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Original Article

Developing a maturity-level model for interprofessional collaboration in elective surgery preparation

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Abstract

Interprofessional collaboration plays a crucial role in the preparation for elective surgeries to enhance the quality, safety, and efficiency of patient care. However, its implementation continues to encounter substantial obstacles, which require the creation of a customized maturity model to effectively resolve these concerns. The aim of this study was to develop an interprofessional collaboration maturity model that is specifically designed for the context of elective surgery preparation. This qualitative study employed a case study approach, conducted in 2024. This maturity model was developed through four stages: (1) a literature study to identify key interprofessional collaboration indicators in surgery; (2) in-depth interviews with ten healthcare professionals at Universitas Muhammadiyah General Hospital, Malang, Indonesia; (3) adaptation of existing maturity models (Fleming, Hudson, collaboration maturity model, and quality management system) as a framework for synthesizing data from the findings of stage 2 (in-depth interviews); and (4) expert panel review to evaluate the maturity model. We successfully developed an interprofessional collaboration maturity model specifically applied to elective surgery preparation, Preoperative Interprofessional Collaboration Maturity Model (P-ICMM), consisting of five maturity levels: emerging, developing, coordinated, integrated, and optimized. Each level's assessment criteria are based on indicators of interprofessional collaboration. This maturity model has been evaluated by the experts in elective surgery preparation to ensure its validity and applicability. This maturity model is expected to help hospitals identify the level of interprofessional collaboration, design strategies to enhance collaboration, and ultimately improve the quality of healthcare services and patient safety in the preparation for elective surgeries.

Keywords: Interprofessional collaboration, maturity model, elective surgery preparation, patient safety, P-ICMM

Introduction

Interprofessional collaboration (IPC) is fundamental to ensure the success of medical procedures, particularly in the preparation for elective surgery. Effective IPC enhances the quality, safety, and efficiency of patient care [1,2], reduces hospital stay duration, improves interprofessional communication and satisfaction [3,4], and fosters active engagement among healthcare professionals [5]. Despite the widely acknowledged importance of IPC, its

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implementation remains challenged by interpersonal and systemic barriers, including hierarchical power dynamics, role ambiguity, and inconsistent objectives across disciplines [6].

A significant gap in the standardization of IPC implementation in elective surgery preparation further complicates the coordination of roles and responsibilities among healthcare professionals. The absence of a universally accepted framework leads to variability in collaboration practices, ultimately affecting patient outcomes [7]. Addressing these challenges requires a structured approach that assesses and enhances IPC effectiveness. Maturity models have been widely applied in various industries to evaluate and improve processes systematically. For instance, the Fleming maturity model has been utilized in offshore oil and gas industries [8], while the Hudson maturity model has been implemented in aviation, manufacturing, and energy sectors [9]. The Collaboration Maturity Model (CollabMM) is commonly used in business and software development [10], and the quality management system (QMS) maturity model has been integrated into diverse industries [11,12]. However, these models primarily focus on operational quality and safety management, often overlooking key aspects of IPC such as communication, teamwork, and role delineation in healthcare settings.

To bridge this gap, we adapted concepts from existing maturity models and integrated them with IPC determinants to develop a novel maturity model tailored specifically for IPC in elective surgery preparation. The framework is informed by organizational behavior theory, which offers insights into individual, team, and organizational dynamics that influence IPC effectiveness [13]. The aim of this study was to develop an IPC maturity model that was specifically designed for the context of elective surgery preparation. The model is expected to provide hospitals with practical advice on how to identify the level of IPC maturity, develop strategies for IPC improvement and enhancement across professions, and improve the quality of healthcare services and patient safety in the preparation of elective surgery.

Methods

Study design and setting

A qualitative case study was conducted at Universitas Muhammadiyah General Hospital, Malang, Indonesia, to analyze IPC in the preparation of elective surgeries. This study used a qualitative method with a case study approach [14]. This method concentrates on the factors or indicators that influence IPC, making it a viable foundation for the development of the IPC maturity model. The study began with the first stage, performing a literature study to design a framework that will serve as the basis for further analysis, in accordance with the exploratory case study approach [15-17]. In the second stage, in-depth interviews with healthcare professionals involved in elective surgery preparation were conducted using case study principles, guided by the first-stage framework. The third stage involved adapting existing maturity models and developing a new model based on interview findings. In the fourth stage, experts reviewed the model to validate its reliability and relevance in IPC.

Development of the maturity model

The development process consisted of four stages. In stage 1, a literature study was conducted to identify key indicators and their interrelationships in IPC practices within surgical settings. These findings formed the initial framework that guided the qualitative data collection process through in-depth interviews.

Stage 2 involved conducting in-depth interviews with ten healthcare professionals at Universitas Muhammadiyah General Hospital, Malang, Indonesia, including surgeons, anesthesiologists, internists, clinical pathologists, radiologists, nurses, nutritionists, pharmacists, and case managers. The selection of these professionals was carefully considered based on a previous study [18]. The interviews explored IPC practices, challenges, and key determinants, generating empirical data for model development.

In stage 3, the model was refined by adapting well-established maturity models that had been widely recognized in the safety culture approach and applied across various industries. These included the Fleming maturity model [8], Hudson maturity model [9], CollabMM [10], and QMS [11,12] models. The adaptation process involved assessing the objectives, scope, assessment

criteria, and limitations of these models to identify gaps in IPC implementation. Model development followed a structured four-phase approach [19,20]: (1) defining the scope of IPC in elective surgery preparation; (2) establishing assessment indicators from empirical data; (3) conceptualizing the maturity framework; and (4) validating the model. The application of adapted maturity models for healthcare contexts has been demonstrated in previous studies [21-24].

Stage 4 involved expert panel reviews, which evaluated the model's assessment indicators at each maturity level. The refined model provided the foundation for developing a structured questionnaire to assess IPC in elective surgery preparation. Future studies employing a mixed-methods framework were expected to further validate the tool. A schematic diagram of the research procedure is presented in **Figure 1**.

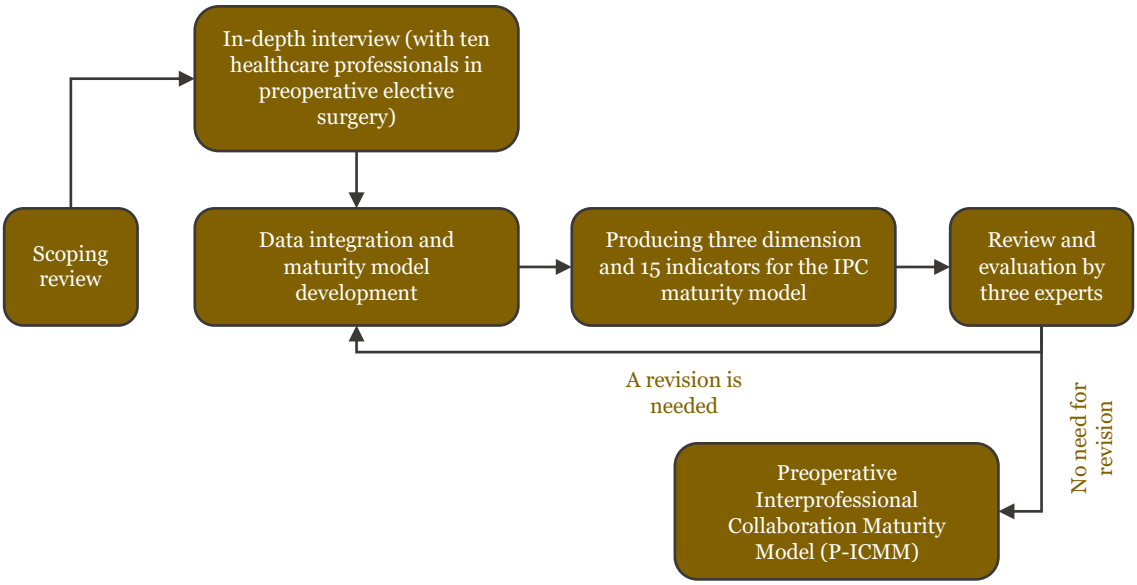

Figure 1. Schematic diagram illustrating the four-stage development process of the Preoperative Interprofessional Collaboration Maturity Model (P-ICMM).

Literature study

The literature study aimed to identify factors influencing IPC in the context of elective surgery preparation. A systematic literature search was performed in ProQuest, Scopus, and ScienceDirect, focusing on English-language articles published between 2017 and 2023. The search strategy incorporated the following keywords: ("hospital" OR "healthcare" OR "surgery process" OR "surgical") AND ("interprofessional collaboration") AND ("implementation" OR "practice"). Studies were screened for relevance based on title and abstract, followed by full-text assessment. Data extraction focused on identifying key determinants of IPC in elective surgery preparation, including structural, organizational, and communication-related factors. The findings from the selected studies were synthesized to highlight recurring themes and barriers affecting IPC.

Data collection through in-depth interviews

Data collection was conducted through in-depth interviews with ten respondents from different healthcare professions, all selected based on their direct involvement in elective surgery and a minimum of three years of professional experience. Respondents included two nurses and one professional from each of the following roles: surgeon, anesthesiologist, internist, clinical pathologist, radiologist, nutritionist, pharmacist, and case manager. Purposive sampling was employed to ensure the inclusion of individuals with relevant expertise.

The interviews explored factors influencing IPC in elective surgery preparation and how IPC was operationalized within the hospital setting. Each interview was conducted in a private space, involving only the respondent and the researcher, to ensure confidentiality and minimize external influence. Interviews lasted between 30 and 60 minutes and followed a structured interview guide designed to facilitate consistency while allowing flexibility for in-depth discussions. To ensure

data integrity, all interviews were recorded using two separate devices as a safeguard against technical issues. Audio recordings were securely stored in a restricted-access database available only to the research team.

Data analysis followed an inductive thematic approach. All interviews were transcribed verbatim in Indonesian to preserve linguistic accuracy and prevent loss of meaning. Transcribed data was systematically imported, organized, and coded using NVivo 12, following the framework outlined by Miles *et al.* [25,26]. The coding process incorporated open coding with categories such as evaluative, process, descriptive, and emotional codes. Codes with similar meanings, such as "miscommunication" and "canceled surgery," were grouped under broader indicators like "collaboration." This process was applied across all transcripts, and emerging indicators were subsequently classified according to organizational behavior theory, distinguishing factors at the individual, team, and organizational levels [27,28].

The study adhered to established methodological standards to ensure credibility, dependability, confirmability, and transferability [29]. Credibility was maintained by having interviews conducted by a trained researcher and ensuring that each respondent was interviewed separately. Dependability was supported through comprehensive documentation of the data collection process and systematic supervision of the coding procedure by multiple researchers. Confirmability was reinforced through reflective journaling, weekly research meetings, and triangulation strategies, including data source, investigator, and theoretical triangulation, to minimize bias. Transferability was addressed by operationalizing theoretical data saturation to enhance the applicability of the findings beyond the study setting.

Maturity model adaptation and development

This study adapted and refined established maturity models [8-12] to develop a maturity model specific to IPC in the context of elective surgeries. These models were selected for their emphasis on safety culture, which enabled a systematic and progressive evaluation of IPC maturity within this context. They have been widely applied in various organizational settings to assess and enhance safety culture [30-32].

Each reference model consisted of multiple maturity levels and assessment indicators. The Fleming model categorized maturity into five stages: emerging, managing, involving, cooperating, and improving [8]. Similarly, the Hudson model defined five levels: pathological, reactive, calculative, proactive, and generative [9]. The CollabMM outlined four levels: reflexive, aware, planned, and ad-hoc [10,11]. Additionally, the QMS model comprised five stages: certainty, regression, awakening, enlightenment, and uncertainty [12]. A synthesis of these models was conducted to extract and modify assessment criteria most relevant to IPC in elective surgery preparation. This process involved aligning key indicators across the models, refining their definitions, and adapting them to reflect collaborative practices in surgical settings. The synthesized framework served as the basis for qualitative data analysis, facilitating the development of a new IPC maturity model tailored to elective surgery preparation.

Validation through expert review

The newly developed maturity model was validated through an expert review process involving three professionals in Indonesia over a two-week period. The selection of three experts was based on prior literature, which suggests that a minimum of three experts is necessary for validation [33]. The experts were chosen for their complementary expertise in elective surgical preparation, IPC in healthcare, and healthcare management within Indonesian institutions.

The panel included a professor specializing in medical-surgical nursing, who also oversees quality assurance for the Bachelor's nursing program at Universitas Airlangga, Surabaya, Indonesia. The second expert was a certified consultant orthopedic specialist with managerial experience in hospitals in Malang, Indonesia. The third expert was a hospital management advisor, a consultant for multiple hospitals, and a member of medical committees in Indonesia, with a background in public health. This diversity ensured a balance between theoretical foundations and practical applicability, strengthening the maturity model's relevance to elective surgery preparation.

The draft maturity model was evaluated, focusing on content analysis based on criteria such as clarity, language use, alignment with objectives, and overall presentation. Each expert

provided specific recommendations for refinement and categorized the model as either suitable for use, requiring revision, or unsuitable. This qualitative approach ensured that both the measurement framework and the conceptual understanding of IPC maturity were thoroughly assessed [34].

The validation results were compiled, and refinements were made based on expert feedback. Key assessment criteria were adjusted, and further analysis was conducted to enhance the model's applicability [35]. The revised version was reviewed by all three experts, and the process was repeated until a consensus was reached on its feasibility. The validated maturity model will serve as the foundation for developing an IPC measurement tool for elective surgery preparation, which will include questionnaire items.

Results

Literature study outcomes

Several indicators influencing IPC in the context of surgery were identified in 11 articles [2,36-45] based on the literature study. These indicators were categorized into three primary dimensions based on organizational behavior theory: individual, team, and organization [13]. Within the individual dimension, work experience and age emerged as the primary indicators, with age showing a linear correlation with work experience. These factors influence professional relationships and an individual's capacity for collaboration [39,40]. In the team dimension, physical proximity and hierarchical structures were identified as the most significant factors affecting collaboration. Close physical proximity among professionals fosters effective communication [41], whereas hierarchical structures prevent collaboration [2]. The impact of hierarchy is further shaped by factors such as interprofessional education, cultural norms, beliefs, and attitudes, all of which contribute to collaborative barriers [2]. At the organizational level, the most influential indicators include hospital design programs and broader organizational characteristics [38]. Supportive hospital designs, such as structured weekly reporting and proactive interprofessional communication systems in surgical settings, have been shown to enhance collaboration among medical teams [38]. Conversely, organizational isolation and certain institutional characteristics can impede teamwork and communication [36]. The indicators identified in this literature study contribute to the existing body of knowledge and serve as a valuable reference for developing more precise indicators through in-depth interviews that accurately reflect real-world conditions.

Key findings from the in-depth interview

The qualitative analysis of in-depth interviews identified 15 key indicators that influence IPC in elective surgery preparation. These indicators were classified into three dimensions: individual, team, and organizational, based on organizational behavior theory [13].

In the individual dimension, five key indicators were identified: individual initiatives, personal characteristics of specialist doctors, patient characteristics and psychology, differences in professional backgrounds, and compliance of specialist doctors with standard operating procedures (SOPs). Among these, 'individual initiative' emerged as the most frequently mentioned factor, particularly regarding the role of nurses in facilitating communication between specialist doctors. Nurses act as intermediaries, ensuring that patient conditions are effectively conveyed to relevant specialists. A surgeon highlighted this role by stating, *"...the main key (to interprofessional communication) is with the nurses, as a liaison between specialist doctors, because they always meet patients."* A nurse further reinforced this, saying, *"We definitely have interactions with the specialist doctor during patient visits. For instance, the nurse will be informed in advance if the patient has any complaints. We are present with the patients 24 hours a day, so we will certainly inform the specialist doctor of any concerns."* These statements emphasize the critical function of nurses in bridging communication gaps and enhancing interprofessional coordination in elective surgery preparation.

In the team dimension, six primary indicators were identified: communication, knowledge sharing, coordination, collaboration, professional hierarchies, and limitations in

professional roles. Among these, 'collaboration' was the most frequently cited, as preoperative agreements and conflict resolution were regarded as fundamental to IPC. One significant challenge was miscommunication leading to surgical delays. A nutritionist provided an example, stating, *"There was a time when a surgery had to be canceled due to miscommunication. A patient mistakenly consumed food intended for their family, even though we (the nutritionists) had attached food labels."* An anesthesiologist confirmed this issue, adding, *"That (the miscommunication regarding the patient's food) will be communicated again, rescheduled in the operating room."* These findings highlight the importance of structured communication protocols to prevent errors that could disrupt surgical schedules and compromise patient care.

In the organizational dimension, four key indicators were identified: hospital program design, information systems and technology, hospital resource limitations, and internal operational systems. Among these, 'hospital program design' was the primary focus, as the efficiency of preoperative workflows, including administrative procedures, scheduling, diagnostics, and treatment planning, relies on effective interprofessional coordination. A surgeon described the current preoperative workflow, stating, *"Patients come to the polyclinic and, if necessary, undergo supporting examinations first."* A case manager highlighted improvements in the process over time, explaining, *"In the past, patients would come to the hospital and immediately receive an admission order, then go directly to the operating room, even for elective surgeries. That is no longer the case, though, as structured plans are now in place (for elective surgery preparation)."* These findings indicate that hospital policies and operational systems play a crucial role in enhancing IPC by ensuring systematic and coordinated elective surgery preparation.

Following the identification of these IPC indicators, the next phase involved developing maturity levels to assess the effectiveness of IPC. Each indicator was mapped to structured assessment criteria to determine varying levels of IPC maturity. This process was guided by adaptations from existing maturity models, ensuring that benchmarks for evaluating IPC were aligned with best practices. The structured approach enables targeted improvements in IPC, fostering a more efficient and standardized framework for elective surgery preparation

Adaptation and development of the maturity model

A comprehensive analysis of four existing maturity models was conducted to establish reference levels and assessment indicators for developing a maturity model tailored to elective surgery preparation. These models provided foundational structures, which were critically assessed for applicability, relevance, and limitations. The Fleming maturity model [8] was adopted due to its capacity to assess safety culture and guide strategic improvements. Its assessment criteria facilitate the evaluation of current conditions, development of enhancement strategies, and promotion of a sustainable safety culture. Given the technical and regulatory challenges in healthcare settings, the criteria were modified to align with the specific requirements of elective surgery preparation. The Hudson maturity model [9] was also integrated, as it provides a framework for transitioning from a reactive to a generative safety culture, embedding safety into operational and strategic decision-making. This model was particularly useful for defining assessment criteria in elective surgery readiness. However, its limited emphasis on managerial support and structured safety systems necessitated the incorporation of these elements into the adapted model. The CollabMM, widely used in organizations with complex, collaborative processes [10], was adapted to enhance interprofessional coordination in elective surgery preparation. While this model emphasizes effective teamwork, challenges were identified in its reliance on technological tools and standardized assessment methods. To ensure practical applicability, the assessment criteria were refined to better align with healthcare environments. The QMS maturity model, which integrates process management, ISO 9001 implementation, information system integration, and stakeholder engagement [11,12], was also considered. This model offers essential criteria for policy integration and procedural standardization, ensuring quality objectives are met. However, inconsistent managerial support, a challenge within CollabMM, was also evident here. Therefore, modifications were made to reinforce leadership commitment and structured implementation within the elective surgery context.

Following the evaluation of these models and their limitations, a new framework was developed, the Preoperative Interprofessional Collaboration Maturity Model (P-ICMM). This model specifically addresses gaps in prior frameworks and defines five progressive levels of maturity: emerging (level 1), developing (level 2), coordinated (level 3), integrated (level 4), and optimized (level 5), as illustrated in **Figure 2**. At the 'emerging level', IPC is minimal or non-existent, with professionals operating independently within their respective domains. Communication and coordination are absent, and interactions occur only in response to urgent needs rather than through structured efforts. There are no formal mechanisms to facilitate collaboration, leading to fragmented workflows and potential inefficiencies in elective surgery preparation.

At the 'developing level', there is growing recognition of the importance of collaboration, but practical implementation remains limited. Although there is an intention to engage in interprofessional teamwork, interactions are sporadic and lack a structured framework. Communication remains uncoordinated, and collaboration occurs on an ad hoc basis without established protocols or shared objectives.

The 'coordinated level' marks a transition where IPC begins to take shape, although it remains situational and dependent on specific individuals or circumstances. Efforts to enhance teamwork are initiated, and structured communication pathways start to emerge. However, collaboration is not yet standardized across all aspects of elective surgery preparation, and integration into routine workflows is incomplete.

At the 'integrated level', collaboration becomes systematically organized, involving multiple professional groups working together toward shared goals. Communication is more structured, with defined roles and responsibilities. However, challenges such as inconsistencies in coordination, varying professional priorities, and occasional misalignment of objectives persist. Despite these hurdles, interprofessional teamwork is increasingly recognized as an essential component of elective surgery preparation.

The 'optimized level' represents the full integration of IPC into the organizational culture. At this stage, teamwork is seamless, communication is automatic, and collaboration is an ingrained practice rather than an enforced process. The team operates cohesively with well-defined workflows, continuous knowledge-sharing, and a shared commitment to achieve optimal patient outcomes. This level ensures sustained efficiency and high reliability in elective surgery preparation through an institutionalized culture of collaboration.

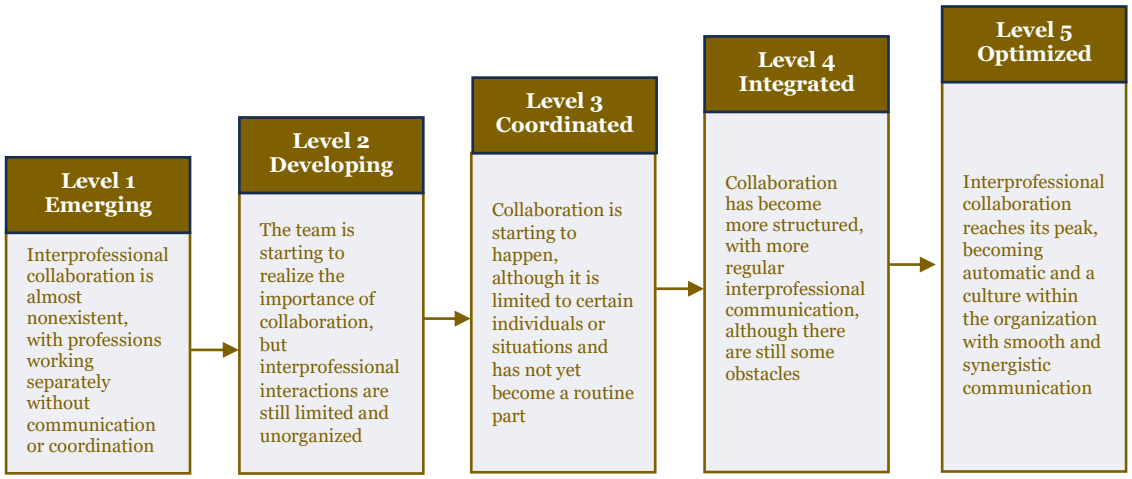

Figure 2. Maturity model of Preoperative Interprofessional Collaboration Maturity Model (P-ICMM).

Maturity model assessment indicators

The assessment indicators in the P-ICMM were derived from qualitative data obtained through in-depth interviews, which were systematically analyzed and refined based on the four existing maturity models. These indicators represent key factors influencing the implementation of IPC

and are categorized into three dimensions: individual, team, and organizational, in accordance with organizational behavior theory [13].

The individual dimension encompasses attributes such as professional competence, willingness to collaborate, and communication skills, which influence an individual's ability to engage in interprofessional teamwork. The team dimension includes factors such as role clarity, shared decision-making, and mutual trust, which are critical for fostering effective interprofessional interactions. The organizational dimension addresses structural and policy-related aspects, including leadership support, institutional commitment, and resource availability, which facilitate or hinder IPC in elective surgery preparation.

These factors were then translated into assessment indicators within the P-ICMM to systematically evaluate and measure the maturity of IPC across different levels. The complete set of assessment indicators and their definitions, outlining their scope within the context of elective surgery preparation are presented in **Table 1**.

Table 1. Dimensions, indicators, and the scope of assessment indicators in the Preoperative Interprofessional Collaboration Maturity Model (P-ICMM)

Dimensions	Indicators	Definition of assessment indicators
Individual	Individual initiative	Behavior is defined by the capacity to autonomously and proactively initiate actions, as well as to surmount existing obstacles to attain specific objectives [46,47]. The P-ICMM maturity model encompasses individual initiative indicators that focus on consistency in collaboration, voluntary participation, and ongoing efforts to enhance the quality of collaboration.
	Individual attitudes towards interprofessional collaboration (IPC)	The P-ICMM maturity model includes indicators of individual initiative that emphasize consistency in collaboration, which can be influenced by factors such as education, experience, and culture [48]. The range of personal attitude indicators regarding IPC encompasses knowledge and responsibility sharing, openness, and the individual's aspiration for development.
	Individual characteristics	Individual characteristics refer to a person's knowledge, skills, behavior, and attitudes that shape their personality and influence the way they solve problems, make decisions, and take action [49]. The scope of individual characteristic indicators includes being active in collaboration and responsibility, as well as being open to feedback.
Team	The nature of IPC within the team	IPC is a process in which various professionals work together to improve patient outcomes, based on mutual respect, trust, and open communication [50-52]. As shown in this P-ICMM maturity model, the IPC characteristics indicators for the team include activities that encourage continuous collaboration and a culture of collaboration.
	Team motivation in implementing IPC	The drive that makes team members work effectively to achieve organizational goals, where high motivation enhances individual and team performance, while low motivation can decrease efficiency even when skills are adequate [53]. In this P-ICMM maturity model, the scope of team motivation in conducting IPC includes moral awareness and shared responsibility for patient safety, as well as a culture of collaboration in the preparation service for elective surgeries.
	Coordination	The activity involves managing and integrating separate tasks into the team's workflow efficiently [54]. The scope of coordination indicators within the team includes collaboration and adaptation in elective surgery preparation tasks, equal contribution, and the active participation of team members.
	Team and patient safety	There are efforts to encourage cooperation and communication among medical teams to create safe, effective, and coordinated care [55]. The scope of team indicators and patient safety includes moral responsibility for patient safety, as well as the prevention of patient safety incidents.
	Professional hierarchy or gaps	The traditional healthcare approach overemphasizes the roles and status of each individual. Although hierarchy is important for determining priorities and the distribution of care, it can also create professional gaps that hinder cooperation [56]. The scope of the hierarchy or professional gap indicators includes the flexibility

Dimensions	Indicators	Definition of assessment indicators
		of team structure, the activities and participation of team members, as well as the appreciation of opinions or contributions.
	Sharing knowledge or information	Interactive activities through various media involve the exchange of information, specifically in relation to health services [57]. The scope of the knowledge-sharing indicator includes team members' agreement on patient safety and equality in expressing opinions.
	Collaboration	Teamwork is a job that requires task coordination among groups of people [58]. The scope of cooperation indicators includes smooth communication, clear task division, and active and equal collaboration.
Organization	Systems within the organization	The system within an organization is a strategic process that regulates operations through a framework of instructions and guidelines designed to achieve objectives [59]. In this P-ICMM maturity model, system indicators in the organization include how clear standard operating procedures (SOPs) are, how often teams are evaluated, and key performance indicators (KPIs).
	Hospital program design	Designing hospital programs is a creative process that includes both physical and non-physical parts. Non-physical parts include things like experiences, multimedia, and guide materials; these are used to improve the quality of care and the patient experience [60]. An important part of the hospital program design indicators is making sure that a collaborative culture and facilities are created and that change suggestions are put into action to enhance the quality of preparation for elective surgery.
	Information and technology systems	Information and technology systems in the health sector are defined as the use of electronic devices by healthcare professionals for the purposes of health promotion, prevention, treatment, and rehabilitation [61]. Digitization, system integration, minimal system errors, and data security are some of the information and technology system indicators that are used in procedures for getting ready for elective surgery.
	Hospital limitations	A number of challenges are faced by hospitals or healthcare facilities, including resource constraints, high readmission rates, and rigidity in protocol implementation that affect service quality [62]. Some of the things that hospital limitation indicators look at are how well SOPs are followed, how facilities are used, how well service flow is evaluated and improved, and how open hospital management is to new information.
	Impact of IPC practices on hospitals	The impact includes improved patient outcomes, reduced morbidity and mortality, and enhanced patient safety in healthcare services [1,63]. Some of the ways that IPC practices affect hospitals are better health outcomes for patients, outputs from how well collaboration processes work (like length of stay), and making sure that procedures are followed and time is managed.

Evaluation of the maturity model by the experts

Three experts provided comprehensive evaluations and specific recommendations regarding the assessment indicators across all five maturity levels. Their feedback focused on refining the clarity, structure, and contextual relevance of the model to enhance its applicability to elective surgery preparation.

The first expert emphasized the need for precise variations in sentence construction at each maturity level to ensure clear differentiation between stages. Additionally, this expert highlighted the importance of using terminology that accurately reflects the progression of IPC. The second expert concentrated on restructuring the assessment indicators, ensuring logical progression and consistency across levels. This expert's recommendations helped refine the hierarchical framework of the maturity model, improving its coherence and usability. The third expert focused on contextual adjustments to terminology, the inclusion of affirmative statements at each level, and the integration of input, process, and output (or outcome) elements relevant to IPC. These modifications aimed to enhance the practical applicability of the model by aligning it with real-world healthcare dynamics. The expert also suggested refinements to ensure that the indicators accurately capture the complexities of elective surgery preparation.

The qualitative feedbacks from these three experts, including detailed comments and recommendations on each assessment indicator are summarized in **Table 2**. Following a thorough review of their input, the assessment criteria for each indicator in the P-ICMM maturity

model were revised accordingly. The revised model was then reassessed by the experts until a final version was agreed upon (**Table 3**).

Table 2. Experts' evaluation and recommendations of the Preoperative Interprofessional Collaboration Maturity Model (P-ICMM)

Dimensions	Indicators	Expert	Specific recommendations
Individual	Individual initiative	Expert 1	Level 3: The team members are equipped with a type of close relationship that limits interprofessional collaboration (IPC) Level 4: The indicators at this level are readjusted, as they are not significantly different from those at level 3
		Expert 2	Level 1–5: Clarified regarding the changes in indicator levels for each level, starting with a hierarchy up to voluntary participation
	Individual attitudes towards IPC	Expert 1	Level 3–4: The assessment indicators incorporate the context of IPC Level 1–5: Subject mention is standardized (team members or profession or individual)
		Expert 2	Level 1–5: Clarified the changes in indicator levels for each level, starting with a lack of interest, gradually showing interest, desire, responsible participation, and finally constructive participation
	Individual characteristics	Expert 1	Level 1–5: Subject mention is standardized (team members or profession or individual), and the sentence direction at each level clarifies the changes in indicators
		Expert 2	Level 1–5: Clarified regarding the changes in indicator levels for each level
Team	The nature of IPC within the team	Expert 1	Level 1–5: Subject mention is standardized (team members or profession or individual)
	Coordination	Expert 1	Level 2: Marked by coordination, but no commitment from team members yet Level 3–4: The assessment indicators prioritize collaboration or the coordinator's role first
	Professional hierarchy or gaps	Expert 1	Level 1: It is confirmed again that the presence of a hierarchy is an assessment indicator at level 1 Level 1–5: The direction of the sentence at each level clarifies the changes in the indicators
		Expert 3	Level 1: The mention of the word 'tension' was changed to 'gap,' and it was clarified that there is a gap between team members Level 2: The mention of the word 'rule' is changed to 'SOP' Level 5: The direction of the sentence is clarified that all team members at various levels of career stages (competence, skills, and seniority) can freely collaborate equally. Furthermore, it clarifies the meaning and context of the word 'equal.'
	Collaboration	Expert 1	Level 5: Clearly define the context of the term 'collaboration'
Organization	Systems within the organization	Expert 3	Level 2: The mention of the word 'encouragement' was changed to 'SOP' Level 3: Added the affirming sentence 'performance evaluation of each team member' within the scope of elective surgery preparation Level 5: It is facilitated by three important points, the existence of standard operating procedure (SOP), SOP evaluation, and SOP being used as an indicator of hospital service performance
	Hospital program design	Expert 3	Level 2: Added a statement emphasizing that IPC has not yet become a culture in the context of elective surgery preparation Level 5: Added a statement affirming that IPC has become a culture in the context of elective surgery preparation
	Information and technology systems	Expert 1	Level 2: Clarified the context of the transition from conventional information systems to digital
	Hospital limitations	Expert 3	Level 1–5: Must explain the aspects of hospital limitations, including input, process, and output/outcome aspects

Dimensions	Indicators	Expert	Specific recommendations
	Impact of IPC practices on hospitals	Expert 1 Expert 3	Level 1: Clarified the context of the failure in question Level 1: Place the word 'plan' with 'SOP.' In addition, the direction of the impact of the failure of elective surgery preparation services was explained. Level 1–5: It must be explained regarding the input, process, and output or outcome in the implementation of IPC in the scope of elective surgery preparation

Discussion

Using a maturity model is an effective method for describing the growth and development of maturity in IPC over time [64,65]. The maturity model we have created, P-ICMM, was designed to help stakeholders prepare for elective surgeries by assessing and pursuing maturity through a structured and gradual approach. This approach utilized clear steps and a variety of maturity levels to enhance the quality and safety of patients.

P-ICMM offers a framework for the development, implementation, and systematic enhancement of the assessed aspects or parameters. This maturity assessment is crucial for understanding the healthcare service system, regulations, patient engagement and safety, along with the quality of care [65]. Each indicator in the P-ICMM is derived and developed from four foundational maturity models. These elements are subsequently adapted to the context of IPC in elective surgery preparation, utilizing data from in-depth interviews, to facilitate a more focused evaluation of IPC maturity within the elective surgery preparation team.

The P-ICMM model emphasizes the individual dimensions of initiative, attitude, and characteristics of team members, highlighting their courage and willingness to engage in IPC to enhance service quality and ensure the safety of elective preoperative patients. According to a previous study [66], that the readiness and willingness of healthcare workers are factors that can enhance IPC. Meanwhile, at the team dimension, the P-ICMM model indicators encompass various aspects in the comprehensive preparation of elective operations. One of the most critical evaluation indicators is the motivation of team members to perform IPC. The reason for this is that the motivational characteristics of team members with varying professions, such as effort and direction in IPC, may differ based on their competencies [67]. Indicators of interprofessional hierarchy are a significant factor in the development of the maturity model, as the implementation of IPC will be challenging if negative inter-disciplinary hierarchies persist. This hierarchy can generate power disparities within collaborative teams, leading to ineffective communication and coordination challenges [68]. This communication issue is also closely associated with the knowledge-sharing dimension, where communication competence and teamwork in the elective surgery preparation team become critical components of IPC. These competencies are essential for the safe and optimal care of patients, as well as the improvement of teamwork effectiveness. This has been reported by numerous prior studies [69-72].

The P-ICMM model assesses the dedication of hospital management to the sustainability of IPC, as evidenced by the implementation of standardized service procedures, the provision of adequate facilities, the implementation of policies that promote cross-professional collaboration, and other strategic measures. Previous studies have recommended the importance of institutional policies to facilitate IPC, as well as the development of strategies and collaboration models to address the various challenges that healthcare workers encounter when collaborating [7,71]. This P-ICMM also emphasizes the importance of technology integration in enhancing the efficiency of interprofessional communication through digital platforms, including more optimal information exchange, ensuring consistency in communication, and promoting structured coordination [73]. One practical illustration is the utilization of electronic health records (EHR), which enhances communication, facilitates interprofessional practice, enhances performance, and reduces the cognitive burden on healthcare professionals [74]. Finally, P-ICMM serves as a strategic guide that promotes the development of a collaborative culture, conflict management, team-based decision-making, and continuous training, in addition to serving as a measurement or evaluation tool. This ensures the sustainable improvement of healthcare quality.

Table 3. Final interprofessional collaboration (IPC) maturity assessment index of the Preoperative Interprofessional Collaboration Maturity Model (P-ICMM)

Dimensions	Indicators	Maturity level of the P-ICMM				
		Level 1: Emerging	Level 2: Developing	Level 3: Coordinated	Level 4: Integrated	Level 5: Optimized
Individual	Individual initiative	Team members are concentrating on their individual tasks and have not yet demonstrated a desire to collaborate across professions	Team members recognize the importance of IPC, but the desire to collaborate is very low or limited	(a) IPC occurs in a limited manner and depends on the initiative and skills of each team member. (b) Team members sometimes engage in IPC, but it is still limited to those with close relationships, such as colleagues with the same profession or those who have worked together for a long time.	Team members began proactively initiating IPC by discussing, sharing information, and solving problems related to the preparation of elective surgeries together, without relying on previous close relationships	(a) Each team member consistently engages in IPC, prioritizing the meaning of collaboration itself. (b) Team members participate voluntarily, without being influenced by personal relationships or social closeness, and continuously strive to improve the quality of service for preoperative elective patients.
	Individual attitudes towards IPC	(a) Team members are not interested in the issue of IPC and its impact on the quality and safety of elective surgery patients. (b) The team members lack a genuine commitment to the group.	(a) There is a growing interest in collaborating, but there is still no courage to start IPC. (b) Team members feel the need for the support of hospital leadership and management to organize IPC practices.	Team members are beginning to show personal responsibility in IPC, marked by the willingness and courage to ask questions, share information, and provide input to colleagues from other professions in an effort to improve service quality in the preparation for elective surgeries	(a) Each team member pays attention to the tasks, commitments, and responsibilities assigned in preparation for elective surgery. (b) Each team member participates in self-organized and simultaneous IPC, coordinating with colleagues from other professions to improve the quality of elective surgery preparation services.	(a) Each team member actively exchanges knowledge and participates responsibly in discussions regarding the preparation for elective surgeries. (b) Team members are open to feedback, eager to improve in IPC, and receptive to the involvement of external parties to enhance the quality of IPC.
	Individual characteristics	Team members are still indifferent and do not show interest in IPC, not considering IPC as something important that can impact the quality of service and the safety of elective preoperative patients	(a) Team members engage in IPC only to comply with regulations or to obtain incentives. (b) Team members are starting to show interest in IPC within the scope of service quality and safety of elective surgery patients.	Team members desire to collaborate in an effort to prevent patient safety incidents	(a) Team members make IPC a commitment and responsibility inherent to their duties. (b) Team members participate in IPC as an effort to prevent incidents of patient safety in elective surgeries.	(a) Collaboration has become a primary necessity, with all team members viewing it as the core of service success. (b) Team members participate constructively and responsibly to maintain safety standards and achieve common goals.

Dimensions	Indicators	Maturity level of the P-ICMM				
		Level 1: Emerging	Level 2: Developing	Level 3: Coordinated	Level 4: Integrated	Level 5: Optimized
Team	The nature of IPC within the team	IPC is not explicitly visible	Collaboration can occur, but it depends on the initiative and skills of each individual in the elective surgery preparation team	IPC can occur, but it is still influenced by the relationships and closeness of team members	IPC has been routinely occurring, marked by group discussions	Every team member actively collaborates interprofessionally, and every elective surgery preparation service conducts this collaboration automatically
	Team motivation in implementing IPC	Team members are still lacking concern, and there is no motivation or desire to engage in IPC	The team engages in IPC due to external demands (such as accreditation or other external audits)	There is already evidence of IPC as an effort to prevent patient safety incidents	IPC has already occurred within the team as a form of commitment and responsibility assigned to each team member	(a) IPC is based on the moral awareness that patient safety is the responsibility of all team members. (b) This collaboration has become an automatic culture in every elective surgery preparation service.
	Coordination	The elective surgery preparation team is ineffective, each team member works independently, more like a group of people brought together without a leader and a clear goal	(a) Team coordination has begun, but member commitment has not. (b) A coordinator's job is to centralize, organize, and foster each team member's commitment to collaboration.	IPC among team members is beginning to develop and integrate as a single group, although it still requires centralized coordination	(a) IPC among team members runs without requiring centralized coordination or a coordinator. (b) Coordination within the team tends to be decentralized.	(a) The team is collaborative, adaptive, and actively contributes to the preparation of elective surgeries according to their expertise. (b) All team members are free to contribute equally, so each team member plays an active role in IPC.
	Team and patient safety	(a) Incidents of patient safety in elective surgeries are considered something normal that cannot be avoided. (b) A member of the elective surgery preparation team was responsible for a preoperative patient safety incident.	Safety incidents in elective surgical procedures are considered preventable	Each team member has already engaged in IPC as an effort to prevent patient safety incidents in elective preoperative care	IPC has already occurred within the team as a form of commitment and responsibility of team members in preventing patient safety incidents during the preparation for elective surgery	(a) Every team member is very aware that patient safety is a moral responsibility. (b) There haven't been any patient safety incidents in a while, and team members are receptive to suggestions about IPC for event prevention.
	Professional hierarchy or gaps	(a) There is a gap between team members and the rigid hierarchical structure, which hinders IPC.	(a) The team involved in the preparation of elective surgeries requires standard operating procedures (SOPs) from management	Since they feel equal, healthcare professionals have started collaborating with professionals other than	(a) There is already an IPC that is being carried out and happening naturally among all healthcare professionals, although	The team structure is flexible according to each profession's role. All team members at various career levels can be active, free,

Dimensions	Indicators	Maturity level of the P-ICMM				
		Level 1: Emerging	Level 2: Developing	Level 3: Coordinated	Level 4: Integrated	Level 5: Optimized
		(b) A rigid hierarchy in each team creates limitations in communication and IPC in the preparation of elective surgeries.	to collaborate interprofessionally. (b) There has been no effort or follow-up from the hospital management to mediate the tension while still tolerating the existing gaps in IPC in the preparation of elective surgeries. (c) Healthcare professionals are not yet brave and confident enough to collaborate because there is a feeling of inferiority (inequality between professions), especially with doctors.	doctors, but IPC with doctors has not yet begun	sometimes there are still those who lack confidence. (b) Hospital management is taking action to address IPC tensions and firmly combat gap practices within the scope of elective surgery preparation.	and equal in IPC. Each member is valued for their opinions, contributions, and expertise.
	Sharing knowledge or information	There has never been any discussion or knowledge sharing at all among team members in the preparation for elective surgery	There has never been any discussion or knowledge sharing at all among team members in the preparation for elective surgery	There has already been some exchange of ideas or information through IPC regarding the patient's condition and safety issues that may arise during the preparation for elective surgery	There have already been knowledge-sharing activities, especially through interprofessional team discussions regarding the preparation for elective surgeries	All team members share the belief that safety is important in the preparation for elective surgery, with the achievement of equality in expressing or voicing opinions
	Collaboration	(a) The existence of unstructured practices, and without performance predictions for each team member in the preparation of elective surgeries. (b) There is no sign of IPC among the members of the elective surgery preparation team.	Collaboration on elective surgery preparation is only possible between the same or closely related professions	Team members collaborate interprofessionally with the role of a central coordinator (nurse or case manager)	Team members actively collaborate interprofessionally according to their respective authority and expertise without any coercion or coordinator	(a) Hospital management enables more effective IPC through smooth communication, organized coordination, and clear task division. (b) All team members routinely collaborate actively, equally, and always think about improving the quality of elective surgery preparations.
Organization	Systems within the organization	The commitment of hospital management to IPC and its impact on patient safety in the context of elective	The commitment of the hospital management is starting to emerge, but it has not been implemented according to plan, resulting	There are now SOPs from hospital management for IPC practices, but the evaluation and improvement program for practices in the scope of	There has already been a program to evaluate IPC practices in the context of elective surgery preparation, but it is still	IPC has become a key part of the hospital's main strategy, supported by clear SOPs, routine evaluations, and key

Dimensions	Indicators	Maturity level of the P-ICMM				
		Level 1: Emerging	Level 2: Developing	Level 3: Coordinated	Level 4: Integrated	Level 5: Optimized
		surgery preparation tends to be less evident	in the failure of the elective surgery preparation program	elective surgery preparation is still not visible	limited to assessing the performance of each team member	performance indicators in elective surgery preparation services
	Hospital program design	(a) There are no policies or efforts from the hospital management to improve IPC and the quality of elective surgery preparation services. (b) The new management will start building commitments and policies.	(a) The management of the hospital reacts to the participation of healthcare professionals in IPC for the preparation of elective surgery. (b) The hospital management has implemented an external audit program to obtain certification and ensure service quality to enhance patient and family satisfaction during preparation for elective surgery. (c) IPC in the context of elective surgery preparation has not yet become a culture in the hospital.	The study identified the activity of hospital management in monitoring and recording the implementation of IPC practices within the scope of elective surgery preparation	(a) Improvements at the hospital management level, and better IPC between departments, patients, and patients' families. (b) The team monitors and controls IPC within the context of elective surgery preparation.	(a) Hospital management promotes IPC practices as an organizational culture. (b) Routine evaluations are conducted to generate change recommendations for better preparation of elective surgeries.
	Information and technology systems	The absence of the application of information systems and digital technology in elective surgery preparation services, everything is still conventional	The hospital management is making efforts to transition from a conventional system to a digital-based information system in order to improve the quality of IPC, as well as the quality of elective surgery preparation services	The application of digital-based information and technology systems in elective surgery preparation services has already occurred, but it is not optimal or comprehensive enough	(a) There is an effort to evaluate or improve the digital-based information and technology system in the context of elective surgery preparation. (b) Several members of the elective surgery preparation team and elective patients have reported significant benefits from information systems and digital-based technology.	All procedures for preparing elective surgeries are digital-based and integrated with each other, with no system-related error reports for a long time
	Hospital limitations	(a) The existence of complaints from patients and their families regarding the complicated and unstructured procedures for elective	There are already plans from the hospital management to improve the service flow and add facility completeness in the scope of elective surgery preparation	(a) The hospital management is starting to understand that they need to update their service SOP to make them more useful, finish a number of examination rooms, and	(a) The commitment and willingness of all team members to collaborate interprofessionally in implementing the latest SOP and optimally using	(a) All team members work interprofessionally in implementing the latest SOP and utilizing the facilities optimally. (b) There are significant reports regarding

Dimensions	Indicators	Maturity level of the P-ICMM				
		Level 1: Emerging	Level 2: Developing	Level 3: Coordinated	Level 4: Integrated	Level 5: Optimized
		surgery preparation services. (b) The completeness of examination facilities in hospitals is still very limited, which is one of the main key factors (input) in improving the quality of elective surgery preparation services.		improve the quality of teams of professionals working together to get people ready for elective surgery. (b) Members of the elective surgery preparation team have not fully implemented the latest SOP or utilized the elective surgery preparation facilities optimally.	the elective surgery preparation facilities. (b) The realization is still limited to some team members, with some team members not complying with the implementation of the latest SOP and using the elective surgery preparation facilities.	improvements in service flow and facilities, supported by management's openness to recent updates.
	Impact of IPC practices on hospitals	(a) There was a failure in the elective surgery preparation service due to the actions of team members that did not comply with the SOP. (b) The outcome is a low level of satisfaction, as well as a high number of complaints. c)Input in the form of resources is required, including adequate team members and the sustainability of IPC, as well as a monitoring system within the scope of operational preparation.	(a) The team works separately, without strong IPC, which affects the quality of elective surgery preparation services and the still low satisfaction of elective patients. (b) The implementation of the input has begun, but it has not yet reached full effectiveness. Meanwhile, the process of drafting and implementing the SOP for elective surgery preparation services is ongoing and not yet well-structured. (c) Outputs such as length of stay (LOS) duration, increased safety, and patient satisfaction during the preparation for elective surgery have not shown any changes.	(a) Producing integrated performance of team members as a whole team in the scope of elective surgery preparation services. (b) Development of IPC and commitment related to improving patient safety in the context of elective surgery preparation. (c) The input has been implemented, although it is still in the strengthening stage. Meanwhile, the process of IPC in the scope of elective surgery preparation is becoming more structured, but it is not yet fully consistent. (d) Results like a shorter LOS, higher safety, and happier patients during the preparation for elective surgery are starting to show. This is due to team members following and working together with the SOP for this purpose more often.	(a) The team works in a coordinated manner and collaborates interprofessionally toward patient safety, resulting in high patient satisfaction levels and a tendency for low complaints related to elective surgery preparation services. (b) The input has started to be consistent, and the IPC process is getting better. The output can be seen in the higher compliance with SOPs for preparing elective surgery patients and the lower LOS for elective patients.	(a) There have been no patient safety incidents for a long time, with improvements in health status, patient satisfaction, and active participation from all team members. (b) The IPC process ran smoothly, resulting in optimal outputs such as reduced LOS and increased SOP compliance.

For the purpose of conducting elective surgery preparation reviews and research on IPC, this P-ICMM maturity model has both strengths and limitations. This model was developed, adapted, and revised in accordance with the adaptations of previous maturity models in this field. Consequently, it offers structured measurements and a clear path to collaboration maturity, which can ultimately improve the quality and safety of patient care. The scope of this maturity model is restricted by the number of models that are analyzed, which is determined by the selection criteria of the research design. Additionally, it is applicable only to the context of elective surgery preparation in a single city in Indonesia. Therefore, its application in other contexts needs to be further reviewed. Moreover, the P-ICMM is intended to remain pertinent in the face of changes in policies, regulations, or organizational dynamics, however, it continues to encounter difficulties in adapting to rapid external and internal environmental changes.

Conclusion

This study successively developed the P-ICMM aimed at improving IPC in the context of elective surgery preparation. This model comprises five maturity levels: emerging, developing, coordinated, integrated, and optimized, featuring indicators specifically designed for assessment across individual, team, and organizational dimensions, in alignment with organizational behavior theory. The maturity model's review and evaluation by experts suggest that the P-ICMM has the potential to serve as a strategic tool for the systematic evaluation and enhancement of IPC. The quality of healthcare services, patient safety, and the efficiency of the elective surgery preparation process in hospitals are anticipated to be enhanced by the successful implementation of this model.

Ethics approval

Ethical approval was obtained from the Health Research Commission of the Faculty of Medicine, Universitas Brawijaya, Malang, Indonesia, on October 10, 2023 (No. 451/EC/KEPK-S3/12/2024). All participants involved in interviews for qualitative data collection provided informed consent. The confidentiality and anonymity of the respondents were strictly maintained throughout the study.

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Competing interests

All the authors declare that there are no conflicts of interest.

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Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

Declaration of artificial intelligence use

This study utilized artificial intelligence (AI) tools and methodologies in the following capacities: AI-based language model, QuillBot, was employed for language refinement (improving grammar, sentence structure, and readability of the manuscript). We confirm that all AI-assisted processes were critically reviewed by the authors to ensure the integrity and reliability of the results. The final decisions and interpretations presented in this article were solely made by the authors.

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