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Application of a customized measurement tool for assessing the performance of medical equipment management systems (MEMS) in Indian Public Hospitals

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Abstract
Efficient management of medical equipment is critical for ensuring the delivery of effective healthcare services in public hospitals, particularly in resource-constrained settings like India. This research paper focuses on the practical application of a measurement tool developed specifically for evaluating the performance of Medical Equipment Management Systems (MEMS) in Indian public healthcare facilities. The study involves the implementation of the customized measurement tool in a diverse set of public hospitals across India. It aims to assess the current state of MEMS performance and identify areas for improvement in equipment availability, maintenance, calibration, inventory management, and user satisfaction. Real-world data will be collected through surveys, interviews, and on-site observations. The research will provide a comprehensive analysis of the strengths and weaknesses of MEMS in the Indian public healthcare context. It will also facilitate benchmarking across different hospitals and regions, enabling healthcare administrators and policymakers to make informed decisions to enhance the overall efficiency of healthcare services. By applying the measurement tool and analyzing the results, this study seeks to contribute to the ongoing efforts to optimize the management of medical equipment in Indian public hospitals. It will provide actionable insights to improve the allocation of resources, streamline maintenance processes, and enhance the overall quality of patient care. The findings may also have broader implications for similar healthcare settings globally, underscoring the importance of tailored approaches to MEMS performance evaluation in diverse healthcare environments.

Keywords: Medical equipment, performance of medical

Introduction
The practice of keeping machines in a condition where they can continue to function as intended, or repairing them so that they can be reused, is called "Maintenance." The main objective of maintenance is to improve the availability of production facilities, the secondary objectives are to increase safety and efficiency while reducing costs. The term "Medical technology" refers to the many devices used by hospitals and other medical facilities for diagnosis, treatment, monitoring, rehabilitation, and other types of care and treatment. Medical technology management is an essential part of health service delivery. In order to offer patients high-quality treatment, comprehensive medical device management is essential. To effectively manage the technology, it is essential to create a medical device maintenance plan that takes into account both its functionality and its possible malfunction. 4 Any business that relies heavily on its resources to generate revenue should prioritize building and maintaining a successful maintenance department as one of its top priorities. But even if the technology is state of the art at the time of purchase, within 6-7 years of installation it inevitably risks becoming obsolete. Medical equipment represents approximately 40-50% of the total costs in a tertiary hospital. Maintenance costs represent between 40% and 50% of the total operating budget of companies that rely heavily on their fixed resources. If people have access to new technologies in the field of maintenance, they will be able to drastically reduce this amount [1].
As a result, maintenance costs could become a company's main source of controllable expenses. It is imperative that healthcare organizations explore possible ways to reduce costs and improve the financial management of their operating expenses.

According to research by the National Center for Health Systems Resources, the medical device failure rate can be as high as 60% in some parts of the world, with an average medical device failure rate even in areas with a Moderate presence of medical device industry (eg USA). This is true even though maintaining health technology has a positive impact on the overall safety and efficacy of medical treatments. It also has the additional consequence of increasing the demand for medical care, an effect that cannot be ignored. The availability of services based on the needs of patients is an essential part of the proper functioning of health technologies. The purchase of medical equipment represents the largest investment of any company involved in the health sector. Ensuring the reliability of critical equipment and performing its routine maintenance is essential to ensure patient and user safety and increase service availability [2].

The task of determining the most efficient approach to medical device maintenance is challenging. The full extent of the difficulty lies in the desire to reduce capital costs while improving equipment performance and the need to reduce equipment maintenance costs by extending residual equipment life. Additionally, despite increasingly stringent regulatory requirements, healthcare facilities have retained limited flexibility in the strategic direction of their maintenance strategy. This is despite the fact that regulatory requirements are becoming more stringent. The most important actions that occur during the life of a medical device, the most important of which is the maintenance process, which is still considered the "daily bread" of clinical engineering work. The main goal of the maintenance process is to ensure that the device is usable, always available, and safe to use. The first challenge clinical department's face is determining which preventive maintenance plan to use for each piece of equipment. In the prioritization methods used to make maintenance decisions, the most critical factors to be considered most often are the fitness of the resource for the organization's purpose, patient safety, and the intrinsic maintenance requirements of the resource. The implementation of the chosen strategy requires the allocation of human, material, financial and documentary resources, all specified through the use of multidimensional models. The successful implementation of the chosen strategy requires [3].

Furthermore, the clinically intensive maintenance of resources, long considered a necessary evil, is now recognized as a crucial role contributing to the creation of added value. This recognition came from the fact that this role had previously been underestimated. Performance measurement is just as important in the maintenance function of healthcare organizations as it is in other types of manufacturing organizations In fact, well-designed KPIs have the potential to help with a variety of activities, including evaluating variances between maintenance plans and activities, executing improvement initiatives, and a variety of other activities. In this context, the objective of our research is to develop a conceptual framework to analyze the variables that lead to operational difficulties in medical devices and to evaluate the process of continuity of care. In addition, one of our goals is to determine the effectiveness of health care. With this in mind, the main objective is to determine how value can be generated by monitoring clinical maintenance performance in the context of the health sector [4].

Healthcare in India

In India, there are two distinct sectors that make up the healthcare industry: the government sector and the commercial sector. Consumers do not have to pay for primary and tertiary level of care, which is the provision of public sector health services that covers all levels, from primary to tertiary. Curative and preventive health care, from elementary to tertiary level, is provided by the state sector at the national level at no cost to the user. These services are financed and managed by the public sector (which represents approximately 18% of total health spending and 0.9% of GDP). The private sector, on the other hand, is the industry leader when it comes to individual care through outpatient services. Furthermore, the private sector is responsible for approximately 82% of total health spending and 4.2% of total GDP. Based on national health care consumption rates, private health services are largely focused on providing basic health care and are mostly privately funded. As a result, these services can impose disproportionate costs on the poor and working poor. Public sector health management can be divided into three distinct areas. Maintaining a healthy population is the main task of the state. Second, the center is responsible for providing health care in areas of the union that do not have their own legislature [5].

It is also responsible for developing and monitoring national rules and regulations, being the liaison between states and funding agencies, and promoting a variety of programs implemented by US state governments. These responsibilities fall within the National Institute of Standards and Technology (NIST). In addition, the programmers on the concurrent list share responsibility for their work with the federal and state governments.

Public health goals and strategies are developed through a consultative process involving all levels of government and all stakeholders. This process is overseen by the Central Council on Health and Family Welfare (CCHFW), which acts as a facilitator. Between the early 1950s and early 1980s there was a sharp increase in the number of health care facilities and personnel in India. Furthermore, the number of licensed physicians per 10,000 population fell from a high of 4 per 10,000 in 1981 to three per 10,000 dues to rapid population growth in the late 1980s. This was due to the fact that there were fewer people in India. In 1991 there were about 10 beds for every 10,000 people in the United States. Recent forecasts assume that about 15,000 physicians will graduate each year beginning in 2005. It is estimated that about 250,000 dentists are employed within the national network of 242 accredited institutions. Primary health centers, often referred to as PHCs, are an essential part of the health infrastructure in rural areas. According to official data, in 1991 there were approximately 22,400 primary health care facilities, 11,200 hospitals and 27,400 pharmacies in India [6].

Medical device handling problems

It is well known in the world of health that one of the most important elements of the infrastructure in the provision of services are the various medical devices. It should also be noted that medical devices, along with drugs and many other devices, have played a crucial role in the tremendous advances in health care in the last hundred years. When it comes to designing, building, and maintaining a facility, equipment is often overlooked, but it's certainly essential [7].

This is especially true for less developed countries where the economic situation is already precarious. Based on the results of studies conducted by the World Health Organization (WHO) and other international organizations, it is estimated that between 25% and 50% of all health care devices in developing countries cannot be used for various reasons. This seriously hampers efforts to improve the provision of health services to the citizens of these countries. While some unused equipment was donated, most was acquired through loans from bilateral and multilateral organizations, which would require significant sacrifices on the part of the recipients. In addition, some of the material was offered free of charge. If lack of money is one of the main causes of device downtime, especially when it comes to managing recurring expenses, there are other considerations to take into account as well. The findings of international experts indicate that the most important underlying factor is inadequate management of the problem. According to the results, this is the case [8].

Objectives

1. The sixth objective of this research is to determine the type of link between the usage score and the overall KPI score of medical devices.
2. Evaluate whether there is a correlation between the evaluation of use and the evaluation of maintenance (including preventive, corrective and quality control) of medical devices.

Research Methodology

Criteria for deciding the reliability and validity of research tools

Content validity: For the Content Validity Index (CVI) of each item (for each KPI and each domain of the framework) at least 80% of the experts must agree (they must express their opinion" by 4 on the likes of the scale, which is "Agree" or 5 on the scale, which would be "Totally Agree"). The CVI of 0.80 for this item is determined based on the level of expert agreement, which was determined at 80%.

Element Discrimination: This index helps differentiate the relative relevance and power of each framework component. It is determined by calculating the correlation between the individual scores of each item on the scale and the overall score of the exam. The value of 0.2 is considered the cut-off threshold and it is recommended to discard all objects with values less than 0.2.

Internal consistency and semi-shared reliability: These indices are important to define the accuracy of the meter and guarantee consistent results in case of repetition and duplication of tests/measurements. The criteria for the two coefficients were maintained for the value greater than 0.75 [9].

Declaration of quality of research tools

The visual and content validity of the delivered tools was established taking into account the ideas and opinions expressed by the professionals.

To verify that each element of the framework is correct, we first calculated the percentage of experts who agreed with each element and then analyzed each of the elements individually. However, in order for the KPIs provided to be subsequently registered and selected following the procedure, it was necessary that they previously comply with the requirements of the agreement. To combine scores of 'agree' or 'strongly agree' on the Likert scale, the threshold for agreement was kept at 70% (Murphy, A., Wakai A, Walsh C, Cummins F and O'Sullivan, 2016). The findings were later published in the journal Psychological Science. The Cronbach and Guttman alpha semi-efficients, used in the reliability analysis, showed that the search tools had a high degree of consistency. This was done to meet the requirements of strong two-part reliability and a minimum Cronbach's alpha of 0.70 or better (Ajmera, Gupta, & Singh, 2014). Uncertainties were eliminated and finally questionnaires were developed for data collection based on authorized KPIs and MDSs. These questionnaires were sent for approval after testing. To further verify the validity of the questionnaires, a pilot study was conducted using 25-30 different types of medical devices. Finally, after the corresponding adjustments, investigations were carried out in a total of 4 public hospitals to collect the necessary information on MEMS [10].

Formulas used for calculations

To individually determine the coefficient of use of these devices, it was assumed that the working hours of the hospital wards were the same. Here "N" is the number of hours of actual use of the medical device during a business "day (average time required for a procedure using that device multiplied by the average number of procedures performed during a business day). "M" is the maximum number of hours that the medical team has been available during a working day [11].

Results and Discussion

"The second main objective was to create the components and parameters of the minimum data sets (MDS)" that should be used to analyze the KPIs to be reported (KPIs). Developed by the researchers themselves in the form of a structured questionnaire, it was used to conduct research and analysis on a variety of MEMS properties. The final selection of the proposed MDS was made after extensive analysis and review, including input collected from various industry experts. After determining the percentage of experts sharing the same opinion, a final list of MDSs corresponding to each KPI was created, which is presented in Table 1 [12].

Goal Three

The third objective of the research project was the development of a theoretical and conceptual framework to monitor the key performance indicators (KPIs) of MEMS in public hospitals. The procedure for developing and presenting a conceptual framework for micro electro-mechanical systems was discussed in the previous chapter. To test the statistical reliability and validity of the proposed conceptual framework, the total score of each domain was analyzed for:

1. Face Validity.
2. The Validity of the Contents.
3. Article analysis.
4. Internal consistency and reliability tests; Y
5. Two-part reliability test.

The framework was validated and tested for reliability using SPSS version 23, which was used for the purpose of this

study summarizes the results of the statistical tests and provides the following explanation [13].

Face Validity: With a few notable exceptions, the vast majority of industry professionals agreed that the criteria used for each of the 4 categories were clear, quantitative, realistic, and relevant, and that their evaluation could be completed in as little as one year (as specified in the protocol). They also indicated that the design and content of the framework were appropriate and realistic for implementation in public hospitals to ensure that the face validity of the framework was not compromised in any way was expressed to ensure that the pseudo-validity of the framework is not compromised [14].

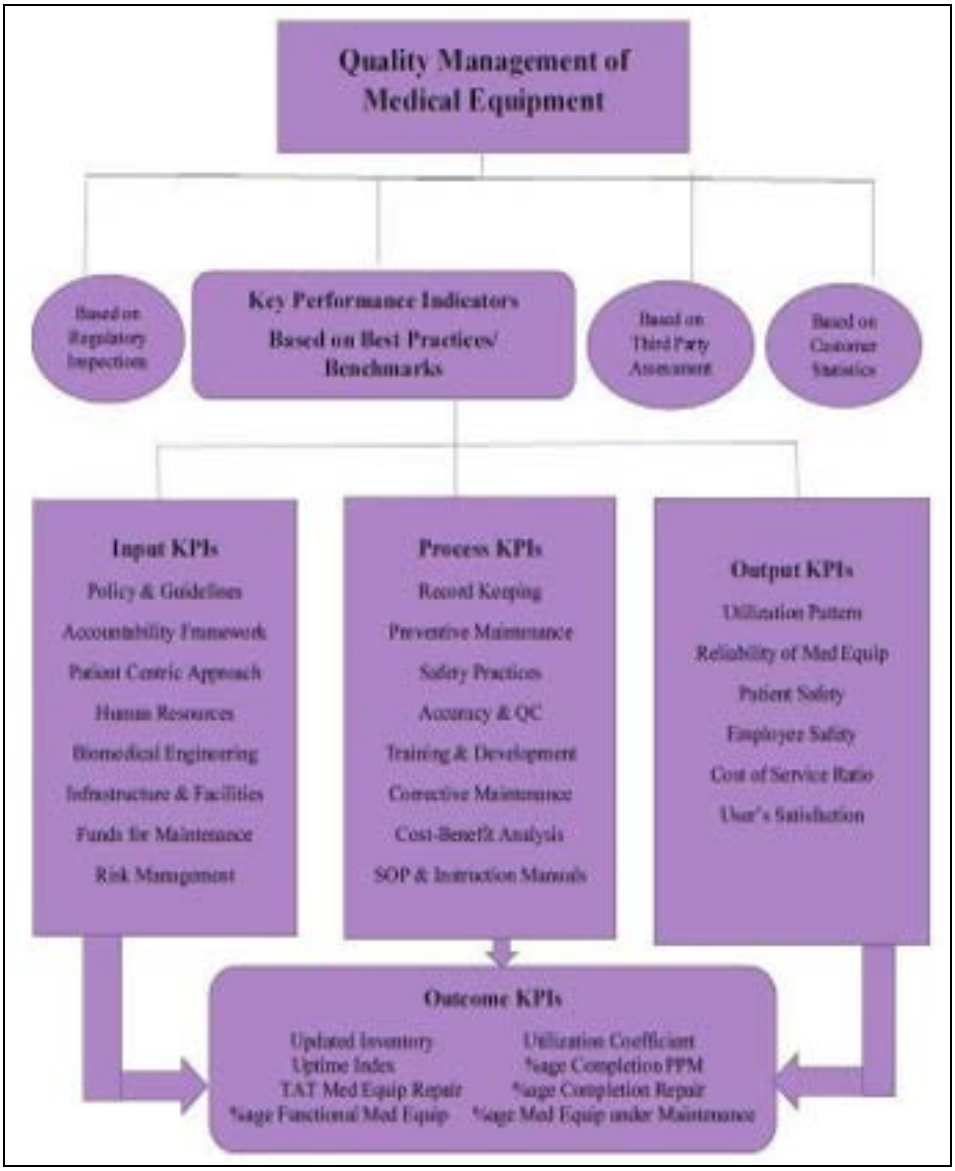

Fig 1: A conceptual framework for measuring KPI-based MEMS performance

Finally, points 15 and 17 of a total of 30 recommended articles were eliminated from the final list. This decision was made after reviewing the results of the content validation and element analysis performed on each element/area included in the framework. This is because these items did not meet all the statistical criteria for CVI and reliability coefficients, leading to the conclusion that they should not be used. Likewise, 96 components were selected from a total of 110 recommended MDS elements. The final decision was made based on the percentage of experts who agreed. According to this study, the overall skeleton had a Cronbach's alpha of 0.93 and the split-half coefficient was 0.82. You can find these two values below.

An exploratory data analysis approach was applied to the collected data (Performance Percentage of Each Hospital) before testing the study hypotheses against them. This was done to better understand the nature and quality of the data before testing hypotheses. In addition to descriptive statistics for the percentage yield data examined (Table 2), normality tests (including skewness and kurtosis values), hypothesis tests with Kolmogorov Smirnov and Shapiro-Wilk, and plot of box.

Table 1: Reliability Statistics: 4 Areas

Domain	Cronbach's Alpha	Division coefficient
Login in	.873	.899
To treat	.861	.846
Production	.869	.923
Results	.889	.950
Full (frame)	.930	.815

Table 2: Descriptive Statistics: Performance data resulting from exploratory data analysis

Descriptive statistics	GMCH	GMSH	CH-22	CH-MM
To mean	74.42	67.75	63.91	66.12
95% confidence interval for the mean	72.52	65.06	60.30	62.29
Lower limit upper limit	76.31	70.43	67.52	69.96
Difference	97,293	121,404	103,773	117,047
Flaw. Deviation	9,864	11,018	10,187	10,819
Asymmetry	-.407	-.353	-.180	-.310
Standard error (SE)	.235	.293	.409	.409
Skewness Z values (= skewness / SE)	-1,731	-1,204	-0.440	-0.757
Flat 10 ing	-.049	-.962	-1,379	-.796
Standard error (SE)	.465	.578	.798	.798
Z-kurtosis values (= kurtosis/SE)	-0.105	-1,664	-1,728	-0.99

To determine whether the data were normal or not, a Kolmogorov-Smirnov test and a Shapiro-Wilk test were performed with a significance level greater than0.05. Examination of normal histograms, box plots, and QQ plots revealed that the performance scores of all participating hospitals were nearly normally distributed, with skewness and kurtosis scores for all hospitals somewhere in the range of -1.96 to 1.96 participating hospitals [15].

Conclusion

Indian public hospitals currently do not have a comprehensive metric or framework to assess the performance of MEMS. This project was started with the intention of producing an integrated tool for MEMS in the form of a model or framework using Key Performance Indicators (KPIs) as the unit of measurement. The research led to the development of a set of thirty key performance indicators (KPIs), one hundred and 10 MDS components, and a conceptual framework for evaluating the effectiveness of MEMS. The reliability and validity of the research approach in question has also been proven through statistical analysis, which has been agreed by all industry experts as the best set of key performance indicators. It is recommended to plan for replacement of key equipment components in emergency scenarios, e.g. B. when the equipment suddenly fails. These plans must take into account the type of equipment, the replacement cost and the importance of the equipment. Protocols exist to verify the safety of medical devices before they are used by the patient, as part of a preventive maintenance program, and after frequent and major repairs. All of these protocols help the hospital prepare and maintain the proper medical equipment. In this scenario, we will have more resilient companies with a higher threshold to face the unexpected.

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