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RESEARCH ARTICLE

Evaluation of Asset Management Maturity in a Public Hospital: A Context of Limited Resources

Evaluación de la madurez de la gestión de activos en un hospital público: un contexto de recursos limitados

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Abstract

This study aimed to evaluate the asset management maturity of a public hospital through the application of the Asset Management Capability Maturity Model (AMCaMM), aligned with ISO 55000 standards. The objective was to identify critical gaps and propose strategic actions to enhance operational sustainability in resource-limited settings. A cross-sectional study with a descriptive-exploratory approach was conducted, assessing ten key AMCaMM areas through a validated 30-item questionnaire and semi-structured interviews with 24 participants (12 administrators and 12 technicians). The analysis combined descriptive statistics and inductive thematic analysis, supported by Excel® and qualitative coding techniques. The hospital achieved an overall maturity score of 2.73 out of 5, corresponding to a "developing stage." The most critical gaps were found in Operational Planning (2.25) and Corrective/Preventive Actions (1.75), while the highest score was recorded in Management and Commitment (3.25). Key deficiencies included the absence of structured policies, limited technical training, and a lack of technologies such as IoT for real-time monitoring. The AMCaMM proved to be a robust tool for diagnosing asset management performance. These findings can guide similar institutions in resource-constrained environments toward more proactive and efficient asset management practices.

Resumen. Este estudio tuvo como objetivo evaluar la madurez en la gestión de activos de un hospital público mediante la aplicación del Modelo de Madurez en Capacidad de Gestión de Activos (AMCaMM), alineado con los estándares ISO 55000:2024. Se buscó identificar brechas críticas y proponer acciones estratégicas para fortalecer la sostenibilidad operativa en contextos con recursos limitados. Se desarrolló un estudio transversal con enfoque descriptivo-exploratorio, evaluando diez áreas clave del AMCaMM mediante un cuestionario validado de 30 ítems y entrevistas semiestructuradas a 24 participantes (12 directivos y 12 técnicos). El análisis combinó estadística descriptiva y análisis temático inductivo, apoyado por Excel® y técnicas de codificación cualitativa. El hospital presentó un nivel de madurez global de 2.73 sobre 5, correspondiente a una "etapa en desarrollo". Las principales brechas se observaron en Planificación Operativa (2.25) y Acciones Correctivas/Preventivas (1.75), mientras que Gestión y Compromiso obtuvo el puntaje más alto (3.25). Las deficiencias incluyeron ausencia de políticas estructuradas, capacitación técnica limitada y falta de tecnologías como IoT para monitoreo en tiempo real. El AMCaMM demostró ser una herramienta sólida para diagnosticar la gestión de activos. Estos hallazgos pueden orientar a instituciones similares en entornos con recursos limitados hacia prácticas de gestión de activos más proactivas y eficientes.

Keywords: Asset management, ISO 55000, Operational sustainability, Public hospital, Resource Optimization. *(Palabras clave: Gestión de activos, ISO 55000, Sostenibilidad operativa, Hospital público, Optimización de recursos.)*

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1. Introduction

The management of physical assets has evolved from an operational activity to a strategic approach, focused on resource optimization and sustainability. Previous studies have not applied the Asset Management Capability Maturity Model (AMCaMM) framework in public healthcare settings, leaving a gap in understanding how this tool performs in resource-constrained environments. Asset Management Systems (AMS) encompass all stages of the asset lifecycle, from design to decommissioning, establishing themselves as a key tool for modern organizations [1][2].

Efficient physical asset management not only enhances operational performance but also ensures organizational resilience, particularly in public sectors dependent on critical infrastructure such as hospitals, transportation systems, or power plants [3][4]. Strategic decision-making, supported by accurate information and technological tools, is essential for optimizing long-term asset performance. However, in regions like Latin America, studies reveal that asset management faces limitations related to the lack of integrated systems [5][6], insuf-

ficient technological resources, and inadequate data, which adversely affect organizational and social development [7].

The ISO 55000 standard, established in 2014 and updated in 2024, provides an international framework for managing assets sustainably and strategically. It defines asset management as the coordinated activity of an organization to realize value from its assets. This standard consists of three core documents (ISO 55000, ISO 55001, and ISO 55002) that collectively establish the principles, requirements, and guidelines for implementing an Asset Management System (AMS). Its purpose is to help organizations align asset-related decisions with strategic objectives, optimize performance, and ensure continuous improvement throughout the asset lifecycle [8][9][10]. Models such as the PAS 55 standard have demonstrated operational benefits in sectors like manufacturing and public services and also served as the conceptual foundation for the development of the ISO 55000 family of standards [11].

In developing countries, asset management systems often face barriers such as limited resources, lack of standardization, and insufficient technical capacity [12]. Nonetheless, the healthcare sector, particularly in hospitals situated between rural communities, faces significant barriers such as limited funding, technological deficiencies, and lack of training [13]. In this context, the AMCaMM expands upon the principles of ISO 55000 by providing a structured framework to evaluate how effectively organizations implement asset management practices. It assesses maturity across 10 areas (such as organizational management, governance, leadership, planning, information systems, and performance improvement) through standardized scoring criteria. This model helps identify gaps, prioritize improvement actions, and measure progress toward a fully integrated and optimized Asset Management System. In this study, AMCaMM serves as the primary diagnostic tool to determine the maturity level of asset management within a public hospital operating under resource constraints. Additionally, the AMCaMM provides managers, directors, and decision-makers with an immediate strategic overview aligned with the requirements and principles of international standards such as ISO 55000, facilitating evidence-based planning and continuous improvement**.**

In the AMCaMM framework, the maturity level represents the degree to which asset management practices are formalized, integrated, and continuously improved within an organization. Maturity is typically assessed on a five-level scale: Level 1 (Reactive and disorganized), Level 2 (Emerging), Level 3 (Developing), Level 4 (Managed and proactive), and Level 5 (Optimized and continuously improving). Each level reflects the organization's capability to align asset management activities with strategic objectives, supported by evidence, documentation, and performance indicators. This structure allows institutions to identify their current position and define concrete actions for advancement toward higher maturity levels [14][15][16].

Understanding these maturity levels is particularly relevant in public healthcare institutions, where asset management plays a crucial role in operational continuity and service quality. Asset management in public hospitals is especially critical, as it directly impacts the quality of medical services and patient care. The absence of preventive strategies, combined with a reliance on corrective approaches, increases operational costs, shortens equipment lifespans, and limits emergency response capabilities [17]. Additionally, authors such as De Vries *et al*. [18] highlight that a lack of trained personnel and an organizational culture oriented towards sustainability hinder the implementation of proactive practices in these settings.

Technologies such as internet of thinks (IoT), enterprises resources planning (ERP), and specialized software present opportunities to improve asset management in hospitals through preventive maintenance and sustainability strategies [19][20]. However, implementation is often constrained by budgetary limitations and insufficient technical knowledge [21]. These barriers underscore the need for diagnostic tools like the AMCaMM [22], which has proven useful in identifying gaps and proposing solutions across various sectors, although its application in public hospitals remains nascent [23].

This study aims to assess the maturity level of asset management in a public hospital using the AMCaMM [22]. The goal is to identify critical areas for improvement and propose concrete strategies that facilitate a transition towards proactive and sustainable approaches aligned with the principles of the ISO 55000 standard [8]. The findings of this research are expected not only to optimize asset management in the evaluated hospital but also to serve as a reference for institutions in similar contexts, fostering more efficient and resilient healthcare delivery.

2. Materials and Methods

A descriptive-exploratory approach was adopted, focusing on a single case study to evaluate the specific conditions of a public hospital with limited resources. This design facilitated the application of the AMCaMM as a tool to identify critical gaps and areas for improvement, aligned with the ISO 55000 standards [8][22].

2.1 Evaluated areas

The analysis focused on ten key areas: organizational management, leadership and culture, management and commitment, governance and integrated policies, strategic planning, tactical planning, and operational planning, information systems, performance and improvement, and lifecycle optimization of assets. These areas allowed a comprehensive evaluation of the current conditions of the hospital's asset management system and propose substantial improvements that Mexico currently presents [23].

Each evaluated area corresponds to one of the dimensions established by the AMCaMM framework and reflects specific aspects of asset management performance that align with the requirements of ISO 55000, taking into account the strategic framework of the public sector and the influence of previous maturity models**. "**Organizational management" examines the alignment between institutional objectives and asset-related processes; "Leadership and culture" assesses management com-

mitment, staff engagement, and organizational values; "Management and commitment" focuses on the existence of risk and sustainability strategies; "Governance and integrated policies" evaluates the presence of formal policies and accountability structures; "Strategic planning", "tactical planning", and "operational planning" measures the degree of coordination between long-term and day-to-day asset management practices; "Information systems" covers the quality and reliability of data supporting decision-making; "Performance and improvement" reviews monitoring, auditing, and feedback mechanisms; and "Lifecycle optimization" analyzes how assets are managed from acquisition to disposal to maximize value and minimize costs.

2.2 Hospital case study

The Public Hospital, classified as a second-level healthcare facility according to its institutional structure, operates in the municipal seat of Misantla, Veracruz, Mexico. This locality is considered urban according to the classification established by the Instituto Nacional de Estadística y Geografía (INEGI), which defines urban areas as those with 2,500 inhabitants or more and rural areas as those with fewer than 2,500 inhabitants, based on the total population of a locality [24]. However, its strategic location within a municipality surrounded by predominantly rural communities positions it as a critical healthcare hub for dispersed and marginalized populations [24].

In Mexico, rural classification includes localities with small populations or those dominated by primary economic activities such as agriculture, livestock, and fishing [24]. These communities meet rural criteria established by Mexico's INEGI and the Secretaría de Salud: populations under 2,500 inhabitants, geographic dispersion, and limited access to specialized health services [25][26][27]. While the hospital is situated in an urban area, its role transcends this classification by serving as a sanitary reference point for rural populations, aligning with international frameworks such as the Rural Urban Commuting Area (RUCA) and Rural Urban Continuum Codes (RUCC) [28][29].

Data from the *Catálogo de Localidades* by INEGI and the *Atlas de Infraestructura en Salud de México* confirm that the communities served by the hospital meet these rural criteria [26]. Further reports from CONEVAL and the Secretaría de Salud de Veracruz underscore the limited health infrastructure in these areas, reinforcing the hospital's essential role in delivering healthcare services to rural populations [28].

2.3 Data collection

A combination of qualitative and quantitative methods was used to ensure validity and reliability. Data collection involved semi-structured interviews with 24 participants (12 managers and 12 technicians) and a validated 30-item questionnaire. Inclusion criteria included hospital staff involved in asset management, while exclusion criteria eliminated those without direct roles in decision-making. The sample size of 24 participants was deemed sufficient based on the hospital´s organizational structure and availability of relevant personnel. It used a five-level maturity scale (Level 1: Reactive and disorganized; Level 5: Fully integrated and optimized). The instrument underwent a pilot test in a hospital with similar characteristics to ensure clarity and relevance, achieving a Cronbach's alpha coefficient of 0.87, which exceeds the commonly accepted threshold of 0.70, indicating good internal consistency [30].

2.4 Application of the AMCaMM

Between July and November 2024, the AMCaMM was applied to assess each area through specific scores obtained from participants. The model was implemented using a structured questionnaire with a five-point response scale (1 to 5), where each respondent evaluated the organization's performance in every sub-area.

For each main area, the AMCaMM survey defines one or more sub-areas identified by alphanumeric codes. For example, Area A "Organizational Management" includes a single sub-area (A1), while Area B "Leadership and Culture" consists of four sub-areas (B1 to B4) that represent specific evaluation criteria. In contrast, Area F "Performance and Improvement" comprises two sub-areas (F1 and F2). The individual scores of these sub-areas are averaged to obtain the overall value for each main area.

Each sub-area was rated by participants on a five-point scale, where 1 represented Reactive/Disorganized and 5 represented Optimized/Continuously Improving. Individual scores were averaged to determine the maturity level for each sub-area and then aggregated to calculate the mean value for each main area, thereby establishing the overall maturity index of the organization, as presented in Table 1**.** This approach enabled a quantitative comparison across organizational dimensions and facilitated the identification of critical gaps in asset management maturity.

2.5 Data analysis

Quantitative analysis. Questionnaire data were processed using descriptive statistical tools in Excel®. For each sub-area of the AMCaMM survey, the arithmetic mean of individual scores was computed, and these values were subsequently averaged to obtain the corresponding area score (equal weighting). The overall maturity index of the hospital was determined as the arithmetic mean of the ten area scores, quantifying progress across five maturity levels that represent increasingly integrated asset management practices. To characterize data dispersion and enhance reproducibility, the standard deviation (SD) was calculated to quantify the variability of scores around the mean, while the range (min–max) indicated the extent of the spread between the lowest and highest values for each area and sub-area. Analyses were based exclusively on available data; no missing values were imputed. Finally, radar charts were generated to visualize global and area-specific maturity levels, facilitating the identification of critical gaps in asset management performance.

To evaluate the global maturity indicator, the authors proposed a five-level (FL) scale based on the principle of partitioning the measurement domain (maximum level – minimum level). Considering a total range (R) of four points, the Class Interval Width (CIW) was determined according to Equation

(1):

$$CIW = \frac{R}{FL} \quad (1)$$

Using the CIW, the lower limits (LL) and upper limits (UP) of each class were computed according to Equations (2) and (3):

$$LL = 1 + (K-1) \cdot CIW \quad (2)$$

$$UP = 1 + K \cdot CIW \quad (3)$$

where K = {1,2,3,4,5} represents the class number within the five-level maturity scale. A constant value of 0.01 was added to the lower limits of classes 2–5 to avoid ambiguity when assigning the organization's maturity indicator to a specific level.

Based on these calculations, the maturity scale was established, allowing the mapping of both area and global averages to their corresponding AMCaMM reference stages: 1.00–1.80 = Reactive, 1.81–2.60 = Developing, 2.61–3.40 = Managed, 3.41–4.20 = Proactive, and 4.21–5.00 = Optimized. This classification rule allowed positioning the hospital's global value within its corresponding maturity stage and facilitated comparative analysis across evaluated areas.

Qualitative analysis. Interview data were analyzed using an inductive thematic approach [31]. This analysis identified patterns and key themes related to asset management in the hospital. To enhance reliability, questionnaire and interview results were triangulated with prior studies and literature on asset management in the healthcare sector, which contextualized findings and assessed their alignment with international standards.

2.6 Output and limitations

The analysis resulted in a final report detailing maturity levels, critical gaps, and areas for improvement. The report included radar diagrams and practical recommendations, such as implementing preventive policies, adopting continuous monitoring technologies, and developing technical training programs, with a focus on optimizing the hospital's operational sustainability.

This study was conducted in a specific public hospital, which may limit the generalizability of the results to other contexts. However, the findings and proposed strategies can serve as a reference for institutions with similar conditions seeking to improve asset management in resource-constrained environments.

3. Results and Discussion

3.1 General assessment of asset management maturity

The analysis of asset management maturity was conducted using the AMCaMM model [22]. The results show a global maturity indicator of 2.73 out of 5, classifying the hospital at maturity level 3 "Developing.". This suggests that while basic practices are in place, significant gaps persist that compromise operational sustainability. Table 1 presents the average maturity levels by area and subareas. Critical areas include "Operational Planning" (2.25) and "Corrective and Preventive Actions" (1.75), both requiring immediate attention. Conversely, "Management and Commitment" (3.25) achieved the highest scores. A radar chart (Figure 1) provides a visual representation of these key gaps.

3.2 Statistical results from the AMCaMM assessment

The statistical analysis of the AMCaMM assessment shows an average global maturity level of 2.73 out of 5, indicating that asset management practices are partially structured and in a "Developing" (Level 3) stage. The standard deviation (0.72) and coefficient of variation (26.4%) suggest moderate dispersion, reflecting heterogeneous performance among the evaluated dimensions.

The analysis of the sub-areas reveals a wide dispersion in the results, indicating significant differences in the degree of maturity among the various evaluated components. In particular, the sub-areas with the highest variability, corrective and preventive actions (CV = 54.9%) and asset performance monitoring (CV = 46.5%), reflect operational instability and a lack of standardized processes. Conversely, the lower dispersion observed in sustainability management (CV = 14.9%) and risk management (CV = 16.9%) suggests more consolidated practices in terms of environmental sustainability and social responsibility.

Regarding the analysis by areas, the distribution of averages shows a progressive imbalance between strategic and operational domains. Areas related to strategic governance, leadership, and sustainability (C1, B, and F) display relatively higher means ($\geq$2.87) and lower variability (CV < 25%), indicating a more consistent managerial and institutional commitment. In contrast, planning-related areas (D1–D3) exhibit lower averages (2.25–2.58) and coefficients of variation exceeding 30%, revealing fragmentation and a predominance of reactive practices in maintenance and decision-making processes.

Overall, the results indicate a developing but uneven maturity profile, characterized by progress in leadership and governance but persistent weaknesses in planning and data-driven operational control. These findings provide a quantitative foundation for the subsequent area-specific analysis.

3.3 Analysis by evaluation areas

In Organizational Management (A: 2.50/5), a basic administrative structure is identified with limited strategic alignment to organizational objectives. Implementing structured plans that connect strategic and operational goals is recommended to improve organizational efficiency [10]. In Leadership and Culture (B: 2.87/5), strengths include leadership (3.25) and organizational competencies (3.25) but change management (2.25), reflects resistance to continuous improvement. Training leaders in change management techniques and adopting standardized processes is key to overcoming this barrier [32].

Management and Commitment (C1: 3.25/5) shows strengths in sustainability (3.50) and risk management (3.25), although communication with community stakeholders (3.00) is insufficient. Strengthening dialogue through inclusive engagement strategies is suggested to consolidate these achievement [11]. Governance and Integral Policy (C2: 2.75/5) reveals a lack of structured policies that limit comprehensive asset management, highlighting regulatory deficiencies, as illustrated in

Table 1. Descriptive Statistics and Global Maturity Level Indicator

Area	Sub-areas	Average	SD	Range	CV (%)
A: Organizational management	A1: Organizational management	2.5	0.72	2.25	28.8
Area A		2.5	0.72	2.25	28.8
B: Leadership and culture	B1: Leadership	3.25	0.58	2.00	17.8
	B2: Change management	2.25	0.85	2.75	37.8
	B3: Organizational competencies	3.25	0.62	2.50	19.1
	B4: Organizational culture	2.75	0.68	2.25	24.7
Area B		2.87	0.68	2.38	23.7
C1: Management and commitment	C1.1: Risk Management	3.25	0.55	2.00	16.9
	C1.2: Sustainability management	3.5	0.52	2.00	14.9
	C1.3: Stakeholder engagement strategy	3.25	0.6	2.25	18.5
	C1.4: Engagement level strategy	3.25	0.58	2.25	17.8
	C1.5: Addressing community concerns	3	0.65	2.25	21.7
Area C1		3.25	0.58	2.15	17.8
C2: Governance and integral policy	C2.1: Comprehensive governance policy framework	2.5	0.78	2.50	31.2
	C2.2: Corporate governance	3	0.67	2.50	22.3
Area C2		2.75	0.73	2.50	26.5
D1: Strategic planning	D1.1: Asset management policy	3	0.71	2.50	23.7
	D1.2: Asset management objectives	2.5	0.76	2.50	30.4
	D1.3: Asset management strategy	2.25	0.82	2.50	36.4
Area D1		2.58	0.76	2.50	29.5
D2: Tactical planning	D2.1: Asset acquisition plan	3	0.69	2.50	23
	D2.2: Asset operational plan	2.5	0.74	2.50	29.6
	D2.3: Asset maintenance plan	2.25	0.88	2.75	39.1
	D2.4: Asset disposal plan	2.5	0.79	2.75	31.6
Area D2		2.56	0.78	2.62	30.5
D3: Operational planning	D3.1: Asset performance monitoring	2	0.93	2.75	46.5
	D3.2: Corrective and preventive actions	1.75	0.96	2.50	54.9
	D3.3: Acquisition strategies and processes	3	0.7	2.50	23.3
Area D3		2.25	0.86	2.58	38.2
E: Information system and support	E1: Data management	2.75	0.71	2.25	25.8
	E2: Asset registry	3.25	0.61	2.50	18.8
	E3: Asset information systems	2.75	0.73	2.50	26.5
	E4: Relational knowledge management	2.5	0.8	2.50	32
Area E		2.81	0.71	2.43	25.3
F: Performance and improvement	F1: Performance evaluation	3	0.68	2.25	22.7
	F2: Audits	2.75	0.74	2.25	26.9
Area F		2.87	0.71	2.25	24.7
G: Lifecycle optimization	G1: Outcome measurement	3.25	0.63	2.50	19.4

Note: SD = Standard deviation; CV = Coefficient of variation; Range = Difference between the highest and lowest observed values.

Figure 1. In this regard, developing policies aligned with ISO 55000:2024 standards are recommended [33].

In Strategic, Tactical, and Operational Planning (D: 2.25–2.58/5), issues include reactive asset management and a lack of preventive strategies. Implementing preventive maintenance and IoT technologies can optimize performance and reduce costs [17].

In Information Systems and Support (E: 2.81/5), asset registry (3.25) is a strength, but relational knowledge management (2.50) is deficient. It is essential to adopt technological tools aligned with ISO 55000 to ensure data-driven decision-making [20]. Regarding Performance and Improvement (F: 2.87/5), while Performance Evaluation achieved a significant score of 3.00, Audits (2.75) need strengthening to ensure a continuous improvement process in asset management [34]. Finally, in Results and Lifecycle Optimization (G: 2.87/5), outcome measurement (3.25) is adequate, but optimization (2.50) shows deficiencies in cost-benefit analysis. Developing strategies that include comprehensive evaluations throughout the asset lifecycle will enhance operational sustainability.

3.4 Identified gaps

The hospital's asset management system faces critical challenges that undermine its efficiency and operational sustainability. A primary gap is the reliance on reactive practices, driven by the absence of structured plans across operational, tactical, and strategic levels. This reliance increases costs and diminishes the effectiveness of asset management processes. Additionally, insufficient technical training perpetuates a reac-

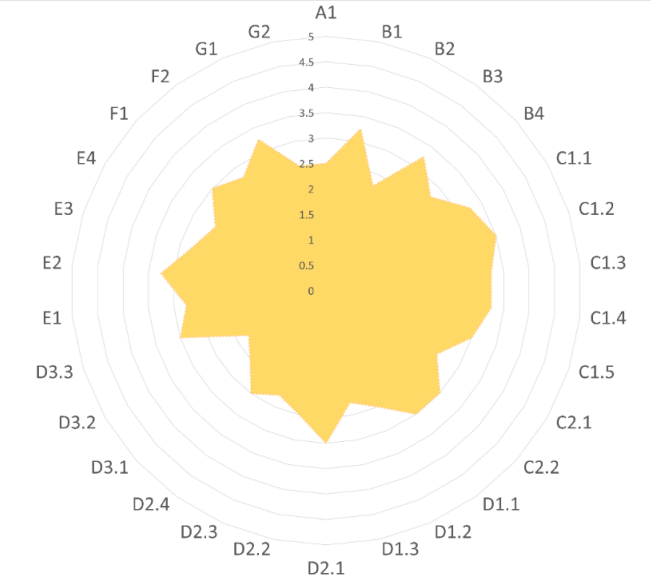

Figure 1. Maturity level across sub-areas. Note: Alphanumeric codes are used to identify the sub-areas in the control radar displayed in Figure 1.

tive approach, further shortening the lifespan of critical equipment. Budgetary constraints exacerbate these issues, limiting the adoption of advanced technologies such as IoT and real-time monitoring tools, which are essential for enhancing asset performance and ensuring long-term sustainability.

Furthermore, deficiencies in leadership, the absence of clear strategies, and insufficient monitoring reinforce the need for a more structured approach. Table 2 and Table 3 summarize these gaps and the factors affecting them.

These results highlight the need to implement a comprehensive model based on preventive planning, technical training, and the use of advanced technologies to enhance operational sustainability and improve service quality.

Strategic plans

To address the gaps in asset management, key strategies are proposed (Table 4). Implementing preventive maintenance plans will reduce dependence on reactive practices by including regular inspections and resource allocation. Staff training will enhance competencies in fault identification and preventive maintenance, fostering a proactive approach. The adoption of advanced technologies, such as IoT systems for real-time monitoring, will optimize the functionality and availability of assets. These actions will transform asset management into a strategic and sustainable model.

4. Discussion

The study results reveal a medium maturity level in asset management at the public hospital, reflecting gaps like those reported in previous research. Similar studies conducted in healthcare and infrastructure sectors support the findings of this research. In Colombia, a Publicly Available Specification 55 (PAS 55) based model applied in hospitals reported medium maturity levels, emphasizing weaknesses in preventive maintenance, asset inventories, and policy integration conditions comparable to those found in this study [11].

Other reviews on maturity models observed that most public institutions in developing countries remain at “emerging” or “developing” stages due to insufficient training and lack of standardized asset management practices [12]. Mahmood *et al*. [15], proposed an integrated approach that bridges technical, human, and organizational dimensions through the AMCaMM, addressing the limitations of earlier frameworks such as PAS 55 and Capability Maturity Model Integration (CMMI). The present study operationalizes that conceptual proposal in a real public healthcare environment, extending its practical application to a sector characterized by resource constraints and operational complexity.

Tarhan *et al*. [39], emphasized that, although numerous maturity models have been developed for healthcare, the majority focus on information systems or digital transformation rather than on physical asset management. This reinforces the originality and relevance of applying the AMCaMM in hospital settings, where infrastructure reliability and equipment availability are critical for service continuity. In parallel, Myrberg *et al*. [40], demonstrated that maturity models are effective tools to support continuous improvement in hospital operations (particularly in capacity and demand management) by aligning operational processes with organizational goals. These findings echo the improvement opportunities identified in the present study, including the need for better planning, leadership commitment, and data-driven decision-making in asset management.

Moreover, the integration of digital technologies into maturity-assessment tools, as evidenced by Abideen *et al*. [41], highlights the potential for combining frameworks like AMCaMM with digital solutions such as Building Information Modeling (BIM) or Internet of Things (IoT) platforms to enhance preventive maintenance, traceability, and sustainability. Likewise, aligning maintenance processes with ISO 55000 has been shown to significantly enhance operational performance, consistent with the need for structured policies and proactive planning identified in the evaluated hospital [1].

Furthermore, several studies highlight that organizational culture, leadership commitment, and limited resources are critical barriers to achieving higher maturity levels in public institutions [34]. This situation is even more evident in Latin American contexts, where structural and financial constraints have historically limited the institutional capacity to implement modern asset management systems [4]. These comparisons confirm that the hospital’s maturity level (2.73/5, “developing”) aligns with similar studies and underscores the practical relevance of applying the AMCaMM framework in resource-constrained healthcare settings.

Hospitals in developing countries face challenges such as limited access to medical equipment, dependence on corrective maintenance, and budgetary constraints issues consistent with the deficiencies identified in this case [13] [21] [23]. The lack of trained personnel and the prevalence of reactive ap-

Table 2. Critical gaps and their impacts

Evaluated area	Maturity level		Identified gap
	Observed	Ideal	
Global planning	Low	High	Lack of a strategy to manage the asset lifecycle.
Relational training	Low	Medium	Untrained personnel unable to integrate effective actions.
Optimization	Low	Medium	Absence of cost-benefit evaluations in the asset lifecycle.
Change management	Very Low	Medium	Dependence on reactive actions due to a lack of standardized processes.
Asset performance monitoring and condition	Very Low	High	Obsolete equipment and lack of real-time monitoring technologies.
Corrective and preventive actions	Very Low	High	Reliance on corrective maintenance and inadequate documentation.
Comprehensive policy framework and objectives in asset management	Low	High	Poor integration of stakeholders due to a lack of committed leadership and clear objectives.

Table 3. Identification of critical factors

Critical factor	Description	Impact on operations
Equipment availability	Frequent inactivity of critical equipment due to lack of maintenance or obsolescence.	Disrupts the continuity of patient services.
Maintenance costs	Increased costs due to the absence of preventive strategies.	Reduces resources available for priority areas.
Staff training	Personnel lacking theoretical/ technical knowledge in asset management.	Limits the implementation of strategic practices.
Technology utilization	No implementation of digital tools for monitoring and maintenance.	Hinders efficient management and prediction of critical failures.
Limited resources	Resources are not allocated according to needs.	Encourages reactive approaches and increases the risk of critical failures.
planning and continuous improvement	Inadequate performance tracking and poor alignment between organizational objectives and strategic, tactical, and operational plans.	Generate operational inefficiencies and reactive actions to unexpected failures or changes.

Table 4. Strategic Plan for improving asset management in hospitals with limited resources

Improvement area	Objective	Strategies and actions	Indicators
Global planning	Implement an asset management system to optimize resources and asset availability	Develop a strategy to implement the system all strategic, tactical, and operational levels.	Global maturity index
		Assign responsible personnel to supervise plans.	N/A
		Monitor and adjust plans monthly to evaluate performance.	Implementation of performance indicators.
Training and human resources	Increase staff qualifications in asset	Implement a training program in asset management for key personnel.	Number of training sessions conducted.
		Prioritize training in fault identification and preventive maintenance.	% of staff trained in fault identification.
Equipment maintenance and infrastructure	Develop preventive protocols for hospital maintenance	Create preventive protocols with weekly inspections of infrastructure and equipment.	Number of preventive inspections conducted.
		Allocate specific budgets and collaborate with local suppliers to reduce costs.	N/A
Service delivery	Increase the availability of critical equipment and reduce downtime.	Optimize critical equipment management through inventories, downtime analysis, and schedule maintenance.	Critical equipment availability rate. Service quality index.
		Implement an internal loan system between departments for critical equipment.	Average downtime of equipment.

proaches compromise operational sustainability. The absence of retention strategies for skilled personnel exacerbates asset management challenges, underscoring the need to strengthen strategic planning and performance evaluation practices [18].

The absence of strategic indicators to optimize asset management was also observed, aligning with prior studies that highlight how a lack of organizational culture and planning increases operational costs and reduces the availability of critical equipment, ultimately affecting service quality [35]. Preventive maintenance and continuous monitoring models, proven effective in sectors such as highways and energy [36] [37], remain uncommon in public hospitals due to financial and technical constraints [23] [38]. However, this study confirms their transformative potential in such contexts [38].

The findings highlight the need for evidence-based maintenance management and emphasize the urgency of implementing sustainable and holistic policies to enhance asset management in resource-constrained public hospitals [19].

5. Conclusions

This study demonstrates that asset management in public hospitals faces significant challenges, evidenced by an overall maturity level of 2.73 out of 5, classifying the hospital in a "developing" stage. While basic practices have been implemented, gaps persist, limiting operational sustainability and service quality. Optimizing key areas such as strategic planning, preventive maintenance, and the adoption of advanced technologies is essential for achieving more efficient asset management.

Public hospitals face unique challenges due to inadequate funding, technological deficiencies, and limitations in staff technical training. These factors increase reliance on reactive approaches, shortening the lifespan of assets and negatively impacting the quality of medical services.

The application of the AMCaMM identified gaps such as the absence of structured policies, deficiencies in asset lifecycle planning, and a limited organizational culture. The results emphasize the importance of adopting a strategic and proactive approach.

Alignment with the ISO 55000 standard underscores the value of leveraging international frameworks. Furthermore, future studies are encouraged to incorporate the Sustainable Development Goals (SDGs) related to health (SDG 3) and responsible consumption (SDG 12). Additionally, evaluating the impact of emerging technologies, such as artificial intelligence, to further enhance asset management, along with continuous training programs to strengthen leadership and foster an organizational culture focused on continuous improvement, is recommended.

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8. Author Contributions (CRediT)

Conceptualization, M.A.A.M.; Methodology, L.E.G.S. and Y.B.P.; Investigation, M.A.A.M., L.E.G.S., and Y.B.P.; Data curation, D.R.G.; Formal analysis, M.A.A.M. and L.E.G.S.; Validation, L.E.G.S. and Y.B.P.; Visualization, M.A.A.M.; Writing – original draft, M.A.A.M., L.E.G.S., and Y.B.P.; Writing – review & editing, A.A.LL. and D.R.G.; Supervision, A.A.LL.

9. Conflict of Interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and / or publication of this article

10. Data Availability Statement

The data are available from the corresponding author upon reasonable request.

11. Bioethics

The study was approved by the Ethics Committee of Tecnológico Nacional de México, Campus Misantla, and all personal data were treated confidentially in accordance with applicable data protection regulations.

12. Artificial Intelligence Use Disclosure

Generative AI tools were used solely for grammar and language editing support. All scientific content, analysis, and conclusions are the exclusive responsibility of the authors.

13. References

[1] P. Okoh, P. Schjølberg, and A. Wilson, "AMMP: A new maintenance management model based on ISO 55000," Infrastruct. Asset Manag., vol. 3, no. 1, pp. 21–28, 2016. [Online]. Available: https://www.researchgate.net/publication/291165766_AMMP_a_new_maintenance_management_model_based_on_ISO_55000

[2] A. Sola-Rosique and A. Crespo-Marquez, "Marco de referencia para la gestión de activos de alta capitalización: definición de procesos de negocio y de técnicas avanzadas de soporte a la gestión," Universidad de Sevilla, 2017. [Online]. Available: http://hdl.handle.net/11441/64008

[3] E. Gavrikova, I. Volkova, and Y. Burda, "Strategic aspects of asset management: an overview of current research," Sustainability, vol. 12, no. 15, art. no. 5955, 2020, doi: https://doi.org/10.3390/su12155955

[4] M. García-Mejía, A. Pareja, and P. Farias, Nuestra riqueza inexplorada: hacia una gestión moderna de los activos públicos. Banco Interamericano de Desarrollo, 2021. [Online]. Available: https://publications.iadb.org/es/nuest

ra-riqueza-inexplorada-hacia-una-gestion-moderna-de-los-activos-publicos

[5] M. Aruna, U. Gunasilan, and S. Naeem, "Efficient equipment management for biomedical engineering department in the hospital," Int. Rev. Manag. Mark., vol. 8, no. 3, pp. 69–74, 2018. [Online]. Available: https://www.proquest.com/openview/024dbc7e848855be27aabdc71313a5c9/1?pq-origsite=gscholar&cbl=816339

[6] CEPAL, Estudio económico de América Latina y el Caribe 2019. El nuevo contexto financiero mundial: efectos y mecanismos de transmisión en la región. CEPAL, 2019. [Online]. Available: https://www.cepal.org/es/publicaciones/44674-estudio-economico-america-latina-caribe-2019-nuevo-contexto-financiero-mundial

[7] W. M. Mendoza-Zamora, T. García-Ponce, M. I. Delgado-Chávez, and I. M. Barreiro-Cedeño, "Internal control and its influence on the administrative management of the public sector," Dominio Cienc., vol. 4, no. 4, pp. 206–240, 2018, doi: https://doi.org/10.23857/dc.v4i4.835

[8] International Organization for Standardization (ISO), Gestión de activos. Sistemas de gestión. ISO 55000:2024. Ginebra, Suiza, 2024. [Online]. Available: https://www.iso.org/standard/83053.html

[9] F. Márquez-Artola, A. Alfonso-Llanes, and Y. Borroto-Pentón, "Evaluación de la gestión de activos a partir de la ISO 55000," Universidad Central "Marta Abreu" de las Villas, 2015. [Online]. Available: https://dspace.uclv.edu.cu/items/73f875f9-c394-477a-b893-deabcf1f4939

[10] T. A. Depool-Malavé, "Mejora de la gestión de activos físicos según PAS 55 - ISO 55000 evaluando el desempeño de los roles del marco de competencias del IAM," Ph.D. dissertation, Universitat Politècnica de València, 2015, doi: https://doi.org/10.4995/Thesis/10251/57047

[11] B. J. Galeano, N. Escobar, D. Cuartas, and J. C. Botero, "Modelo integrado de gestión de activos hospitalarios basado en la PAS 55," Rev. Ing. Biomédica, vol. 9, no. 18, pp. 95–102, 2015. [Online]. Available: http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S1909-97622015000200011

[12] I. Ibrahim, U. B. Sa'ad, D. Daud, H. U. Yaro, and R. Bello, "Asset management performance benchmarking: a maturity model review," Int. J. Sci. Eng. Res., vol. 5, no. 9, 2021. [Online]. Available: https://ijses.com/wp-content/uploads/2021/10/57-IJSES-V5N9.pdf

[13] S. H. Kabeta, T. K. Chala, and F. Tafese, "Medical equipment management in general hospitals: experience of Tulu Bolo General Hospital, South West Shoa Zone, Central Ethiopia," Med. Devices Evid. Res., vol. 16, pp. 57–70, 2023. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/36959832/

[14] Global Forum on Maintenance and Asset Management (GFMAM), Asset Management Maturity – A Position Statement, 1st ed. GFMAM, 2015. [Online]. Available: https://gfmam.org/sites/default/files/2019-08/GFMAM_ASSET%20MANAGEMENT%20MATURITY_FIRST%20EDITION_ENGLISH%20VERSION.pdf

[15] M. N. Mahmood, S. Dhakal, A. Wiewiora, K. Brown, and R. Keast, "A comparative study on asset management capability maturity models," Int. J. Strategic Eng. Asset Manag., vol. 2, no. 4, pp. 328–347, 2015. [Online]. Available: https://www.inderscienceonline.com/doi/abs/10.1504/IJSEAM.2015.075412

[16] M. García-Mejía, F. Aguirre, P. Brankevich, B. Roseth, and S. Naranjo, Public Asset Management Maturity Assessment, Inter-American Development Bank, Technical Note No. IDB-TN-3010, 2024. [Online]. Available: https://publications.iadb.org/en/public-asset-management-maturity-assessment

[17] A. Badnjevic, "Evidence-based maintenance of medical devices: current shortage and pathway towards solution," Technol. Health Care, vol. 31, no. 1, 2023, doi: https://doi.org/10.3233/THC-229005

[18] N. De Vries, O. Lavreysen, and A. Boone, "Retaining healthcare workers: a systematic review of strategies for sustaining power in the workplace," Healthcare, vol. 11, no. 13, art. no. 1887, 2023. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/37444721/

[19] C. K. M. Lee, C. M. Na, and N. C. Kit, "IoT-based asset management system for healthcare-related industries," Int. J. Eng. Bus. Manag., vol. 7, 2015, doi: https://doi.org/10.5772/61821

[20] M. Saputra, I. Hermawan, W. Puspitasari, and A. Almaarif, "How to integrate enterprise asset management system for smart hospital: a case study," in Proc. 7th Int. Conf. ICT Smart Soc. (ICISS), IEEE, 2020. [Online]. Available: https://ieeexplore.ieee.org/document/9307535

[21] S. Eze, W. Ijomah, and T. C. Wong, "Accessing medical equipment in developing countries through remanufacturing," J. Remanufact., vol. 9, no. 3, pp. 207–233, 2019, doi: https://doi.org/10.1007/s13243-018-0065-7

[22] Asset Institute, "Asset management capability maturity assessment survey tool and guide." [Online]. Available: https://assetinstitute.com/asset-management-capability-maturity-assessment-survey-tool-and-guide/

[23] C. P. Quiroz-Flores, "La gestión de equipo médico en los retos del Sistema Nacional de Salud: una revisión," Rev. Mex. Ing. Bioméd., vol. 41, no. 1, pp. 141–150, 2020, doi: https://doi.org/10.17488/RMIB.41.1.11

[24] Instituto Nacional de Estadística, Geografía e Informática (INEGI), "Población rural y urbana." [Online]. Available: https://cuentame.inegi.org.mx/poblacion/rur_urb.aspx?tema=P

[25] Comité Estatal de Información Estadística y Geográfica de Veracruz (CEIEGV), "Cuadernillos Municipales 2021. Misantla," SIEGVER, 2021. [Online]. Available: http://ceieg.veracruz.gob.mx/wp-content/uploads/sites/21/2021/06/MISANTLA_2021.pdf

[26] Instituto Nacional de Estadística, Geografía e Informática (INEGI), "Sistemas de consulta." [Online]. Available: https://gaia.inegi.org.mx/mdm6/?v=bGF0OjIwLjAwMjgzLGxvbjotOTYuNjQ0OTIsejo4LGw6YzExMXNlcnZpY2lvc3x0MTExc2VydmljaW9z

[27] Servicios de Salud de Veracruz (SESVER), "Hospital Regional de Misantla." [Online]. Available: https://www.ssaver.gob.mx/buscar/#gsc.tab=0

[28] Consejo Nacional de Evaluación de la Política de Desarrollo Social (CONEVAL), "Pobreza Rural en México." [Online]. Available: https://www.coneval.org.mx/Medicion/MP/Documents/PATP/Pobreza_rural.pdf

[29] B. E. Pelcastre-Villafuerte, S. Meneses-Navarro, H. Reyes-Morales, and J. Á. Rivera-Dommarco, "The health of indigenous peoples: challenges and perspectives," Salud Publica Mex., vol. 62, no. 3, pp. 235–236, 2020. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/32520480/

[30] K. Imasuen, "Sample size determination in test-retest and Cronbach alpha reliability estimates," Br. J. Contemp. Educ., vol. 2, no. 1, pp. 17–29, 2022. [Online]. Available: https://abjournals.org/bjce/wp-content/uploads/sites/20/journal/published_paper/volume-2/issue-1/BJCE_FY266HK9.pdf

[31] V. Braun and V. Clarke, "Reflecting on reflexive thematic analysis," Qual. Res. Sport Exerc. Health, vol. 11, no. 5, pp. 589–597, 2019, doi: https://doi.org/10.1080/2159676X.2019.1628806

[32] M. Jaafar, N. A. A. Salim, and N. M. Salleh, "Developing a framework for fire safety management plan: the case of Malaysia's public hospital buildings," Int. J. Build. Pathol. Adapt., vol. 41, no. 4, pp. 713–733, 2023, doi: https://doi.org/10.1108/IJBPA-04-2021-0060

[33] H. Dion, M. Evans, and P. Farrell, "Hospitals management transformative initiatives: towards energy efficiency and environmental sustainability in healthcare facilities," J. Eng. Des. Technol., vol. 21, no. 2, pp. 552–584, 2023, doi: https://doi.org/10.1108/JEDT-04-2022-0200

[34] D. Maletič, N. Marques de Almeida, B. Gomišček, and M. Maletič, "Understanding motives for and barriers to implementing asset management system: an empirical study for engineered physical assets," Prod. Plan. Control, vol. 34, no. 15, pp. 1497–1512, 2023, doi: https://doi.org/10.1080/09537287.2022.2026672

[35] J. L. Sandoval-Gutiérrez, "Proyección en el sector salud 2018-2024, análisis y consecuencias," Rev. Med. Inst. Mex. Seguro Soc., vol. 58, no. 2, pp. 5–9, 2021. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/34101550/

[36] O. Alshboul, A. Shehadeh, and O. Hamedat, "Development of integrated asset management model for highway facilities based on risk evaluation," Int. J. Constr. Manag., vol. 23, no. 8, pp. 1355–1364, 2023, doi: https://doi.org/10.1080/15623599.2021.1972204

[37] M. Mirhosseini and F. Keynia, "Asset management and maintenance programming for power distribution systems: a review," IET Gener. Transm. Distrib., vol. 15, no. 16, pp. 2287–2297, 2021, doi: https://doi.org/10.1049/gtd2.12177

[38] E. Rogan and J. Lewis, "Rural health care: big challenges require big solutions," AHA News, Jan. 2020. [Online]. Available: https://www.aha.org/news/insights-and-analysis/2020-01-28-rural-health-care-big-challenges-require-big-solutions

[39] A. Tarhan, V. Garousi, O. Turetken, M. Söylemez, and S. Garossi, "Maturity assessment and maturity models in healthcare: a multivocal literature review," Digital Health, vol. 6, art. no. 2055207620914772, 2020, doi: https://doi.org/10.1177/2055207620914772

[40] K. Myrberg, M. Wiger, and A. Björkman, "Development of a maturity model for demand and capacity management in healthcare," BMC Health Serv. Res., vol. 24, art. no. 1109, 2024, doi: https://doi.org/10.1186/s12913-024-11456-4

[41] D. K. Abideen, A. Yunusa-Kaltungo, C. Cheung, and P. Manu, "Development and evaluation of a maturity assessment tool for integrating building information modelling into operations and maintenance phase of buildings," Dev. Built Environ., vol. 95, art. no. 110417, 2025, doi: https://doi.org/10.1016/j.dibe.2025.100619