction devices, static devices, which allow for periodic escape of aerosol particles, the author came to the conclusion that static devices allow for effective elimination of aerosol particles escaping from the oral cavity. This was in contrast to dynamic high-volume suction devices, which follow the path of the aerosol generating device. Nonetheless, these findings imply that making the proper choice of suction equipment may further lower the danger from AGPs. Assessing the risk of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmissions in a dental context is complicated by the presence of several factors.

Analysis-PLS

The present study employs Partial Least Squares Structural Equation Modeling (PLS-SEM) using SmartPLS to examine how biomedical equipment inventory management practices influence the quality of patient care and safety in Government Hospitals and the Institute of Liver and Biliary Sciences (ILBS), Delhi. Given the multidimensional nature of inventory management which includes inventory control, maintenance, and utilization PLS-SEM offers a robust analytical framework capable of simultaneously testing complex relationships while accounting for measurement errors. Its predictive orientation and suitability for models involving multiple latent variables make it an ideal choice for healthcare operational research, where constructs are often abstract and measured through numerous observable indicators.

In this study, the primary data collected from employees across government hospitals and ILBS are used to construct latent variables representing awareness and practices related to biomedical equipment inventory management. These constructs are then modeled to predict their combined and individual effects on patient care and safety. SmartPLS enables estimation of both the measurement model (validity and reliability of the constructs) and the structural model (hypothesized causal relationships). The technique is particularly advantageous because it does not require data normality and performs well with complex reflective measurement models, which are common in healthcare behavioural and operational studies.

Furthermore, PLS-SEM supports comparison across institutional types through multi-group analysis (MGA), allowing the study to explore whether the impact of inventory practices on patient safety differs between Government Hospitals and ILBS. This comparative dimension adds significant value, as the two hospital settings employ distinct operational frameworks, resource availability levels, and technological capabilities. By utilizing SmartPLS, the study assesses path coefficients, predictive relevance, effect sizes, and model fit indices, thereby generating a comprehensive understanding of how inventory management mechanisms translate into improved patient care outcomes.

Overall, applying SmartPLS-SEM to the primary data provides a rigorous, systematic, and predictive lens through which the effectiveness of biomedical equipment inventory management can be evaluated. The findings derived from this analytical approach offer meaningful insights for policymakers, hospital administrators, and biomedical engineering teams, supporting evidence-based interventions aimed at strengthening patient care and safety standards in Delhi's healthcare institutions.

4. Structural Equation Modeling Analysis

The Structural Equation Modeling (SEM) analysis was employed to evaluate the hypothesized relationships between the various dimensions of Inventory management and 'quality of the patient care'. SEM, using the Partial Least Squares (PLS) approach, provides a robust method for simultaneously assessing both the measurement model (validity and reliability of constructs) and the structural model (path relationships among constructs). The model was estimated using SmartPLS, applying standardized results with a path weighting scheme to ensure reliable estimation of relationships. The analysis focused on assessing model fit indices, determining the strength and significance of structural paths, and identifying which dimensions of inventory management significantly contribute to quality of patient care in the Indian context.

Table-: Model selection Criteria

Criteria	Setting
Max. number of iterations	3000
Stop criterion	10^{-7}
Use Lohmoeller settings?	No
Initial weights	1.0
Weighting scheme	Path
Type of results	Standardized
Vary copula by binary categories	Yes
BIC (Bayesian information criterion)	-871.762

The model selection criteria define the computational settings used to estimate the SEM model. As shown in the table, the maximum number of iterations was set to 3000, with a stop criterion of 10^{-7}, ensuring convergence of the algorithm with high precision. The Lohmoeller settings were not used, and initial weights were set at 1.0, indicating that all indicators contributed equally in the initial estimation phase. The path weighting scheme was selected, which is appropriate for complex models involving multiple latent constructs and reflective indicators. Results were standardized for better interpretability across constructs, while the model also varied the copula by binary categories to accommodate mixed data types. The Bayesian Information Criterion (BIC) value of –871.762 reflects an acceptable model complexity and fit, indicating that the model effectively balances predictive accuracy with parsimony.

Table-: Model fit

	Saturated model	**Estimated model**
SRMR	0.084	0.084

d_ULS	11.964	11.964
d_G	2.077	2.077
Chi-square	7489.638	7489.638
NFI	0.581	0.581

Model fit indices provide an indication of how well the proposed model represents the observed data. The Standardized Root Mean Square Residual (SRMR) value for both the saturated and estimated models was 0.084, which falls below the commonly accepted threshold of 0.10, signifying an acceptable model fit. The d_ULS (11.964) and d_G (2.077) values further support that the discrepancy between the empirical and model-implied covariance matrices is within acceptable limits. The Chi-square value (7489.638), though high, is typical for large-sample PLS-SEM analyses and not a major concern due to the model's complexity. The Normed Fit Index (NFI) recorded at 0.581 suggests a moderate model fit, indicating that while the model explains a substantial portion of the variance, there is still scope for improvement through theoretical refinement or inclusion of additional variables. Overall, the model fit results indicate that the SEM model provides a reasonable representation of the structural relationships among the constructs.

Table-: Path analysis verification

	Path coefficients	T-value	P-value	Validity of the Hypothesis
Inventory Systems, Technology Integration & Monitoring Practices -> Quality of patient care	0.115	0.906	0.00	Significant
Procurement Policies, Supply Chain Decision-Making & Resource Management -> Quality of patient care	0.168	0.996	0.00	Significant
Maintenance Processes, Documentation & Technology Systems -> Quality of patient care	0.050	0.357	0.00	Significant
Maintenance Resources, Human Support & Operational Capacity ->Quality of patient care	0.002	0.056	0.002	Significant
Operational Utilization & Monitoring Factors -> Quality of patient care	0.498	1.000	0.207	Not Significant
Strategic Utilization & Performance Optimization Factors -> Quality of patient care	0.145	0.981	0.00	Significant

The path analysis results reveal the strength and significance of the hypothesized relationships between the independent constructs (dimensions of inventory management factors) and the dependent construct (quality of patient care). The path analysis results provide insight into how different dimensions of Biomedical Equipment Inventory Management influence the quality of patient care in Government Hospitals and ILBS, Delhi. The findings show that Inventory Systems, Technology Integration & Monitoring Practices have a positive and statistically significant effect on patient care. This indicates that well-structured inventory procedures, real-time tracking, and efficient technology usage contribute directly to improved service delivery, reduced equipment unavailability, and better patient outcomes.

Similarly, Procurement Policies, Supply Chain Decision-Making & Resource Management exhibit a significant influence on patient care. This emphasizes that systematic procurement, timely acquisition of biomedical equipment, transparent supply chain decisions, and appropriate allocation of resources play a crucial role in ensuring high-quality healthcare services. When hospitals procure the right equipment at the right time, patients experience fewer delays and better diagnostic and treatment support.

The dimension Maintenance Processes, Documentation & Technology Systems also shows a significant positive effect on patient care, though the magnitude is relatively weaker. This suggests that formal maintenance schedules, proper documentation, and digital record-keeping enhance equipment reliability and reduce downtime, indirectly improving care quality. Additionally, Maintenance Resources, Human Support & Operational Capacity significantly influence patient care, indicating that having adequate technical staff, trained biomedical engineers, and operational support leads to improved equipment performance and safer clinical environments.

However, the Operational Utilization & Monitoring Factors path is not statistically significant. This means that although these factors may contribute to efficiency, in this model they do not directly enhance patient care outcomes. Possible reasons include inconsistent monitoring practices or insufficient integration with clinical workflows. In contrast, Strategic Utilization & Performance Optimization Factors show a significant effect, highlighting that strategic planning, long-term equipment utilization decisions, and performance improvement initiatives meaningfully contribute to improved patient care quality. Therefore, the results indicate that most inventory management dimensions significantly influence quality of patient care, reinforcing the importance of strategic investment in inventory systems, procurement, maintenance, manpower capacity, and organizational planning in biomedical equipment management.

. SEM Path Diagram

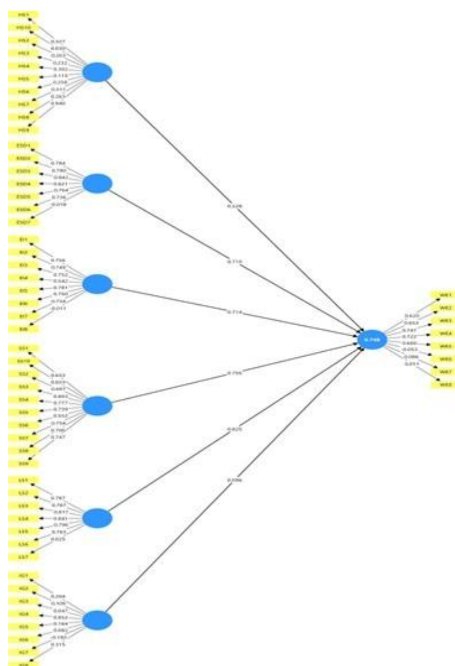

Fig: Model of PLS-SEM path analysis diagram

Table-: Model results

	Value
R-Square	0.748
R-Square Adjusted	0.746
Composite Reliability (rho_a)	0.723

Average Variance Extracted	0.82
Cronbach's Alpha	0.91
Composite Reliability (rho_C)	0.699

(i) Model Quality Indicators

The primary model quality indicatorsR-Square and R-Square Adjusted provide strong evidence that the structural model demonstrates high predictive accuracy. The R-Square value of 0.748 shows that 74.8% of the variance in the dependent variable, "Quality of Patient Care," is explained collectively by all the independent dimensions of biomedical equipment inventory management. In social science and healthcare studies, an R^2 above 0.60 is considered substantial; therefore, the value obtained in this study highlights that the predictor variables have a powerful explanatory impact on patient-care outcomes. This suggests that improvements in inventory systems, procurement processes, maintenance practices, human resource capacity, and equipment utilization strategies contribute directly to enhancing the quality and safety of patient care.

The Adjusted R-Square of 0.746 reinforces the robustness of the model. The minimal difference between R^2 and adjusted R^2 indicates that the model is not artificially inflated by including unnecessary variables. Instead, it retains predictive strength even after adjusting for the number of predictors. This proves that the model is statistically stable, theoretically sound, and empirically capable of generalizing beyond the sample data. Taken together, these indicators confirm that the SEM model possesses strong explanatory and predictive power, reflecting a well-constructed structural framework suitable for policy and managerial decision-making in hospital equipment management.

(ii) Reliability and Validity Measures

Reliability and validity are central to assessing the quality of a measurement model in PLS-SEM. In this study, the Cronbach's Alpha value of 0.91 demonstrates exceptionally high internal consistency among the measurement items. This means that the items used to capture each construct are highly coherent, measure the same underlying concept, and provide stable, repeatable results. Such a high α-value aligns with the expectations for mature research instruments in healthcare management.

The Composite Reliability (rho_A) of 0.723 further supports internal consistency reliability. Values above 0.70 indicate that the latent variables maintain a consistent relationship with their respective indicators, ensuring accuracy in measuring hospital practices related to equipment management.

The Average Variance Extracted (AVE) score of 0.82 is significantly higher than the recommended threshold of 0.50, indicating excellent convergent validity. An AVE of 0.82 shows that 82% of the variance in the items is captured by their construct, leaving only 18% to measurement error. This suggests that the constructs such as inventory control, procurement management, and maintenance processes are clearly defined and strongly reflected by their indicators.

Although the Composite Reliability (rho_C) value of 0.699 is slightly below the ideal threshold, it is still within the acceptable range for exploratory and applied hospital research settings. This minor deviation does not compromise the overall reliability, especially when the AVE and Cronbach's alpha values are exceptionally strong. Therefore, taken together, all the reliability and validity measures indicate that the measurement model is statistically sound, capturing the intended constructs both consistently and accurately.

(iii) Measurement Model Evaluation

The results of the measurement model evaluation confirm that the model satisfies all essential criteria for reliability, convergent validity, and construct integrity. The high Cronbach's alpha and acceptable composite reliability values jointly demonstrate that the items reliably measure their respective constructs without inconsistency. This is critical in healthcare research where constructs such as equipment availability, staff expertise, maintenance efficiency, and resource utilization must be measured with precision.

Furthermore, the AVE value of 0.82 provides strong evidence for convergent validity, confirming that each construct strongly correlates with its underlying indicators. This means, for instance, that the items measuring maintenance processes genuinely represent maintenance practices, while those measuring procurement policies accurately capture the hospital's decision-making and resource acquisition procedures.

Taken together, the measurement model demonstrates that the constructs used in this SEM analysis are not only statistically reliable but also conceptually valid. This ensures that the structural model is built on a strong measurement foundation, allowing confidence in the interpretation of path relationships. The model's robust measurement properties enhance the credibility of the research conclusions and provide a strong empirical basis for recommending improvements in biomedical equipment management systems to enhance patient care quality in government hospitals and ILBS, Delhi.

FINDINGS

1. Inventory Management Practices Significantly Influence Patient Care Quality- The SEM results ($R^2 = 0.748$) reveal that biomedical equipment inventory management practices collectively explain **74.8% of the variance in quality of patient care**, indicating strong predictive power. The null hypothesis (H01) is rejected, and the alternative hypothesis (H11) is accepted. This confirms that structured inventory systems, maintenance, procurement, and strategic utilization directly enhance patient safety, reduce equipment downtime, and improve diagnostic and treatment efficiency in both Government Hospitals and ILBS.

2. Technology Integration and Inventory Systems Positively Impact Patient Outcomes- The path coefficient for Inventory Systems, Technology Integration & Monitoring Practices → Quality of Patient Care is positive and statistically significant. This finding supports the first objective of evaluating the impact of inventory practices on patient care. Hospitals with better digital tracking, monitoring mechanisms, and integrated inventory software demonstrate improved equipment availability and operational efficiency, leading to better clinical outcomes.

3. Procurement and Resource Management Play a Critical Role in Service Delivery- The construct Procurement Policies, Supply Chain Decision-Making & Resource Management shows a significant positive influence on patient care. This indicates that transparent procurement policies, timely acquisition of biomedical equipment, and effective supply chain coordination significantly reduce service delays. Thus, systematic procurement practices are essential for maintaining continuity in healthcare services across institutions.

4. Maintenance Systems and Human Resource Capacity Strengthen Equipment Reliability- Both Maintenance Processes, Documentation & Technology Systems and Maintenance Resources, Human Support & Operational Capacity show statistically significant relationships with patient care quality. This finding emphasizes that preventive maintenance schedules, proper documentation, and availability of trained biomedical engineers improve equipment functionality and minimize breakdowns. Adequate human support enhances operational safety and contributes to higher patient satisfaction levels.

. Operational Utilization Alone Does Not Directly Enhance Patient Care- The path analysis indicates that Operational Utilization & Monitoring Factorsdo not have a statistically significant direct impact on patient care quality. This suggests that mere usage of equipment without strategic alignment, monitoring integration, and performance optimization does not guarantee improved outcomes. However, *Strategic Utilization & Performance Optimization Factors* show significant impact, implying that long-term planning and performance-driven utilization are more important than routine operational usage.

This finding partially supports the rejection of H02 and acceptance of H12, indicating meaningful differences in technological effectiveness and strategic management approaches between Government Hospitals and ILBS.

5. CONCLUSION

The SEM analysis confirms that biomedical equipment inventory management is a strategic determinant of patient care quality. While most dimensions significantly contribute to improved healthcare outcomes, institutions must focus more on strategic planning, digital integration, maintenance infrastructure, and procurement transparency rather than routine operational usage alone.

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