Decision Making Model for Biomedical Equipment Selection in Public Hospitals in Sri Lanka: Development of a Need Assessment and Prioritization Framework

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Abstract

Introduction

Biomedical equipment represents a critical component of healthcare infrastructure, supporting diagnosis, treatment, monitoring, and rehabilitation services. However, ineffective selection and prioritization of medical technologies remain significant challenges in many low- and middle-income countries (LMICs), where procurement decisions are often influenced by incomplete information, limited planning mechanisms, and inadequate assessment of institutional readiness. In Sri Lanka, biomedical equipment requests within the public healthcare sector have traditionally relied on paper-based processes with limited standardized criteria for objective prioritization. This study aimed to develop a structured decision-support model to strengthen evidence-based biomedical equipment selection within the public health system.

Objectives

The objective of this study was to develop and validate a Need Assessment and Prioritization Model (NAPM) for systematic assessment and prioritization of biomedical equipment requests submitted by public hospitals in Sri Lanka.

Methods

An implementation research design using a mixed-methods approach was conducted from March 2022 to November 2023 within the Biomedical Engineering Services (BES) Division of the Ministry of Health, Sri Lanka. Four representative line Ministry hospitals in the Western Province were purposively selected, representing different levels of healthcare delivery. The existing biomedical equipment selection process was assessed through process mapping, document review, Key Informant Interviews (KIIs), and Focus Group Discussions (FGDs). Biomedical equipment requests submitted between April 2022 and April 2023 were reviewed using a structured assessment checklist. Qualitative data were analysed using thematic analysis, and findings were triangulated to identify critical gaps and determinants influencing equipment selection. Based on identified gaps, a multidisciplinary expert panel developed assessment criteria and weighting mechanisms through an iterative consensus process. The final model incorporated five principal domains: equipment-related characteristics, infrastructure readiness, human resource availability, service demand and workload, and financial and operational considerations. A weighted prioritization algorithm was developed separately for equipment replacement and new acquisition requests. The model was validated through expert review and comparison of manually calculated scores with scores generated by a web-based decision-support system.

Results

The assessment demonstrated substantial variability in existing biomedical equipment selection practices. Most equipment requests lacked standardized documentation regarding clinical justification, infrastructure readiness, workforce availability, expected workload, and financial implications. Key stakeholders identified the absence of institutional guidelines, standardized prioritization criteria, and systematic pre-submission evaluation mechanisms as major limitations. The developed NAPM provided a structured framework incorporating five assessment domains essential for evidence-based decision-making. The weighted algorithm generated reproducible priority scores for biomedical equipment requests, with complete agreement between manual calculations and computerized outputs during validation. Integration of the model into a web-based platform enabled standardized electronic submissions, automated prioritization, improved traceability, and enhanced transparency in the decision-making process.

Conclusions
The Need Assessment and Prioritization Model provides a practical and context-specific framework for strengthening biomedical equipment governance within Sri Lanka's public healthcare system. By integrating clinical need, institutional readiness, workforce capacity, service demand, and financial sustainability into a single decision-support mechanism, the model addresses key limitations associated with conventional request-based procurement approaches. Further prospective evaluation is recommended to assess its long-term impact on procurement efficiency, equipment utilization, lifecycle management, and health system performance.

Key words: *Biomedical equipment management; Health technology assessment; Medical device procurement; Healthcare resource allocation; Decision-support system; Multi-criteria decision analysis; Sri Lanka; Public health system*

I. INTRODUCTION

Biomedical equipment represents a critical and highly resource intensive component of modern healthcare infrastructure, contributing significantly to disease prevention, diagnosis, treatment, rehabilitation, and continuous patient monitoring. The availability of appropriate, functional, and sustainable medical technologies is fundamental to ensuring quality healthcare delivery, improving patient safety, and enhancing the overall efficiency of health systems. The World Health Organization (WHO) recognises medical devices and health technologies as essential components of a functional health system and emphasises that decisions regarding medical technology investments should be guided by evidence, population health needs, cost-effectiveness, and sustainability considerations [1,2].

Despite significant advances in healthcare technology, many low-and middle-income countries (LMICs) continue to experience challenges related to the planning, selection, procurement, utilization, and maintenance of biomedical equipment. Studies have demonstrated that a considerable proportion of medical equipment in resource-constrained settings remains underutilized, non-functional, or inappropriate for the intended level of care. These challenges are commonly associated with inadequate technology planning, insufficient infrastructure, shortage of trained personnel, weak maintenance systems, and ineffective procurement processes [3,4]. Consequently, international guidance recommends systematic health technology assessment (HTA) and comprehensive needs assessment approaches before decisions are made regarding acquisition of medical technologies [1,5].

Sri Lanka maintains a well-established publicly funded healthcare system providing universal access to essential health services. The country allocates substantial public resources annually towards healthcare infrastructure development and biomedical equipment procurement. However, despite these investments, biomedical equipment selection within the public health sector has historically relied largely on institution-initiated requests submitted through predominantly paper-based administrative mechanisms. Evidence from healthcare technology management literature indicates that procurement systems lacking standardized assessment processes may result in inappropriate technology selection, inefficient resource utilization, and difficulties in ensuring equitable allocation of healthcare investments [2,4].

Preliminary assessments within the Sri Lankan public health sector identified several limitations in the existing biomedical equipment request process, including incomplete documentation, inconsistent information provided by requesting institutions, absence of standardized assessment criteria, and limited mechanisms for transparent prioritization. Similar challenges have been reported in other LMIC healthcare systems, where equipment procurement decisions are frequently influenced by immediate institutional demands rather than comprehensive assessment of clinical requirements, operational readiness, and long-term sustainability [3,6].

The economic constraints experienced by Sri Lanka in recent years have further emphasized the need to maximize value from public healthcare expenditure. Under conditions of limited financial resources, biomedical equipment investments require structured decision-making approaches that consider not only acquisition costs but also infrastructure requirements, human resource availability, maintenance capacity, consumables, and lifecycle costs [1,5]. Effective healthcare technology management therefore requires a transition from procurement-focused approaches towards strategic planning throughout the technology lifecycle [2].

Health Technology Assessment (HTA) has become an established approach internationally for supporting evidence-informed healthcare technology decisions. HTA integrates clinical effectiveness, safety, economic evaluation, ethical considerations, and organizational implications to guide decisions regarding adoption and utilization of healthcare technologies [5,7]. However, formal HTA mechanisms remain limited in many LMIC settings due to constraints related to technical expertise, institutional capacity, and available resources. Therefore, developing simplified, context-specific decision-support frameworks represents an important step towards strengthening healthcare technology governance in resource-constrained environments [6].

Within Sri Lanka, a structured mechanism specifically designed to assess and prioritize biomedical equipment requests has not been fully institutionalized. The absence of such a framework creates challenges in objectively comparing competing requests, ensuring institutional readiness, and aligning biomedical technology investments with national healthcare priorities.

Therefore, this study aimed to develop a structured Need Assessment and Prioritization Model (NAPM) to support evidence-based assessment and prioritization of biomedical equipment requests submitted by public hospitals in Sri Lanka. The proposed model

integrates equipment characteristics, infrastructure readiness, human resource capacity, service demand, and financial considerations to strengthen transparency, accountability, and efficiency in biomedical equipment decision making.

Low and middle income countries continue to experience considerable challenges in the management of biomedical equipment. Studies have reported that between 40% and 70% of medical equipment in resource constrained settings remains underutilized, non-functional or inappropriate for the intended level of care. These shortcomings are frequently attributed to inadequate planning, insufficient infrastructure, lack of trained personnel and weaknesses in procurement and technology management systems. International guidance therefore advocates structured health technology assessment and comprehensive need assessment before procurement decisions are made.

Sri Lanka maintains a comprehensive publicly funded health system that allocates substantial financial resources annually for the procurement of biomedical equipment. Despite these investments, the Ministry of Health has historically relied on predominantly paper-based mechanisms for hospitals to submit equipment requests. Preliminary assessments identified several deficiencies in this process, including incomplete documentation, inconsistent information, absence of standardized institutional criteria and limited transparency in prioritization. Consequently, decision makers frequently lacked the comprehensive information required to objectively evaluate competing requests.

The recent economic constraints experienced by Sri Lanka have further highlighted the necessity of maximizing value from public expenditure. Limited financial resources demand that procurement decisions are guided by transparent, evidence-based mechanisms that consider institutional readiness, workforce capacity, infrastructure availability and anticipated service demand rather than relying solely on individual requests or subjective judgement.

Although Health Technology Assessment has become an integral component of technology selection in many high-income countries, similar structured mechanisms remain insufficiently institutionalized within the Sri Lankan public health sector. Developing a standardized framework for biomedical equipment prioritization therefore represents an important step towards strengthening governance, accountability and efficient resource allocation.

This study aimed to develop a structured decision making model to support the assessment and prioritization of biomedical equipment requests submitted by public hospitals in Sri Lanka.

II. METHODS

Study design

This implementation research study was conducted to develop a structured decision-making model for biomedical equipment selection and prioritization within public hospitals in Sri Lanka. An implementation research approach was selected as it provides a systematic framework for identifying health system gaps, developing context-specific interventions, and translating evidence-based solutions into routine practice [8].

A mixed-methods study design incorporating qualitative and quantitative approaches was adopted to understand existing biomedical equipment selection practices, identify operational challenges, develop an evidence-informed prioritization framework, and translate the framework into a web-based decision-support system. Mixed-methods approaches are increasingly recognized as valuable in health systems research as they enable integration of contextual understanding with measurable evidence to support complex decision-making processes [9].

Study setting

The study was conducted within the Biomedical Engineering Services (BES) Division of the Ministry of Health, Sri Lanka, which is responsible for coordinating and supporting the management and procurement of biomedical equipment for line ministry hospitals.

Four representative line ministry hospitals located in the Western Province were purposively selected to capture different levels of healthcare service delivery. The selected institutions included a National/Teaching Hospital, a Specialised Hospital, a District General Hospital, and a Base Hospital, representing varying levels of service complexity, resource availability, and equipment requirements.

Study period

The research was conducted from March 2022 to November 2023.

Development of the Decision-Making Model

The Need Assessment and Prioritization Model (NAPM) was developed through a systematic multi-stage process informed by principles of health technology assessment (HTA), healthcare technology management, and evidence-based resource allocation. HTA provides a structured approach for evaluating healthcare technologies by considering clinical requirements, organizational capacity, economic implications, and system-level priorities [10].

The model development process consisted of four main phases:

1. Assessment of existing biomedical equipment selection practices
2. Development of assessment criteria
3. Development and validation of the prioritization algorithm
4. Development and testing of the web-based decision-support system

Phase I: Assessment of existing practices

The existing biomedical equipment selection and prioritization process was assessed through process mapping, document review, Key Informant Interviews (KIIs), Focus Group Discussions (FGDs), and analysis of biomedical equipment requests submitted to the Biomedical Engineering Services Division.

Document Review

Biomedical equipment requests submitted between April 2022 and April 2023 were reviewed using a structured checklist developed based on international recommendations for healthcare technology management and existing Ministry of Health procedures. The review assessed the completeness, consistency, and adequacy of information provided to support objective decision-making.

Healthcare technology management frameworks emphasize that effective equipment planning requires systematic assessment of clinical needs, technical feasibility, infrastructure capacity, financial implications, and lifecycle considerations before procurement decisions are undertaken [1].

Key Informant Interviews

Semi-structured Key Informant Interviews were conducted with senior administrators and technical stakeholders involved in biomedical equipment planning and management. Participants included representatives from the Ministry of Health, Biomedical Engineering Services Division, Hospital Directors, Biomedical Engineers, and representatives from the medical equipment industry.

The interviews explored existing equipment selection processes, institutional challenges, decision-making factors, technical requirements, and opportunities for improving transparency and efficiency in equipment prioritization.

Focus Group Discussions

Focus Group Discussions were conducted with clinicians, Medical Planning Officers, nursing managers, and unit heads involved in initiating biomedical equipment requests. The discussions explored operational requirements, service delivery constraints, perceived barriers within the existing process, and expectations regarding an improved prioritization mechanism.

Qualitative data obtained from KIIs and FGDs were analysed using thematic analysis following an established six-phase approach involving data familiarization, coding, identification of themes, review of themes, definition of thematic categories, and interpretation of findings [11].

Findings from document reviews, KIIs, and FGDs were triangulated to identify key factors influencing biomedical equipment selection and prioritization.

Phase II: Development of Assessment Criteria

Findings from Phase I were synthesised to develop a comprehensive assessment framework for biomedical equipment prioritization. A multidisciplinary expert panel comprising senior biomedical engineers, medical administrators, health planners, and academic supervisors reviewed the proposed criteria through a structured consensus-building process.

Expert consensus methods are widely applied in healthcare decision-making where empirical evidence alone may be insufficient, particularly in developing context-specific prioritisation frameworks [11].

The final framework consisted of five major assessment domains:

- Equipment-related factors
- Infrastructure readiness
- Human resource availability
- Service demand and workload
- Financial and operational considerations

Each domain consisted of multiple sub-criteria reflecting clinical necessity, institutional preparedness, sustainability, and operational feasibility.

The criteria were reviewed iteratively until consensus was achieved regarding their relevance, applicability, and feasibility within the Sri Lankan public healthcare context.

Development of the Prioritization Algorithm

Following finalization of the assessment criteria, weighted scores were assigned to each domain using expert consensus. Separate weighting mechanisms were developed for replacement requests and new equipment acquisition requests to recognize differences in decision priorities between these two categories.

For replacement equipment requests, higher weighting was assigned to factors including age, functional condition, availability of maintenance support, infrastructure readiness, and existing equipment performance.

For new equipment requests, greater emphasis was placed on service demand, anticipated workload, infrastructure preparedness, availability of trained personnel, and alignment with healthcare service requirements.

The weighted criteria were incorporated into a mathematical prioritisation algorithm capable of generating an institutional priority score for each biomedical equipment request. Multi-criteria decision analysis (MCDA) principles were applied, as these approaches are increasingly used in healthcare resource allocation when decisions require consideration of multiple competing technical, clinical, and organizational factors [13].

The algorithm was tested using hypothetical biomedical equipment scenarios. Manual calculations were compared with computer-generated scores to confirm computational accuracy before implementation.

Development of the Web-Based Decision Support System

The validated prioritisation model was integrated into a secure web-based decision-support application developed for the Biomedical Engineering Services Division.

The system enabled healthcare institutions to submit biomedical equipment requests electronically through standardised data entry forms incorporating mandatory information fields. Structured electronic submission systems have been demonstrated to improve data quality, reduce administrative variability, and strengthen transparency in healthcare resource management [14].

User-access controls were incorporated to ensure confidentiality and appropriate institutional review before final submission. The system automatically calculated priority scores using the validated algorithm and generated ranked equipment request lists to support evidence-based decision-making by Ministry of Health authorities.

The platform included secure cloud-based data storage, electronic record management, automated retrieval of historical requests, and improved traceability of equipment prioritisation decisions.

Validation of the Model

Face validity and content validity of the assessment framework were established through expert review involving senior officials from the Biomedical Engineering Services Division and academic supervisors.

Practical validation was conducted by comparing priority scores generated manually with scores automatically calculated by the web-based application using simulated biomedical equipment requests.

Validation approaches involving expert assessment and comparison of system generated outputs are commonly used in the development of clinical and health management decision-support tools to establish reliability and usability before operational implementation [15].

Ethical Considerations

Ethical approval for the study was obtained from the Ethics Review Committee of the Postgraduate Institute of Medicine, University of Colombo. Administrative approval was obtained from the Ministry of Health and participating hospitals.

Written informed consent was obtained from all participants involved in KIIs and FGDs. Confidentiality of participant information and institutional data was maintained through anonymisation of research records and restricted access to study materials.

III. RESULTS

Assessment of the Existing Biomedical Equipment Selection Process

The preliminary assessment identified substantial variability in biomedical equipment selection practices among participating hospitals. Process mapping and document review demonstrated that equipment requests were predominantly initiated through paper-based administrative mechanisms without a standardized framework for documenting institutional needs, technical requirements, or readiness for sustainable utilization.

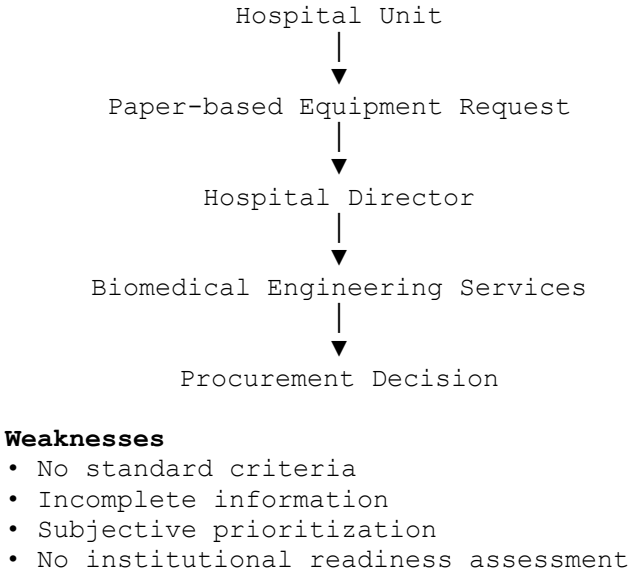
The majority of reviewed requests contained only basic information, such as the requested equipment name and general specifications, while critical information required for evidence-based prioritization was frequently unavailable. Missing information included clinical justification, expected service utilization, infrastructure requirements, availability of trained personnel, maintenance capacity, and financial implications associated with equipment operation.

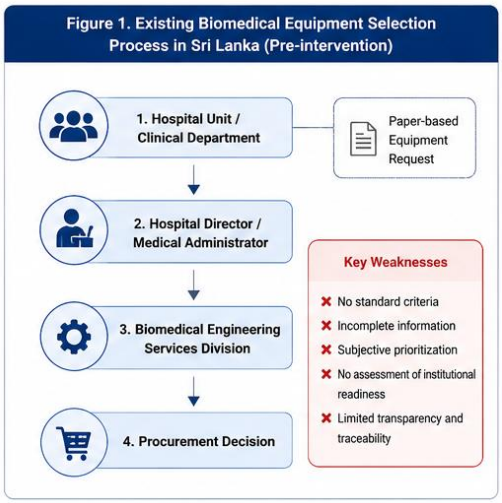
Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs) consistently identified major weaknesses within the existing selection process. Participants highlighted the absence of institutional guidelines for biomedical equipment prioritization, lack of standardized assessment criteria, inadequate documentation of infrastructure and human resource capacity, and limited consideration of service demand.

Participants further reported that equipment requests were often initiated independently by individual clinical departments without a systematic institutional review mechanism. This resulted in variations in justification, duplication of requests, inconsistent prioritization, and increased dependence on subjective decision-making. Similar challenges have been reported internationally in healthcare technology management systems, where inadequate planning mechanisms and weak governance structures contribute to inefficient utilization of medical technologies [1,2].

Process mapping demonstrated the absence of a uniform pre-submission evaluation mechanism. Consequently, decision-makers within the Ministry of Health frequently received incomplete and inconsistent information, limiting their ability to objectively compare competing equipment requests and allocate resources according to institutional priorities.

Figure 1. Existing Biomedical Equipment Selection Process in Sri Lanka (Pre-intervention)





The process mapping further demonstrated the absence of a uniform mechanism for evaluating requests before submission to the Biomedical Engineering Services Division. Consequently, decision makers at the Ministry of Health frequently received incomplete information, making objective comparison and prioritization of competing requests difficult.

Development of the Need Assessment and Prioritization Model

Findings from the preliminary assessment informed the development of the Need Assessment and Prioritization Model (NAPM). Expert consultation confirmed that biomedical equipment selection should extend beyond technical specifications and incorporate broader considerations related to institutional preparedness, service requirements, operational sustainability, and healthcare system capacity.

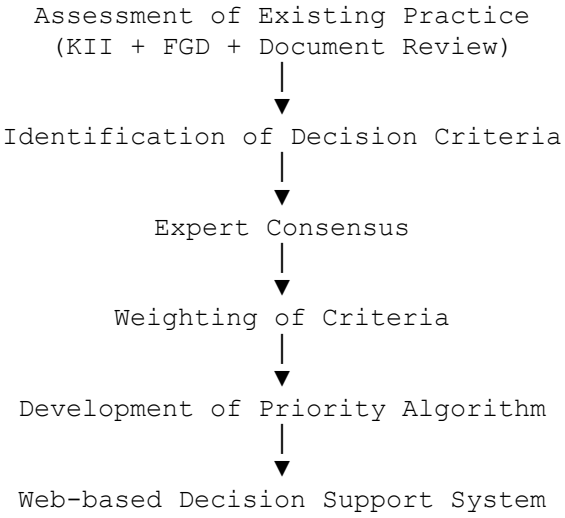
Health technology assessment frameworks emphasize that technology acquisition decisions should consider multiple dimensions, including clinical need, organizational readiness, resource requirements, and long-term sustainability rather than relying solely on equipment availability or individual requests [10].

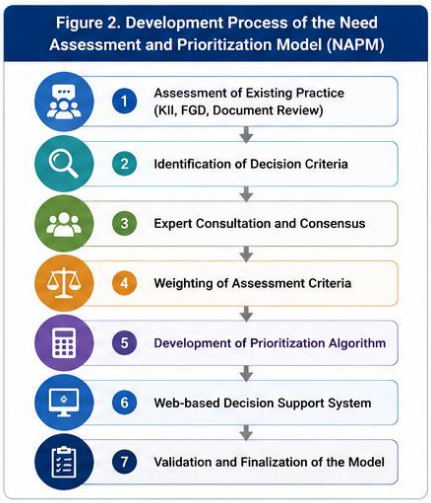
Following an iterative expert review and consensus-building process, the final assessment framework consisted of five principal domains:

- Equipment-related characteristics
- Infrastructure readiness
- Human resource availability
- Service demand and workload
- Financial and operational considerations

These domains represented the minimum essential information required to support evidence-based assessment and prioritization of biomedical equipment requests.

Figure 2. Development Process of the Need Assessment and Prioritization Model (NAPM)





These domains collectively reflected the minimum information required for evidence-based decision-making and represented the core structure of the prioritization model.

Development of Assessment Criteria

Analysis of KIIs demonstrated strong agreement regarding the importance of incorporating standardized assessment criteria into the equipment selection process. Experts identified information relating to the requesting institution, equipment characteristics, infrastructure availability, staffing capacity, workload, financial requirements, and operational considerations as either “necessary” or “highly necessary” for objective evaluation.

Based on these findings, a standardized assessment checklist was developed incorporating:

- Institutional and service information
- Equipment-specific requirements
- Infrastructure and installation requirements
- Human resource availability
- Service workload indicators
- Financial and operational considerations

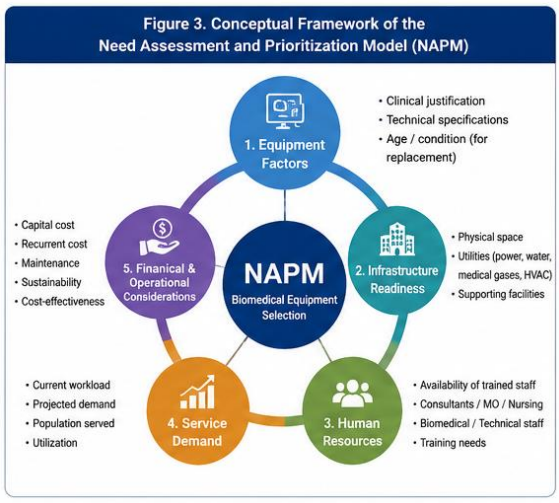
The checklist established a structured mechanism for collecting comparable information from all requesting institutions. Standardised data collection approaches are recognised as essential components of effective healthcare technology management, as they improve transparency, comparability, and accountability in resource allocation decisions [2].

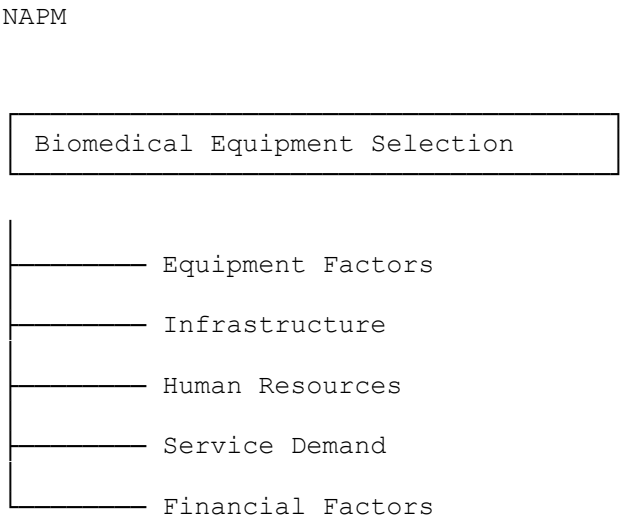
The checklist provided a comprehensive framework for collecting consistent information from all requesting institutions.

Table 1. Principal domains incorporated into the Need Assessment and Prioritization Model (NAPM)

Assessment domain	Purpose
Equipment-related factors	Establish clinical justification and equipment characteristics
Infrastructure readiness	Assess institutional preparedness for installation and operation
Human resources	Determine availability of trained personnel
Service demand	Assess workload and projected utilization
Financial and operational considerations	Evaluate sustainability, maintenance and resource implications

Figure 3. Components of the NAPM Framework





Development of the Prioritization Algorithm

A weighted scoring system was developed to enable objective prioritization of biomedical equipment requests. Separate scoring mechanisms were created for replacement requests and new equipment acquisition requests to reflect differences in decision priorities.

For replacement equipment requests, greater weighting was assigned to factors related to the age and functional condition of existing equipment, availability of technical support, institutional readiness, and continuity of clinical services.

For new equipment acquisition requests, greater emphasis was placed on clinical demand, anticipated service utilization, infrastructure preparedness, availability of trained personnel, and alignment with institutional service requirements.

The weighted assessment criteria were incorporated into a mathematical prioritization algorithm capable of generating an overall institutional priority score for each equipment request. The use of multi-criteria decision analysis approaches supports structured decision-making where multiple competing technical, clinical, and organizational factors must be considered simultaneously [13].

Manual calculations using hypothetical biomedical equipment scenarios demonstrated complete agreement with scores generated by the computerized system, confirming the accuracy and reproducibility of the algorithm before implementation.

Development of the Web-based Decision Support System

The finalized prioritization framework was integrated into a secure web-based decision-support application developed specifically for the Biomedical Engineering Services Division of the Ministry of Health.

The system standardized the biomedical equipment request process by introducing mandatory electronic data-entry fields covering all assessment domains. Requesting institutions were required to provide complete information regarding equipment specifications, clinical justification, infrastructure availability, staffing capacity, workload requirements, and operational considerations before submission.

The application automatically calculated priority scores using the embedded algorithm and generated ranked equipment request lists to support transparent and evidence informed decision making.

Role-based access controls were incorporated to ensure appropriate authorization and review at institutional and national levels. Cloud-based storage and electronic record management functions enhanced data security, traceability, and long-term monitoring of biomedical equipment planning activities.

Digital health information systems and electronic decision-support platforms have demonstrated potential to improve data quality, strengthen governance, and enhance accountability in health system management [14].

Validation of the Decision Making Model

Content validity of the Need Assessment and Prioritisation Model was established through iterative expert review involving senior biomedical engineers, healthcare administrators, and academic supervisors.

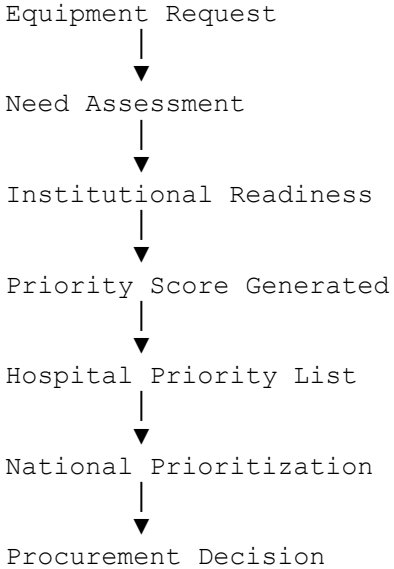
The assessment criteria, weighting framework, and scoring methodology achieved consensus regarding their relevance, completeness, feasibility, and applicability within the Sri Lankan public healthcare context.

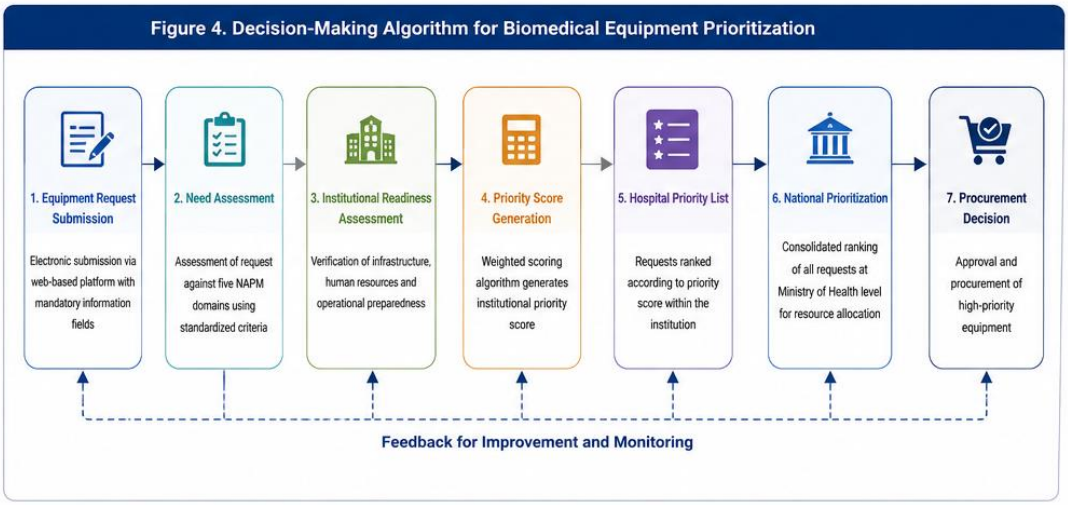
Operational validation demonstrated that the computerised prioritisation system generated consistent and reproducible priority scores when compared with manually calculated results. The electronic platform eliminated variability associated with manual documentation and provided a transparent mechanism for comparing competing biomedical equipment requests.

The validation process confirmed that the developed model was practical, reliable, and suitable for supporting structured biomedical equipment prioritisation within the public health sector.

Overall, the findings demonstrate that the Need Assessment and Prioritisation Model provides a comprehensive, standardised, and evidence-informed framework for biomedical equipment selection. The model strengthens institutional decision-making, improves transparency, and supports equitable allocation of limited healthcare resources.

Figure 4. Decision-Making Framework for Biomedical Equipment Selection





Collectively, these findings demonstrate that the Need Assessment and Prioritization Model provides a comprehensive, standardized and evidence based framework for biomedical equipment selection within the public health sector, thereby strengthening institutional decision making and supporting more equitable allocation of limited healthcare resources.

IV. DISCUSSION

This study presents the systematic development of a structured Need Assessment and Prioritization Model (NAPM) designed to strengthen evidence-based biomedical equipment selection within the Sri Lankan public health sector. The findings demonstrate that the existing equipment selection process was largely dependent on institution-generated requests supported by limited documentation and lacked a standardized mechanism for assessing clinical necessity, institutional preparedness, operational sustainability, and resource implications. The NAPM addresses these limitations by transforming biomedical equipment selection from a predominantly administrative procurement activity into a structured health system decision-making process.

The findings highlight an important distinction between procurement-driven decision-making and health technology management approaches. Biomedical equipment acquisition is frequently treated as a purchasing function; however, international evidence emphasizes that effective healthcare technology management requires a comprehensive lifecycle approach encompassing needs assessment, technology selection, acquisition, installation, utilization, maintenance, replacement, and eventual disposal [1,2]. The absence of such systematic approaches in many low- and middle-income countries (LMICs) has contributed to inappropriate technology selection, poor utilization, premature equipment failure, and inefficient allocation of limited healthcare resources [1,3].

Contribution of NAPM Compared with Existing Health Technology Assessment Approaches

A major contribution of this study is the adaptation of Health Technology Assessment (HTA) principles into a practical operational framework suitable for routine use within a public healthcare system. Established HTA processes in high-income countries typically incorporate assessments of clinical effectiveness, safety, economic impact, ethical considerations, and organizational implications before technology adoption decisions are made [5]. However, comprehensive HTA systems often require specialized expertise, institutional capacity, and substantial resources, limiting their direct application in many resource-constrained settings.

The NAPM provides a simplified and context-specific approach that incorporates core HTA principles while addressing practical challenges faced by healthcare institutions in Sri Lanka. Rather than evaluating technology solely on technical specifications or immediate clinical demand, the model incorporates five interconnected domains: equipment-related factors, infrastructure readiness, human resource availability, service demand, and financial sustainability.

This approach is consistent with WHO recommendations that medical device decisions should be based on evidence, health priorities, technical feasibility, and sustainability considerations rather than isolated procurement requests [1,2]. By operationalizing these principles into a structured scoring mechanism, the NAPM provides a feasible pathway for embedding evidence-informed decision-making within routine health sector planning.

Advantages Over Conventional Request-Based Procurement Systems

The study identified significant limitations associated with the traditional request-based biomedical equipment procurement process. Conventional approaches often rely heavily on individual institutional requests, resulting in variability in justification, incomplete documentation, and limited comparability between competing proposals. Such systems may unintentionally favour institutions with stronger administrative capacity rather than those with the greatest clinical need.

The NAPM improves upon this approach by introducing standardized assessment criteria applicable to all requesting institutions. Mandatory documentation of infrastructure availability, trained personnel, expected workload, and financial implications ensures that equipment requests are evaluated within the context of institutional readiness and long-term feasibility.

International studies have demonstrated that lack of adequate preparation, including insufficient infrastructure and maintenance capacity, is a major contributor to medical equipment becoming non-functional or underutilized in LMIC settings [3,4]. By incorporating readiness assessments before procurement decisions are finalized, the NAPM has the potential to reduce inappropriate investments and improve equipment utilization outcomes.

Another important advantage is the reduction of subjective decision-making. Procurement prioritization often involves competing institutional demands and limited financial resources, creating challenges for transparent allocation. Multi-criteria decision analysis (MCDA) approaches, such as the methodology adopted in this study, are increasingly recommended for healthcare priority-setting because they allow multiple clinical, operational, and economic considerations to be assessed simultaneously [13].

Implications for Health System Governance and Resource Allocation in Sri Lanka

The findings have important implications for strengthening healthcare governance within Sri Lanka's Ministry of Health. Public healthcare systems operating under financial constraints require mechanisms that ensure limited resources are directed towards interventions with the greatest potential health benefit and sustainability.

The NAPM provides a transparent decision-support mechanism that can strengthen accountability by documenting the rationale behind equipment prioritization decisions. The availability of standardized assessment information enables policymakers to compare requests objectively, identify institutional gaps, monitor investment patterns, and improve long-term capital planning.

The integration of the model into a web-based platform further enhances governance by reducing dependence on manual documentation, improving traceability, and creating opportunities for evidence-based forecasting of future equipment requirements. Digital health systems have been increasingly recognized as important tools for improving information management, strengthening health system accountability, and supporting better decision-making [14].

The model also supports a shift from reactive procurement towards proactive healthcare technology planning. Rather than responding primarily to individual requests, health authorities can use aggregated information generated through the system to identify regional disparities, anticipate future requirements, and align biomedical technology investments with national health priorities.

Applicability to Other Low- and Middle-Income Healthcare Systems

Although developed within the Sri Lankan public health context, the principles underlying the NAPM may have broader relevance for other LMIC healthcare systems facing similar challenges. Many countries experience comparable constraints, including limited financial resources, inadequate technology planning mechanisms, insufficient biomedical engineering capacity, and fragmented procurement practices [1,3].

The adaptability of the model lies in its emphasis on fundamental determinants of sustainable technology utilization rather than country-specific procurement requirements. Domains such as infrastructure readiness, workforce capacity, service demand, and lifecycle costs are universally relevant considerations when introducing biomedical technologies.

However, successful adaptation in other settings would require contextual modification of assessment criteria, weighting mechanisms, institutional structures, and procurement regulations according to national healthcare priorities and available resources. Future multicountry evaluations could assess whether similar prioritization frameworks improve efficiency, equity, and sustainability of biomedical equipment investments across different health systems.

Strengths of the Study

A major strength of this study is the systematic and participatory approach adopted for model development. Incorporating perspectives from biomedical engineers, healthcare administrators, clinicians, and institutional users ensured that the framework reflected practical operational realities while maintaining alignment with international health technology management principles.

Another strength was the translation of the conceptual prioritization framework into a functional digital decision-support system. The integration of automated scoring, standardized data collection, and electronic record management increases the feasibility of implementing the model within routine health sector operations.

Limitations and Future Research Directions

Several limitations should be considered when interpreting the findings. First, the model was developed and tested within selected line Ministry of Health hospitals in Sri Lanka. Although these institutions represented different levels of healthcare delivery, further validation is required before extending application to Provincial Council hospitals, private healthcare institutions, or other health systems.

Second, weighting of assessment criteria was based primarily on expert consensus. Although expert-based weighting is commonly used in healthcare decision-making frameworks where empirical evidence is limited [8], future studies could apply more advanced quantitative approaches such as the Analytic Hierarchy Process (AHP) or other MCDA methodologies to refine weighting and explore stakeholder preference variations [13,16].

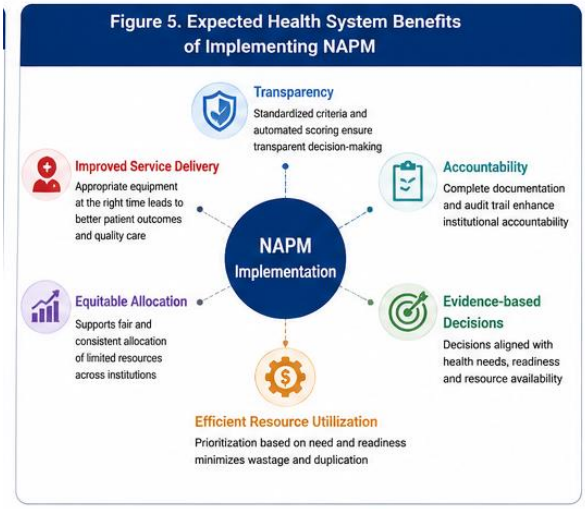
Third, validation of the prioritization algorithm was conducted using simulated scenarios rather than long-term prospective implementation data. Future research should evaluate the model under real operational conditions to assess its impact on procurement efficiency, equipment utilization, maintenance outcomes, financial savings, and equity of resource distribution.

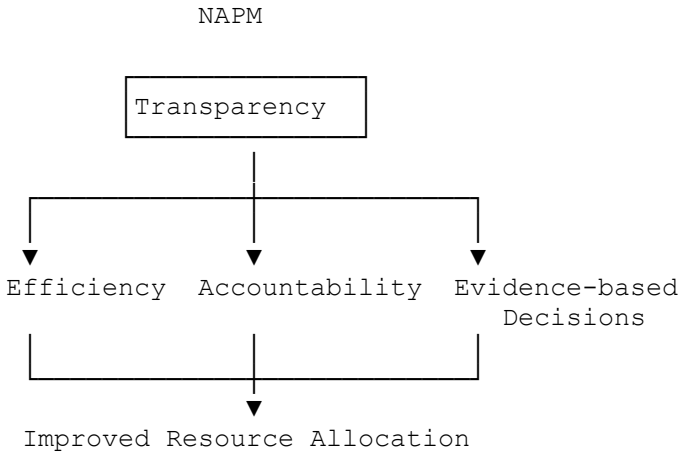
Finally, future studies should explore integration of additional parameters such as environmental sustainability, climate resilience of healthcare infrastructure, total lifecycle costing, and patient outcome indicators to further strengthen the model.

Despite these limitations, this study represents an important advancement in biomedical equipment governance within Sri Lanka’s public health sector. The Need Assessment and Prioritization Model provides a structured, transparent, and evidence-informed mechanism for moving beyond conventional request-based procurement towards strategic healthcare technology planning.

By integrating institutional readiness, clinical demand, workforce capacity, and financial sustainability into a single decision-support framework, the model supports improved accountability, equitable resource allocation, and sustainable investment in biomedical technologies. The approach provides a practical foundation for strengthening health technology management in Sri Lanka and offers potential applicability to other LMIC healthcare systems seeking to improve the efficiency and effectiveness of biomedical equipment investments.

Figure 5. Expected Benefits of Implementing NAPM





V. CONCLUSION

This study successfully developed a structured Need Assessment and Prioritization Model (NAPM) to support evidence-based biomedical equipment selection within the Sri Lankan public health sector. The findings demonstrated that the existing paper-based request mechanism lacked standardized assessment criteria, comprehensive documentation requirements, and a systematic approach for comparing competing biomedical equipment needs. Consequently, decision-makers were frequently required to evaluate requests based on incomplete information, limiting transparency, consistency, and evidence-informed allocation of healthcare resources.

The developed NAPM addresses these limitations by integrating key determinants of sustainable healthcare technology utilization, including equipment-related characteristics, infrastructure readiness, human resource capacity, service demand, and financial and operational considerations. This multidimensional approach is consistent with international recommendations that biomedical technology decisions should consider the complete healthcare technology lifecycle rather than focusing solely on procurement and acquisition [1,2].

The weighted prioritization algorithm provides a transparent and reproducible mechanism for evaluating biomedical equipment requests while balancing clinical requirements with institutional preparedness and long-term sustainability. By incorporating structured assessment criteria and automated scoring, the model reduces subjectivity and supports more consistent decision-making among competing institutional priorities.

The integration of the NAPM into a secure web based decision support platform further strengthens its operational potential by enabling standardized data collection, electronic documentation, automated prioritization, and improved traceability of equipment planning decisions. Digital decision-support systems have increasingly demonstrated value in improving information management, accountability, and evidence-informed planning within health systems [14].

Overall, the NAPM represents a practical and contextually appropriate framework for strengthening biomedical equipment governance within Sri Lanka's publicly funded healthcare system. While further operational evaluation is required to determine its long-term impact, the model provides a foundation for improving transparency, efficiency, and sustainability of healthcare technology investments, particularly in resource-constrained environments.

VI. RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proposed:

1. Institutionalization of the Need Assessment and Prioritization model

The Ministry of Health should consider adopting the Need Assessment and Prioritization Model as the standard assessment mechanism for biomedical equipment requests submitted by line Ministry hospitals. Institutionalizing a standardized approach would promote consistency, transparency, and evidence-based prioritization across healthcare institutions.

2. Integration into National Biomedical Equipment Planning and Procurement policies

The NAPM should be incorporated into national biomedical equipment procurement policies, planning frameworks, and healthcare technology management guidelines to establish a unified decision-making process across the public health sector. WHO recommends that countries develop structured medical device management systems incorporating appropriate planning, selection, procurement, and lifecycle management processes [1,2].

3. Establishment of Institutional Biomedical Equipment Assessment Guidelines

Hospital-level guidelines should be developed to define the minimum information requirements for biomedical equipment requests before submission for national-level consideration. These guidelines should include clinical justification, infrastructure readiness, staffing requirements, expected workload, maintenance arrangements, and lifecycle cost considerations.

4. Strengthening Capacity Development for Healthcare Technology Planning

Regular training programmes should be conducted for hospital administrators, clinicians, biomedical engineers, and relevant technical officers on evidence-based biomedical equipment planning, technology assessment principles, lifecycle management, and sustainable utilization of medical technologies.

5. Further Enhancement through Health Technology Assessment and Economic Evaluation

Future iterations of the NAPM should incorporate advanced Health Technology Assessment approaches, including cost-effectiveness analysis, lifecycle costing, and total cost of ownership assessments. Such approaches would further strengthen investment decisions by considering long-term financial and health system implications [5].

6. Expansion and Validation Across Different Healthcare Settings

The model should undergo further validation within Provincial Council hospitals, specialized healthcare institutions, and other healthcare delivery settings to evaluate its adaptability, reliability, and applicability across diverse organizational contexts.

7. Long-Term Evaluation of Model Effectiveness

Future research should evaluate the impact of NAPM implementation through prospective studies assessing changes in procurement efficiency, equipment utilization rates, maintenance costs, lifecycle performance, equity of resource allocation, and contribution to improved healthcare service delivery.

Strengths of the Study

This study is one of the first in Sri Lanka to develop a structured, evidence based decision support framework specifically designed for biomedical equipment prioritization. The model was developed using a mixed methods approach involving extensive stakeholder consultation, expert consensus and practical validation. The integration of a weighted prioritization algorithm within a web based platform enhances transparency, consistency and institutional accountability while supporting sustainable healthcare technology management.

Limitations

The study was conducted within selected line Ministry hospitals and therefore may not fully represent the operational environments of Provincial Council hospitals or private healthcare institutions. The weighting assigned to assessment criteria was based on expert consensus rather than advanced multi-criteria decision analysis techniques. Although the prioritization model demonstrated satisfactory operational validity, further prospective evaluation is required to determine its long-term impact on procurement efficiency, equipment utilization and health system performance.

Implications for Health Policy

The findings support the establishment of a nationally standardized framework for biomedical equipment prioritization within Sri Lanka. Institutionalising structured needs assessment before procurement would improve transparency, accountability and evidence-informed allocation of limited healthcare resources. The NAPM also provides an operational platform that could support future national Health Technology Assessment initiatives and contribute towards strengthening healthcare governance.

Ethical Approval

Ethical approval for the study was obtained from the Ethics Review Committee of the Postgraduate Institute of Medicine, University of Colombo. Administrative approval was obtained from the Ministry of Health and the participating hospitals prior to commencement of the study.

Informed Consent

Written informed consent was obtained from all participants involved in Key Informant Interviews and Focus Group Discussions. Participation was voluntary and confidentiality of all respondents was maintained throughout the study.

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Conflict of Interest

The authors declare that they have no competing interests.

Authors' Contributions

R.M.Ranagala conceived and designed the study, conducted data collection, developed the Need Assessment and Prioritization Model, analysed the findings and prepared the manuscript. G.S.K.Dharmaratne and S.M.Samarage supervised the research, provided methodological guidance, critically reviewed the manuscript and approved the final version for publication.

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