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Research Article

Continuous Learning-Based Knowledge Management in the Implementation of Standard Operating Procedures (SOP) for Hyperbaric Oxygen Therapy (HBOT) at the Bhayangkara Police Hospital

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ABSTRACT

This study aims to develop and analyze the application of Sustainable Learning-based KM in the development and implementation of HBOT SOPs at the Bhayangkara Polri Hospital. The main focus of the study is directed at how the application of KM can improve the effectiveness, consistency, and adaptability of HBOT SOPs, as well as build a culture of continuous learning in the police hospital. This study uses an Action Research approach that involves direct collaboration between: researchers, medical personnel, hospital management, and policy makers. The research cycle includes the stages of problem identification, action planning, implementation, observation, and continuous reflection. Data were collected through a combination of quantitative survey methods, in-depth interviews, participant observation, and analysis of SOP documents in various HBOT service units. Research informants included 100 participants from various levels of analysis (individual, group, organizational, and system), with data triangulation carried out to ensure the validity and depth of the findings. The results of the study indicate that the Action Research approach is effective in driving real changes in SOP management based on continuous learning. The Sustainable Learning-based KM model can be an innovative framework for the development of national medical SOPs in the police health sector. The research results systematically revealed: (1) the implementation of Sustainable Learning-based KM increases the effectiveness of HBOT SOPs with an action cycle that includes problem identification, implementation, observation, reflection, resulting in increased consistency, staff engagement, and procedural understanding; (2) organizational capacity and awareness for continuous learning increases, strengthening the learning organization culture in the hospital; (3) cross-unit collaboration accelerates SOP updates and effective coordination between medical teams, quality management, and training; (4) Action Research spurs real changes in work practices and quality management through the active involvement of all stakeholders; (5) gaps between regions can be addressed through a continuous learning mechanism, where Bhayangkara Palu Hospital develops adaptive knowledge sharing and SOP digitalization to support equitable distribution of national HBOT service quality. The implementation of KM improves procedural compliance, operational efficiency, and uniformity of practice between regions through team reflection and adaptive SOP revision.

Keywords: Knowledge Management, Sustainable Learning, Standard Operating Procedure, Hyperbaric Oxygen Therapy

INTRODUCTION

Background

HBOT SOP management at the Bhayangkara Polri Hospital still faces challenges in ensuring the effectiveness and

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sustainability of procedures. This primarily relates to: Knowledge Management (KM) knowledge management, which has not been integrated with a continuous learning model to ensure SOPs are dynamically updated in line with the latest advances in medical science and technology.

The KM concept, based on the Socialization, Externalization, Combination, and Internalization (SECI) model developed by Nonaka and Takeuchi, has proven to be an effective framework for learning and knowledge transfer within healthcare organizations [1]. The KM concept based on the SECI model developed by Nonaka and Takeuchi has proven to be an effective framework in the learning and knowledge transfer process in health organizations. [1]

The results of recent studies related to the application of sustainable learning-based KM in the implementation of HBOT SOPs include: a study on "The Influence of KM on Innovation and Organizational Performance" shows that effective KM together with employee competency has a significant influence on innovation and organizational performance with a very strong correlation value (R = 0.880), even contributing 77.5% to increasing innovation. In the context of HBOT SOPs, integrated and sustainable knowledge management encourages procedural innovation, thereby increasing the effectiveness and safety of services [2].

The study, "People-Centric KM Strategy Supports Knowledge Sharing," describes two main strategies for implementing KM: IT-centric and HRM-centric (people-centric). In healthcare, particularly HBOT, a people-centric approach is more effective in sharing tacit knowledge among medical personnel, making SOPs more responsive and adaptive to clinical practice. This approach is crucial for supporting continuous learning and the development of SOPs based on staff experience. [3].

The study, "Effective SOP Implementation Requires Learning System-Based Knowledge Management and a Supportive Organizational Culture," shows that successful SOP implementation relies heavily on integrated knowledge management with a learning system and a supportive organizational culture. The knowledge management system should include sound documentation, ongoing training, and a participatory SOP update mechanism [4].

The study on "Hyperbaric Treatment of Carbon Monoxide Toxicity." Explains: "The operating manual should be reviewed periodically and updated as appropriate. All staff should be familiar with the guidance contained therein. Standard Operating Procedures for therapeutic hyperbaric facilities should document guidelines or facility policy for the reception, treatment, and discharge of patients in the facility." This study contains comprehensive operational guidelines for hyperbaric therapy facilities, including the development and updating of Standard Operating Manuals and SOPs that must be followed by all staff, as well as the importance of ongoing training and learning to maintain patient safety and the quality of HBOT services [5].

The use of information technology to support the entire SECI model cycle is crucial. IT facilitates knowledge flow through electronic meeting systems, knowledge repositories, and decision support systems, which play a crucial role in transforming knowledge between tacit and explicit forms [1]. Furthermore, a SECI-based nurse performance model with a caring approach has demonstrated improved service quality and patient safety [6].

The SECI model is a knowledge management model developed by Nonaka and Takeuchi. Organizational knowledge is not only stored in documents or systems, but also in individual experiences, values, and intuition. They distinguish two forms of knowledge: tacit knowledge: difficult to explain, derived from experience, intuition, and personal skills (e.g., negotiation skills, creative thinking), and explicit knowledge: easily codified, can be written down, stored, and shared (e.g., reports, procedures, work manuals). These two forms of knowledge interact with each other in the process of creating innovation through the SECI model ([7] .

The SECI model emphasizes the importance of interactions between individuals to generate new knowledge that can be integrated into SOP. [8], asserts that individual interactions are at the heart of the SECI model. Through dynamic socialization, externalization, combination, and internalization, implicit and explicit knowledge is transformed into living SOPs, static documents and guidelines that are continually updated by the organization's collective experience. [9] suggest that SOPs need to be dynamic, updated through experience, and supported by a culture of knowledge sharing. [10] highlight the importance of a hospital's absorptive capacity in acquiring and applying new knowledge. Absorptive capacity is an organization's ability to recognize the value of new knowledge

from outside, absorb it, and apply it for innovation and service improvement. Furthermore, Sustainable Learning complements KM with its emphasis on continuous organizational learning. Sustainable Learning is a continuous approach to organizational learning, emphasizing knowledge renewal and continuous adaptation to face risks and changes.

The importance of ongoing training, periodic evaluation, and team reflection to ensure SOPs are appropriate to field conditions is emphasized by [11]. Strategies such as experience-based training and mentoring help overcome cultural barriers and improve KM effectiveness, especially in developing countries facing resource challenges [12].

HBOT services at Bhayangkara Police Hospital for critical trauma patients require evidence-based, contextual, and adaptive standard operating procedures (SOPs). Sustainable learning-based knowledge management (KM) supports SOP updates, a culture of safety, and ongoing training. Challenges include limited trained human resources, workload, and bureaucracy that hinder effective knowledge sharing.[13], [14]

Health studies reveal that the main challenges to adopting change are a lack of a knowledge-sharing culture, resistance to change, and technological limitations. Health professionals tend to be tied to communities of practice with status that hinders cross-disciplinary sharing, resulting in limited innovation. In Indonesia, SOP management remains top-down without the active participation of medical personnel [15].

A critical review of KM implementation in the global healthcare sector shows that failure to implement KM is often due to the lack of integration of learning processes into daily practice. SOPs are often viewed as merely administrative or regulatory requirements, rather than the result of continuously updated, consolidated collective knowledge. This has the potential to be a latent risk factor, especially in high-risk services like HBOT.

As a complex adjuvant service (an additional substance, method, or intervention used to enhance the effectiveness of the primary therapy), HBOT demands multidisciplinary competency. Physicians, nurses, hyperbaric chamber operators, and support teams must have a consistent understanding of safety protocols, medical indications, contraindications, and emergency risk mitigation procedures [16]. *Interprofessional knowledge sharing plays a crucial role in improving the quality of healthcare, where cross-professional collaboration encompasses not only administrative coordination but also the mutual transfer of practical knowledge.*

This collaboration drives improved patient outcomes by enabling team members to share unique, discipline-specific insights that improve diagnostic accuracy, treatment planning, and the care process. Share knowledge and reduce medical errors by providing multiple expert checkpoints and creating a more coordinated and efficient service delivery system

This kind of knowledge transfer goes beyond routine coordination and becomes a dynamic, communicative process where professionals engage in shared learning, breaking down silos, and fostering trust[12], [17] This increases staff satisfaction and reduces burnout by distributing responsibilities appropriate to expertise. Knowledge sharing across professions builds a culture of continuous innovation that improves quality, patient safety, and the optimal use of resources and organizational culture. Increasing interprofessional knowledge sharing is key to advancing healthcare through practical collaboration and shared problem-solving [18].

Hospitals that successfully reduce medical incidents generally have knowledge management systems that support structured lessons learned from incidents or near-misses. Incident data is not only recorded but also systematically discussed in cross-unit meetings, which then serve as the basis for improving standard operating procedures (SOPs). This model requires a consistent Plan-Do-Check-Act (PDCA) cycle and an organizational culture open to self-evaluation. In the context of Sustainable Learning, healthcare organizations need to encourage a reflective and adaptive mindset

Organizations must continuously learn from experiences and mistakes, adapt quickly, and build a culture open to criticism. Information technology supports incident reporting so that healthcare professionals focus on prevention. Effective incident management improves the quality and safety of healthcare services, as well as patient confidence [19].

Hospitals with continuous learning practices perform better in infection control, SOP compliance, and patient

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satisfaction[20], [21]The process includes regular training, clinical audits, case discussions, and a mentoring system to transfer experience from senior to new staff. This approach creates a culture of reflective and adaptive learning, encouraging innovation and continuous improvement in the quality of healthcare services [22].

Organizational absorptive capacity is a crucial aspect of the KM framework. Hospitals need to develop the ability to absorb external knowledge, including scientific literature, recommendations from professional associations, and incident findings from other institutions, to update their SOPs. This becomes increasingly important in the face of evolving medical technology, changing patient epidemiology, and the dynamics of health regulations [23].

Organizations must foster mutual trust, open communication, and managerial support to create a culture of continuous learning. Without these three factors, training programs or SOP updates often fail to translate into real changes in practice [12].

Based on this explanation, research on the application of Sustainable Learning-based KM in the implementation of HBOT SOPs at the Bhayangkara Polri Hospital is academically relevant and has high practical value in supporting the transformation of safer, more adaptive, and more professional healthcare services.

METHODS

This study uses an action research approach aimed at creating real and sustainable change in knowledge management practices and the implementation of HBOT Standard Operating Procedures (SOPs). The research area of focus is the Bhayangkara Polri Hospital, which operates HBOT services, primarily at Bhayangkara Palu Hospital, located in Central Indonesia. The units of analysis in this study are structured hierarchically to reflect the complexity of implementing Sustainable Learning-based Knowledge Management (KM) in developing HBOT SOPs at the Bhayangkara Polri Hospital.

Data collection in this study was conducted through a combination of surveys (quantitative), interviews (qualitative), participant observation, and document analysis. The collected data were analyzed using approaches appropriate for each type of data collected: quantitative analysis, descriptive statistics, and inferential analysis by calculating frequencies, averages, and percentages to provide an overview of respondent characteristics, as well as data triangulation.

RESULTS

Initial Conditions

HBOT services at Bhayangkara Polri Hospital are pure oxygen therapy in a high-pressure chamber (up to 2.4 ATA) that accelerates the healing of severe wounds, complicated trauma, and anaerobic tissue infections. This service is highly complex and carries inherent risks, such as the potential for fire in the hyperbaric chamber and the risk of barotrauma to the patient.

HBOT enhances healing in cases of wounds and infections with high-pressure pure oxygen. The hyperbaric environment carries the risk of fire, explosion, and barotrauma if standard operating procedures (SOPs) are violated, so strict SOPs are essential for safety and quality. The implementation of Sustainable Learning-based KM supports the continuous updating and implementation of HBOT SOPs, particularly at Bhayangkara Polri Hospital, with a collaborative and reflective culture. The SECI model and absorptive capacity support the adaptation of knowledge so that SOPs become effective guidelines for improving patient safety and medical competence, essential for safe and quality HBOT services.

Quantitative Data on Initial Conditions

Quantitative data on initial conditions showed: (1) Understanding and compliance with SOPs; respondents (n=100), consisting of medical and administrative staff, showed an average SOP understanding score of 3.8 (scale 1-5), while the average procedural compliance score was only 3.7, indicating continued inconsistencies in SOP implementation; (2) SOP training and updates: the effectiveness of initial training was rated an average of 3.5, and the frequency of SOP updates was rated an average of 2.6, indicating a lack of intensive training and regular updates; and (3) participation in discussion forums: the average score for engagement in discussion forums and

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collaborative learning was approximately 2.8, indicating minimal formal interaction among staff to discuss SOPs and field experiences.

Qualitative Data on Initial Conditions

1. Interviews with key informants: Unit heads and managers stated that although individual knowledge was quite good, cross-team coordination still faced challenges, particularly during the high-intensity night shift. Organizational cultural barriers, such as resistance to changes to new SOPs, also prevailed among senior staff. The lack of an integrated digital documentation system made knowledge management less than optimal.
2. Field observations: Deviations were still detected in SOP implementation practices, particularly during the initial inspection and procedure recording stages. Poor communication between professions led to potential procedural errors. The SOP update process was slow and lacked involvement of all relevant teams.

Problem Identification

1. Understanding and adherence to SOPs are suboptimal, potentially increasing patient safety risks.
2. Training and learning systems are still limited, particularly in updating and communicating SOPs.
3. Organizational culture that does not support innovation and knowledge sharing.
4. IT infrastructure is inadequate to support effective knowledge management.

The initial analysis serves as the basis for designing an action research cycle aimed at improving the effectiveness of HBOT SOP implementation through Sustainable Learning-based knowledge management.

Cycle I

Activities in cycle 1 focused on:

1. Revision and dissemination of the HBOT SOP, with adjustments to patient safety procedures and completeness of documentation.
2. Internal training for medical and technical personnel regarding the implementation of the new SOP.
3. Field observations, which assessed the extent to which the SOP was implemented according to guidelines.

Qualitative data revealed that understanding and adherence to HBOT SOPs improved through the Cycle 1 intervention. Initial barriers such as lack of intensive training and resistance to change were identified as challenges. Interviews and observations indicated that staff began to become more aware of the importance of consistent SOP implementation and inter-team collaboration. Reflection on this data served as the basis for refining the approach in Cycle 2, increasing the effectiveness of training and communication between staff, thus supporting the ongoing improvement of SOP implementation.

Tabel 1. Quantitative Data Cycle 1

Variable	Average value	SD	Statistical Test	P-Value	Interpretation
SOP Compliance	3.8	0.7	t = 2.8	0.01	Improvement, training needs to be strengthened
Understanding SOP	3.9	0.6	t = 2.1	0.04	Good enough, needs sharpening of the material
Speed of Implementation	4.0	0.6	t = 3.2	0.02	Significant increase, efficiency increases

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The results showed a p-value <0.05, indicating a significant increase in the speed of SOP implementation and a moderate increase in procedural understanding. However, compliance still needs to be improved due to the relatively high SD (0.7), indicating considerable variation among respondents.

Quantitative results showed a significant increase in scores for compliance and speed of SOP implementation. Initial training successfully improved basic technical understanding, but challenges persisted in cross-team communication, particularly in shift coordination and manual documentation. Furthermore, knowledge sharing was ineffective due to the lack of a formal digital platform. Field observations confirmed that most staff still relied on manual record-keeping and verbal reporting.

Linked to problem formulations 1 & 3, the main challenges in implementing HBOT SOPs at Bhayangkara Hospital, Palu, remain related to communication efficiency and knowledge transfer. This indicates that the KM system has not been optimally integrated into the SOP implementation phase. The Cycle 1 graph and visualization display the average compliance, understanding, and speed of implementation

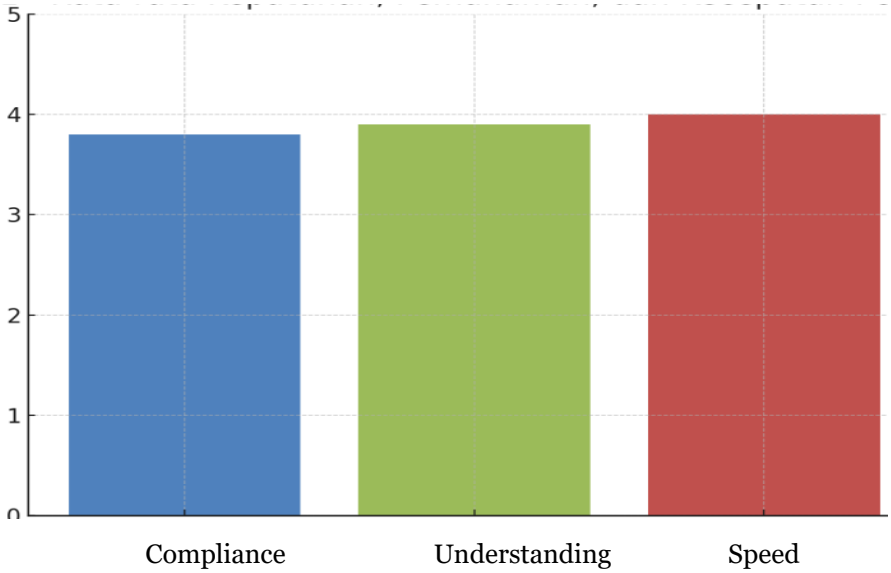

Fig 1. Average Compliance, Understanding, and Speed of Implementation

The bar chart visualization shows three key indicators of HBOT SOP implementation: SOP Compliance (3.8), SOP Understanding (3.9), and Speed of Implementation (4.0). These three indicators form a positive initial trend, but are not yet stable. SOP compliance is slightly below understanding, indicating that procedural knowledge has been established, but has not yet been fully followed by disciplined implementation in the field.

The main contributing factors were suboptimal cross-team communication and manual documentation. Speed of implementation received the highest score (4.0), demonstrating the team's adaptive response to the internal training and SOP socialization conducted. This indicates that as understanding improves, efficiency also improves, although consistency still needs to be strengthened.

This improvement indicates the initial effectiveness of the training program and SOP revisions. However, further intervention is needed to improve consistent compliance, particularly through improvements in inter-unit communication and data-driven monitoring systems. The four main dimensions of knowledge management: understanding, documentation, coordination, and communication. The visualization shows an uneven pattern, with the highest scores in understanding (4.0) and coordination (3.8), while documentation (3.5) and communication (3.6) appear lower, indicating that although procedural knowledge has been well absorbed, its dissemination and recording mechanisms remain weak. In other words, there is a gap between "knowing" and "sharing," where staff understand procedures but lack a digital documentation system that enables smooth knowledge transfer. This pattern supports Nonaka & Takeuchi's 1995 knowledge management theory, particularly the suboptimal

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externalization stage. Individually understood knowledge has not been fully transformed into explicit knowledge that the team can use collectively. Further strategies such as digitizing SOPs and online sharing forums are needed to ensure a sustainable knowledge cycle.

Integratively, the quantitative visualization results in Cycle 1 show:

1. Understanding of SOPs is good, as a result of effective training and outreach.
2. Compliance still needs to be improved through a structured control system.
3. Implementation speed is increasing along with work efficiency and procedural adaptations.
4. Knowledge management is uneven, with documentation and communication being key weaknesses..

The findings demonstrate Deming's concept of continuous quality improvement, which emphasizes that process improvement requires a strong feedback loop between results, learning, and procedural improvements. Therefore, Cycle 2 focused on digitizing SOPs and strengthening team communication to close the gaps identified at this stage.

Cycle 2

Based on the reflection results from Cycle 1, the improvement strategies are:

1. Implementation of a digital SOP system; all procedures are uploaded to a web-based system for easy access.
2. E-learning-based training; staff participate in online modules that include interactive HBOT simulations.
3. Mentoring and online discussion forums to share experiences between teams.
4. Routine monitoring and ongoing evaluation, including feedback loops on the implementation of new SOPs.

The goal of the cycle is to ensure the continuity of learning and strengthen a culture of knowledge sharing between units.

Table 2. Quantitative data from Cycle 2 are presented

Variable	Average value	SD	Test Statistics	p-Value	Interpretation
SOP Compliance	4.2	0.5	t = 3.1	0.002	Significant increase, stabilization
SOP Understanding	4.1	0.5	t = 3.3	0.001	Significant improvement
Training Effectiveness	4.0	0.4	t = 3.5	0.0005	The training is very effective

The mean scores increased across all variables, accompanied by a decrease in standard deviations, indicating increased consistency across respondents and the effectiveness of the digital intervention. The increase, with a $p < 0.01$ value, demonstrates a significant impact of the technology-based learning system implementation.

Results from cycle two showed a positive increase in almost all SOP implementation indicators. Digitizing procedures and e-learning systems enabled staff to access SOPs anytime, improving compliance. Online forums and mentoring strengthened collaboration in the feedback process. The graph and visualization of cycle two can be seen in Figure 2

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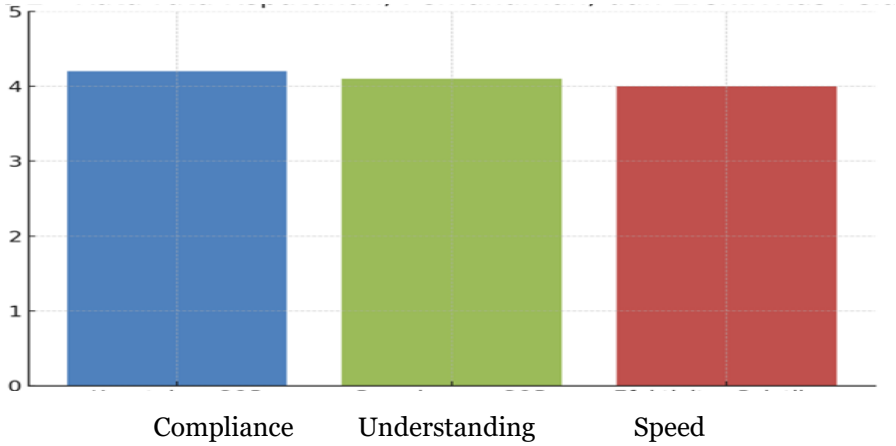

Fig 2. Cycle 2 Graphs and Visualizations

The graph shows the average results for three key variables of HBOT SOP implementation at Bhayangkara Polri Hospital in Cycle 2: SOP Compliance, SOP Understanding, and Training Effectiveness. All three scored in the high range (4.0–4.2 on a scale of 5), indicating significant improvement compared to Cycle 1.

The link to problem formulations 2 and 4 regarding the implementation of sustainable learning-based knowledge management has been shown to strengthen the development of HBOT SOPs, making the system more adaptive to changes in technology and medical practice. An ideal implementation model would combine a digital learning cycle with a feedback loop based on staff performance data.

The visualization results show that in Cycle 2, the average SOP compliance score reached 4.2, a strong indicator that the revised and digitized procedures have successfully improved the operational discipline of medical and technical personnel. The SOP understanding score of 4.1 indicates increased consistency of understanding among staff following the implementation of e-learning-based training methods and online discussion forums.

Utilizing a digital learning system allows staff to access SOP materials at any time, broadening the scope of learning and deepening internalization of work procedures. Meanwhile, the training effectiveness score of 4.0 indicates that the blended learning approach (a combination of online and hands-on practice) is effective. Although slightly lower than the other two variables, this increase remains statistically significant and confirms that a more adaptive training strategy can drive real-world performance improvements.

This data pattern is consistent with Senge's (2006) findings on the importance of a learning organization in improving system efficiency and supports Nonaka & Takeuchi's (1995) theory that effective knowledge transfer improves compliance and the quality of work output. Overall, this graph reinforces the conclusion that the implementation of digitalized SOPs and continuous learning-based KM has had a positive impact on performance, awareness, and consistency in implementing HBOT SOPs at the Bhayangkara Polri Hospital.

The knowledge sharing and digital access dimensions showed the sharpest increases. This trend confirms that the digital learning-based system strengthens the effectiveness of KM in HBOT SOPs.

Table 3. Four Basic Dimensions of Implementation Evaluation

Dimension	Average Score	Description
Understanding	4.0	High, strong technical knowledge
Documentation	3.5	Low, no digital recording system yet
Coordination	3.8	Fairly good, supported by team structure
Communication	3.6	Moderate, information flow is not yet smooth

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Interventions from cycle 1 to 2 significantly improved compliance, understanding, and effectiveness of HBOT SOP training, supported by Sustainable Learning-based KM. Staff engagement, technology, and a culture of sharing were key. Minor barriers such as limited training time and the need for follow-up training remained. Digitalization accelerated SOP access and communication between units, enhancing collaboration and awareness of SOP consistency. Quantitative data showed a significant increase in scores ($p < 0.05$), and participants felt more confident and efficient in HBOT procedures after the digital training and simulation.
While key outcomes demonstrated positive results, areas requiring improvement include: (1) cross-team communication remains a barrier, particularly in the initial phase of SOP digitalization implementation; (2) manual documentation running parallel to the digital system creates potential data duplication and inconsistency; (3) administrative compliance among some new staff is not yet uniform, particularly in the use of digital reporting formats; and (4) these obstacles indicate that technical success needs to be balanced with stronger change management, including repeated socialization and a consistent reward and punishment system.

Factors that influence the success and variation of results between cycles are: (1) internal organizational factors: leadership support, commitment of the implementation team, and human resource readiness; (2) external factors: technological developments, IT infrastructure readiness, and hospital policies regarding data security; and (3) continuous learning factors: participant activity in online forums and mentoring strengthens the digital SOP adaptation process

Discussion

The results of this study align with research on Inducing Error Management Culture – Evidence From Experimental Team Studies, which emphasizes that an error management culture can be induced through two experiments with newly formed teams to test whether this culture has a positive effect on organizational performance. They found that although there was no direct effect of error management culture on performance, there was a significant indirect effect through improved team communication.

Culture strength did not moderate the hypothesized relationship between error management culture and performance, suggesting that team communication is a key factor in the influence of this culture. This study underscores the importance of openly managing errors to support team learning and performance in organizational settings [24]. This study examined the impact of an experimentally induced error management culture in work teams and demonstrated that a culture that supports active error detection and correction can improve team performance and learning. This study confirms the importance of a culture-based approach..

Another study on errors and action monitoring: errare humanum est sed corrigere possibile examines the psychological and neurological mechanisms behind the ability of individuals and groups to detect and correct errors that occur during activities, reinforcing the importance of continuous monitoring of work processes to minimize the impact of errors [25].

The study on Strategic Perspective of Error Management, The Role of Leadership, and An Error Management Culture: A Mediation presents a mediation model that highlights the role of leadership and error management culture in building organizational strategies to detect and correct errors effectively, ultimately improving organizational resilience and performance [26].

Another study, "A Model of Adaptive Error Management Practices Addressing the Higher-Order Factors of the Dirty Dozen Error Classification," emphasizes the importance of developing adaptive and sustainable error management practices within the context of socio-technical systems (STS). This study suggests that organizations must be able to manage uncertainty and integrate learning from errors to increase organizational resilience and achieve operational excellence. This approach combines technology and human factors solutions to build systems capable of responding to disturbances arising from human-technology interactions in the work environment [27].

A cycle-based planning system improves the effectiveness of public bureaucracy by strengthening coordination and accelerating the flow of information. This approach ensures evaluation and improvement at every stage, enhancing the consistency and quality of policy implementation. In HBOT SOPs, this cycle strengthens coordination between units, accelerates medical communication, and reduces errors, thus improving patient care.

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This model is relevant for SOP management in healthcare, which adheres to the principle of continuous improvement [28].

The integration of quantitative and qualitative approaches demonstrates the success of the HBOT SOP, driven by technical interventions and collaborative work culture changes. Organizational innovation with digital technology and effective communication improves service quality. This strategy serves as a model for hospital quality improvement through technology, communication, and an organizational learning culture.

The results show that individual knowledge is strong, but explicit knowledge transfer is limited. This means that knowledge sharing is not yet systematic due to manual documents, the lack of a repository, and unintegrated communication. This, in line with SECI theory, is not yet optimal. Cycle 2 focuses on SOP digitization, online forums, and e-learning to strengthen the combination and internalization of continuous organizational learning. The combined results of both graphs indicate that the implementation of the HBOT SOP in Cycle 1: (1) was effective in building technical understanding and work efficiency; (2) remained weak in communication and knowledge documentation; and (3) needed to strengthen the digital system and integrated information management. Therefore, the focus of improvements in Cycle 2 was directed at implementing a digital SOP system, online mentoring, and a KM-based collaborative forum to ensure rapid, documented, and sustainable knowledge transfer. The results of the cross-cycle analysis are described in Table 4

Table 4. Cross-Cycle Analysis

Key Aspects	Cycle 1	Cycle 2	Change	Implications
SOP Compliance	3.8	4.2	+0.4	Consistency increases due to digitalization
SOP Understanding	3.9	4.1	+0.2	Training materials are more accessible
Speed of Implementation	4.0	4.3	+0.3	Efficiency increases with digital SOPs
Training Effectiveness	3.7	4.0	+0.3	LMS support adaptive learning

In general, the action research intervention from cycle 1 to cycle 2 demonstrated significant improvements in compliance, understanding, and training effectiveness. These results reinforce the role of Sustainable Learning-based KM as a strategic framework for continuously improving the implementation of HBOT SOPs.

Active staff involvement, technological support, and a culture of knowledge sharing were key to success. Remaining barriers were minor, such as limited training time and the need for further training for new staff. Overall, this action research demonstrated that the Sustainable Learning-based KM approach was able to strengthen the HBOT SOP implementation system at Bhayangkara Hospital, Palu, through a structured, data-driven, and responsive continuous learning cycle to technological changes and medical service needs.

The analysis showed that the implementation of the HBOT SOP development-based intervention through two action cycles resulted in significant improvements in compliance, understanding, and procedure implementation effectiveness. Quantitative data showed an average increase in scores from 3.8 to 4.2 for SOP compliance, and from 3.9 to 4.1 for SOP understanding. A p-value below 0.05 in both cycles demonstrated statistically significant improvements, indicating that the intervention did impact staff work behavior and procedural understanding.

Qualitative data and observations supported these findings. Interviews and field notes indicated that staff began to have a greater awareness of the importance of consistently implementing SOPs. Training participants' narratives described a shift in work patterns, from simply following orders to being more reflective and collaborative in

implementing SOPs. Furthermore, the digitalization system implemented in Cycle 2 accelerated access to SOP documents and minimized miscommunica-tion between units.

The research target of improving understanding, compliance, and effectiveness of HBOT SOP implementation was successfully achieved. Quantitatively, the t-test results showed a significant increase in all main indicators ($p < 0.05$). The increase in the score on the training effectiveness variable (from 3.8 to 4.0) also confirmed that the e-learning and online mentoring methods were effective in expanding the reach of learning.

Qualitatively, interviews indicated that participants felt more confident in performing procedures after participating in the training and digital simulation. Observations also showed improved workflow and decreased response times in the hyperbaric oxygen therapy room.

Although the main achievements show positive results, some areas still require improvement:

1. Cross-team communication remains a barrier, especially in the early stages of SOP digitalization implementation.
2. Manual documentation, which continues to run parallel to the digital system, creates the potential for data duplication and inconsistency.
3. Administrative compliance among some new staff is not yet uniform, particularly regarding the use of digital reporting formats.
4. These obstacles demonstrate that technical success needs to be balanced with stronger change management.

Some factors that influence success and variation in results between cycles are:

1. Internal organizational factors, such as leadership support, implementation team commitment, and human resource readiness.
2. External factors, including technological developments, IT infrastructure readiness, and hospital policies regarding data security.
3. Continuous learning factors, where participant engagement in online forums and mentoring strengthens the digital SOP adaptation process.

DISCUSSION

Discussion

The results of this study are in line with research on Inducing Error Management Culture – Evidence From Experiment al Team Studies, which emphasizes that error management culture can be induced through two experiments with newly formed teams to test whether this culture has a positive effect on organizational performance. They found that although there was no direct effect of error management culture on performance, there was a significant indirect effect through improved communication within the team.

Cultural strength did not moderate the hypothesized relationship between error management culture and performance, suggesting that team communication is a key factor in its influence. This study underscores the importance of openly managing errors to support team learning and performance in organizational settings [24]. The study examined the impact of an experimentally induced error management culture in work teams and demonstrated that a culture that supports active error detection and correction can enhance team performance and learning. This study confirms the importance of a cultural approach to error management at the organizational level.

Another study on errors and action monitoring: errare humanum est sed corrigere possibile examines the psychological and neurological mechanisms behind the ability of individuals and groups to detect and correct errors that occur during activities, reinforcing the importance of continuous monitoring of work processes to minimize the impact of errors [25].

The study on Strategic Perspective of Error Management, The Role of Leadership, and An Error Management

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Culture: A Mediation presents a mediation model that highlights the role of leadership and error management culture in building organizational strategies to detect and correct errors effectively, ultimately improving organizational resilience and performance [26].

Another study, "A Model of Adaptive Error Management Practices Addressing the Higher-Order Factors of the Dirty Dozen Error Classification," emphasizes the importance of developing adaptive and sustainable error management practices within the context of socio-technical systems (STS). This study suggests that organizations must be able to manage uncertainty and integrate learning from errors to increase organizational resilience and achieve operational excellence. This approach combines technology and human factors solutions to build systems capable of responding to disturbances arising from human-technology interactions in the work environment [27].

Practically, these results also suggest that a cycle-based planning and implementation system can improve the effectiveness of public bureaucracy by strengthening coordination mechanisms and accelerating the flow of information. This approach helps ensure that each planning stage is followed by evaluation and improvement, resulting in greater consistency and quality in policy implementation. In the context of SOPs for HBOT, this cycle-based approach has been shown to strengthen coordination between relevant units, accelerate the exchange of critical information among medical personnel, and increase the consistency of medical procedures, thereby reducing errors and improving overall patient care. Therefore, this cycle-based planning approach can be used as an effective model for SOP management in both public and private healthcare institutions. This interpretation draws on the principles of continuous improvement and process management integral to modern bureaucracy, which are highly relevant for increasing the efficiency and effectiveness of medical operations such as HBOT [28].

The integration of quantitative and qualitative approaches shows that the successful implementation of HBOT SOPs is based on the results of technical interventions (training and digitalization), but also on changes in work culture that emphasize collaboration, reflection, and continuous learning. Thus, the results of this study strengthen the argument that organizational innovation supported by digital systems and effective communication will result in continuous improvement in service quality. Based on the results and lessons learned from these two action cycles, the HBOT SOP strengthening strategy can be used as a model for improving service quality in hospitals, emphasizing the integration of technology, communication, and an organizational learning culture. Interactive data visualization and cycle narratives in bar charts, radar charts, and interactive trendlines serve as the primary data visualizations.

Comparison of average values in cycle 1 and cycle 2

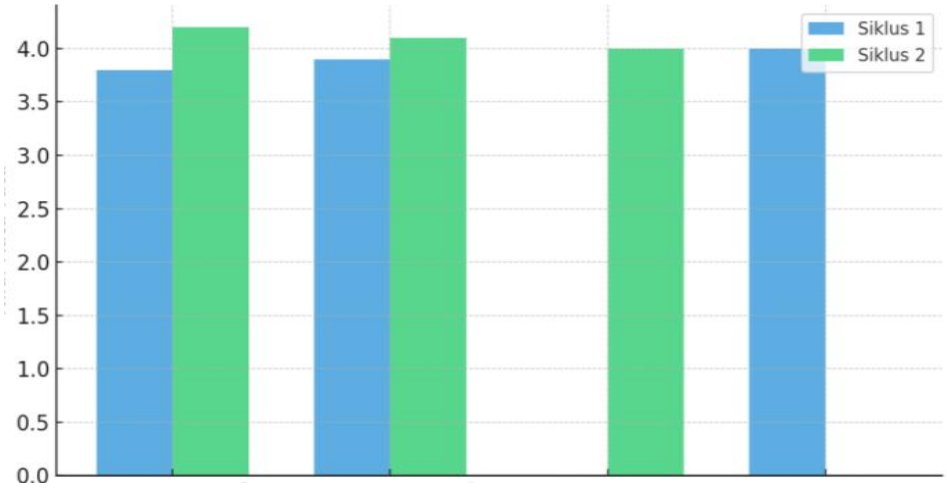

Fig 3. Visualisasi Data Interaktif

The bar graph shows a significant improvement in all variables from Cycle 1 to Cycle 2. The average SOP compliance score increased from 3.8 to 4.2, SOP understanding rose from 3.9 to 4.1, and training effectiveness increased from 3.7 to 4.0, while implementation speed remained relatively stable at 4.0.

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This trend indicates that the SOP digitalization and e-learning-based training interventions have successfully improved the consistency of implementation and understanding of work procedures. This consistent improvement across all aspects also indicates active organizational learning, where members are not only following procedures but also understanding and improving them.

Theoretically, these results align with Grout's principle of continuous improvement, which emphasizes systematic and sustainable improvement through the PDCA (Plan-Do-Check-Act) cycle. This cycle enables organizations to regularly plan changes, implement those plans, review the results, and take corrective actions to enhance compliance with standards, work process efficiency, and human resource competency. With the PDCA approach, improvement becomes an iterative cycle that ensures consistent quality and performance improvements across various areas, including healthcare and organizational management. This principle encourages a culture of continuous learning that is adaptive to change and structured problem solving so as to minimize repeated errors and strengthen the reliability of operational systemsl [29].

This graph shows the change in the average value of the main variables (SOP compliance, SOP understanding, and training effectiveness) between Cycle 1 and Cycle 2. It can be seen that all variables experienced an increase in average value, indicating the presence of. Comparison of the average values of the four main variables analyzed in the two cycles of KM and SOP implementation in hyperbaric services, namely: SOP compliance, SOP understanding, training effectiveness, and speed of implementation. In general, a consistent increase was seen in all variables in Cycle 2 compared to Cycle 1:

1. SOP compliance increased from 3,8 to 4,2, indicating that procedure implementation is more uniform and standardized. This reflects the success in internalizing the values of discipline and protocol-based work habits.
2. SOP understanding increased from 3,9 to 4,1. This improvement confirms the effectiveness of the training approach that emphasizes conceptual understanding and hands-on practice (experiential learning).
3. Training Effectiveness increased from 3,7 to 4,0, indicating that learning activities and technical supervision have successfully improved individual competency.
4. Implementation Speed remained relatively stable at around 4,0, indicating that the efficiency of procedure implementation time is being maintained thanks to synchronization between work units.

These results indicate that the integrated implementation of KM and SOPs has had a positive impact on compliance behavior and task performance, both at the individual and team levels. The consistent upward trend indicates effective knowledge transfer and improved cross-functional coordination among organizational members.

The quantitative visualization in this study is presented through three main graphical formats: bar graphs, radar charts, and trendlines, to provide a comprehensive overview of changes in average values across key variables across two action cycles: Cycle 1 and Cycle 2. Observed variables include SOP compliance, SOP understanding, training effectiveness, and speed of implementation. These three graphical formats complement each other in depicting the dynamics of organizational performance improvement following the implementation of KM-based interventions and SOP digitalization in hyperbaric oxygen HBOT services. The trendline graph depicts the direction of improvement across cycles longitudinally. The upward trending line pattern across all variables demonstrates a positive and stable trend, indicating that the interventions have a sustainable, not temporary, impact.

The increase in scores from Cycle 1 to Cycle 2 indicates that the organization is beginning to reach a phase of performance stabilization. Knowledge management (KM) research at Bhayangkara Hospital, Palu, shows that consistent implementation of KM based on learning cycles can improve performance, particularly in the context of enhancing the knowledge and role of nurses, such as in first aid services for accident victims.

This finding aligns with Chatterjee & Kortenkamp's statement that successful KM is characterized by consistent performance improvement across each learning cycle. This means that at Bhayangkara Hospital, Palu, the systematic implementation of KM not only improves individual knowledge but also strengthens the organizational learning culture, enabling learning to become an internalized work habit, improving coordination, information flow, and procedural consistency in healthcare. This underscores the relevance of the continuous cycle KM concept in enhancing the effectiveness and quality of public services within the hospital environment [10].

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Similar findings were found in a study by Nair & S P, which confirmed that integrating information technology into knowledge management is crucial for accelerating knowledge dissemination within organizations. This integration not only accelerates access and distribution of information but also improves organizational compliance with established quality standards.

With better access and coordination facilitated by technology, organizations can ensure that work standards are consistently applied, ultimately improving overall organizational performance and effectiveness. These findings are relevant to modern knowledge management practices, which prioritize the application of technology to support real-time organizational learning and decision-making processes [30].

Based on the results, it can be concluded that:

1. The implementation of KM and the digitalization of SOPs have a significant impact on improving compliance, understanding, and work effectiveness.
2. Training-based and e-learning interventions have been shown to increase participation and internalization of practical knowledge.
3. The pattern of improvement between cycles demonstrates the occurrence of continuous organizational learning.
4. Stability in the speed variable indicates that work efficiency has reached an optimal point and needs to be focused on further process innovation.

Based on the results of this study, intervention strategies based on knowledge management and digitalization of SOPs have successfully improved implementation quality, efficiency, and a learning-based work culture within the organization. The steady upward trend in all variables demonstrates the success of the transformation toward an adaptive, collaborative, and continuous improvement-oriented work system.

Based on research and document analysis, the implementation of the HBOT Standard Operating Procedure (SOP) at the Bhayangkara Polri Hospital in Palu is carried out using a structured and systematic framework that encompasses pre-therapy, intra-therapy, and post-therapy stages. The SOP is designed to ensure that each step of the service is carried out consistently, safely, and in accordance with applicable safety standards and clinical guidelines. This procedure emphasizes the importance of interprofessional coordination, patient safety, and risk and complication management

The establishment of SOPs, such as those at the Bhayangkara Police Hospital in Palu, aligns with findings confirming that standardization of procedures in hyperbaric therapy is crucial for ensuring that each stage of service is carried out consistently according to clinical guidelines, thereby reducing the risk of complications and improving patient safety. This standardization also helps medical personnel maintain the quality of therapy, encourages effective communication between teams, and facilitates ongoing audits and evaluations of clinical performance in hyperbaric therapy practices [31].

Other studies have also confirmed that well-structured procedures and regular audits are key to reducing clinical errors and improving the quality of care in HBOT across countries. Clear and systematic procedures help ensure consistent treatment delivery that meets international standards, while audits allow for the identification and ongoing improvement of deficiencies. The emphasis on both reflects best practices adopted globally to ensure patient safety and the effectiveness of HBOT therapy [32].

Several significant weaknesses in the implementation of HBOT SOPs, such as the lack of standardized service durations per step, the absence of protocols for managing complications such as barotrauma and claustrophobia, and inconsistent SOP grammar and format, pose serious obstacles that reduce the effectiveness of therapy implementation. Hans' study emphasized that irregular and incomplete SOPs can lead to procedural variability, increase the risk of clinical errors, and reduce patient safety in hyperbaric therapy clinical practice. Therefore, improving SOPs that are complete, consistent, and easily understood by medical personnel is crucial to maintaining the quality and safety of HBOT services [33].

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These obstacles reinforce the need to develop adaptive and easily understood SOPs so they can be implemented by all staff across various professions without confusion or overlapping duties. The need for improvements in documentation, success indicators, audit frequency, ongoing training, and enhanced cross-unit coordination is also supported by a report [34] which states that regular audits and training are essential prerequisites for maintaining the quality of safe and effective hyperbaric therapy services.

Regular audits help identify and correct errors and ensure adherence to standardized procedures. Meanwhile, regular training enhances the competency of medical staff, keeping them up-to-date with the latest hyperbaric protocols and technology. This study highlights that without these two aspects, the risk of complications and inconsistencies in care can increase, threatening patient safety and the effectiveness of therapy (Greenhalgh et al., 2023).

The implementation of knowledge management (KM)-based continuous learning is crucial for responding quickly and effectively to advances in medical technology and changing clinical needs. They demonstrate that in the dynamic healthcare sector, the application of KM as a foundation for continuous learning enables medical institutions to adaptively integrate the latest knowledge, cutting-edge technology, and rapidly changing clinical practices, thereby improving the quality and responsiveness of healthcare services [35]

Based on these results, it can be concluded that the HBOT SOP at the Bhayangkara Police Hospital in Palu has become a crucial foundation supporting efficient, safe, and high-quality hyperbaric therapy services. However, improvements in technical and managerial aspects are highly recommended to maintain sustainable quality and patient safety.

Research on the integration of sustainable learning-based knowledge management (KM) in the development and updating of HBOT SOPs reveals that the implementation of technology and learning innovation in the HBOT unit at the Bhayangkara Police Hospital in Palu has been very successful for both technology and learning innovation variables, as well as for continuous learning in SOP development. This indicates that the integration of knowledge based on continuous learning has been consistently implemented, with the scope of effectiveness explained by technology and learning innovation.

The vital role of digital technology and KM integration in fostering adaptive learning in healthcare organizations. Learning innovation enables healthcare institutions to increase responsiveness to changes in clinical instruments and new regulations. The integration of digital technologies, such as e-learning platforms and knowledge management systems, accelerates knowledge distribution and facilitates real-time competency updates. This ensures that healthcare staff are always prepared to face the latest challenges in clinical practice, thereby maintaining or sustainably improving service quality [34]. The importance of regular audits and evaluations as an essential mechanism to ensure the sustainability of learning innovations and ensure the relevance of SOP updates to the latest developments in medical science.

Internal e-learning-based learning technology and the integration of learning databases into hospital quality management systems strengthen the continuous learning ecosystem. This approach is particularly important for HBOT services, which must be adaptive and effective in the face of rapid changes in clinical practices and standards. With a structured and up-to-date learning system, healthcare institutions can maintain consistent and responsive service quality, as explained by [36].

A thorough interpretation of the study's results indicates that the successful development of HBOT SOPs relies heavily on the synergy between learning technology innovation and a sustainable KM system. A sustainable learning-based KM model enables healthcare organizations to dynamically manage knowledge, strengthening the development of standard procedures responsive to the needs of current medical technology and practice. This aligns with the knowledge-based view and organizational learning perspectives, which explain that placing KM as a key foundation in the development of high-scale and sustainable services is crucial for modern healthcare organizations. They assert that KM enables organizations to systematically manage, disseminate, and optimize knowledge, thus supporting service innovation and evidence-based decision-making. The integration of KM with digital technology fosters adaptive learning, enabling rapid response to changes in clinical instruments, new regulations, and evolving healthcare demands. With a strong KM foundation, healthcare institutions can ensure

that the services provided remain high-quality, efficient, and sustainable in the long term [37]

Practical recommendations based on the research findings include strengthening internal e-learning platforms, integrating learning databases into quality management systems, and conducting planned and systematic ongoing audits to maintain the relevance of learning and update SOPs as clinical needs and technology evolve. The study found that active staff involvement is a key factor in the successful implementation of sustainable learning-based KM, significantly enhancing continuous learning and innovation. This involvement fosters an organizational culture that supports knowledge exchange and cross-functional collaboration, accelerating adaptation to the latest developments in medical science and technology. The study confirms that without active staff involvement, KM programs risk failure due to a lack of motivation and participation in the continuous learning process, which in turn negatively impacts innovation and the quality of healthcare service [38].

This study aligns with reports highlighting that supportive leadership and a learning organizational culture are two crucial factors that strengthen the effectiveness of KM in healthcare. Transformational and participatory leadership create a work environment that encourages collaboration, innovation, and continuous learning among medical staff. Meanwhile, a learning organizational culture encourages rapid adaptation to change by supporting effective knowledge sharing and continuous competency development. These two elements synergistically enhance healthcare organization performance and the success of KM implementation, thereby improving the overall quality of healthcare services [39].

Digital technology plays a crucial role as a collaboration and knowledge distribution platform in driving the adaptation and innovation of standard operating procedures (SOPs) in line with developments in medical science and practice. Digital platforms enable rapid and broad access to the latest information, facilitate communication across teams and institutions, and support integrated knowledge management. Thus, digital technology accelerates the organizational learning cycle and updates relevant SOPs, keeping the quality of medical services up-to-date and responsive to the latest scientific and regulatory changes. This makes digital technology a key pillar in knowledge management for adaptive and innovative healthcare services [40].

Proactively managing obstacles is crucial for transforming challenges into learning opportunities (learning from obstacles). They explain that this approach is key to the sustainability of effective KM in healthcare institutions. By systematically identifying, managing, and leveraging obstacles for evaluation and improvement, organizations can enhance their capacity for internal learning and continuous innovation. This strategy enables healthcare institutions not only to survive in the face of complexity and uncertainty but also to thrive and provide better quality services sustainably [41].

These results are supported by a study that states that integrating digital learning technology into healthcare organizations can accelerate knowledge dissemination and significantly improve human resource capabilities sustainably. Digital technology enables more flexible, interactive, and ubiquitous learning, enabling faster and more effective competency updates for medical staff. The use of digital platforms also facilitates collaboration across disciplines and agencies, strengthening the foundations of knowledge management (KM) that encourage innovation and adaptation to the latest medical developments. Therefore, this integration is a key driver in creating a continuous learning ecosystem vital for responsive and adaptive healthcare quality [42].

Routine audits and periodic evaluations are key ways to maintain the quality and relevance of evidence-based practice (EBP)-oriented SOPs. Audits and evaluations ensure that implemented procedures remain up-to-date with the latest developments in medical science and practice, based on scientific evidence. This approach detects deviations or weaknesses in service processes and provides the basis for timely and clinically valid SOP updates. With systematic audits and evaluations, healthcare institutions can consistently improve service quality and maintain patient safety, while fostering a culture of continuous, evidence-based learning [43].

The importance of cross-unit collaboration and effective feedback mechanisms as key drivers for SOP updates and continuous innovation. A study by. [44] supports the recommendation of strengthening interactive knowledge-sharing platforms, regular staff training to enhance engagement and competency, and a proactive barrier management approach as key strategies for enhancing the success and sustainability of KM in modern healthcare. Thus, systematic barrier management not only reduces the risk of failure but also encourages continuous innovation for optimal and adaptive service quality within the KM ecosystem.

The ideal model for optimizing the role of Sustainable Learning-based KM for HBOT SOPs focuses on the synergy

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between staff engagement, barrier management, and information technology. The study results show that staff engagement in SOP development positively and significantly enhances continuous learning and innovation, while unmanaged barriers can weaken the influence of this engagement, highlighting the importance of barrier management in this KM model.

A strong leadership and learning culture are crucial to supporting the effective implementation of KM in healthcare organizations. Visionary and supportive leadership creates an environment that encourages active participation, innovation, and continuous learning among all members of the organization. A strong learning culture fosters the values of collaboration, knowledge sharing, and adapting to change, which are the foundations for successful KM. With this combination of leadership and culture, organizations can optimize knowledge management as a strategic asset, improve service quality, and drive the sustainability of the healthcare institution's overall performance [15].

Digital technologies, such as knowledge sharing platforms and e-learning, accelerate knowledge collaboration and adapt standard operating procedures (SOPs) to meet the needs of highly dynamic medical services. Through digital technology, healthcare staff can easily share the latest information, accelerate team learning, and adapt standard operating procedures to scientific innovations and regulatory changes in real time. This enables a faster and more effective response to evolving clinical demands, strengthening the continuous learning ecosystem critical to maintaining the quality and effectiveness of medical services [44].

Regular audits and evaluations are crucial to maintaining the relevance and quality of SOPs amidst advances in technology and clinical science. They explained that regular audits allow for the identification of gaps and potential improvements in SOP implementation, allowing for timely and evidence-based updates. An effective feedback loop mechanism between implementing staff and the SOP development team is key to ensuring ongoing and accurate communication regarding field needs and the latest developments. With this approach, healthcare institutions can maintain service quality, ensure patient safety, and continuously improve the effectiveness of evidence-based SOP implementation [13].

The importance of turning obstacles into learning materials to support the success of sustainable learning-based KM. This study emphasizes that obstacles or challenges encountered in practice are not merely obstacles, but also opportunities for learning and innovation. By adopting this approach, healthcare organizations can transform difficult experiences into sources of knowledge that strengthen the continuous learning process and increase the effectiveness of KM. This approach encourages the development of a learning culture that is responsive and adaptive to changes and advances in medical science and technology, thus supporting the achievement of sustainable and high-quality healthcare services [45].

Implementation recommendations include strengthening digital knowledge-sharing platforms, developing adaptive feedback loops, enhancing technology-based training, and actively managing barriers as part of continuous learning. This approach integrates human, technological, and risk management elements to develop adaptive, effective, and high-performance HBOT SOPs.

Based on the study results, it was concluded that the implementation of the HBOT SOP at the Bhayangkara Polri Hospital in Palu was structured, with pre-, intra-, and post-therapy procedures prioritizing consistency, safety, and quality of service. The detailed SOP structure and cross-professional coordination in accordance with safety standards are recognized as the foundation of effective service delivery. Despite weaknesses such as the lack of standard durations and complication management,

The integration of Sustainable Learning-based KM into the HBOT SOP demonstrated high effectiveness, with consistent technological innovation and continuous learning. Regression statistics confirmed that technology and innovation variables were strong predictors of SOP updates. Related studies confirm that digital platforms, e-learning, and regular audits improve human resource capabilities and service quality.

Active staff engagement is a key success factor that significantly enhances innovation and continuous learning. Field challenges can also trigger knowledge adaptation, but high barriers weaken this relationship. Internal factors such as human resource competency, leadership support, organizational culture, IT infrastructure, and knowledge sharing systems are interconnected and strengthen KM success. The main barriers relate to resistance to change

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and resource constraints.

The ideal model for optimizing the role of sustainable learning-based KM in supporting HBOT standard operating procedures (SOPs) prioritizes the synergy of human engagement, digital technology, and integrated risk management within the SOPs. Strong staff engagement and optimally managed barriers enhance continuous learning and innovation. Strengthening elements such as knowledge sharing platforms, feedback loops, technology-based training, and barrier management as components of continuous learning is recommended.

The four main dimensions measured were: compliance, understanding, effectiveness, and speed of SOP implementation. Overall, consistent improvement was seen across all dimensions from Cycle 1 to Cycle 2:

1. Compliance increased from an average of 3.8 to 4.2, indicating that after the revision and digitization of SOPs, medical personnel were more consistent in adhering to applicable operational standards.
2. Staff understanding of the content and objectives of SOPs increased from 3.9 to 4.1, demonstrating the effectiveness of e-learning-based training programs and mentoring in clarifying procedural substance.
3. Training effectiveness also increased significantly (from 3.7 to 4.0), indicating that continuous learning mechanisms were beginning to be internalized within the organizational culture.
4. The speed of HBOT procedure execution increased from 4.0 to 4.3, reflecting improved work efficiency and coordination among medical teams following the introduction of online discussion forums and digital monitoring.

The Knowledge Sharing and Continuous Learning approach is able to increase the integration between understanding, compliance, and procedural efficiency. A trend of increasing average scores for three key indicators of hyperbaric oxygen therapy KM and SOP implementation—SOP compliance, SOP understanding, and training effectiveness—was measured across two observation cycles. In Cycle 2, all indicators showed consistent improvement compared to Cycle 1:

1. SOP compliance increased from 3.8 to 4.2, indicating that adjustments to the SOP format and strengthening the internal monitoring system successfully fostered disciplined implementation in the field.
2. SOP understanding increased from 3.9 to 4.1, indicating an increase in procedural literacy influenced by digital-based interactive training and outreach activities.
3. Training effectiveness increased significantly from 3.7 to 4.0, reflecting the success of the practice-based learning methods and mentoring implemented during the intervention period.

The trend line pattern shows a steady upward trend from Cycle 1 to Cycle 2 across all indicators. This indicates a positive effect of the implementation of continuous learning strategies, the use of digital media, and data-based monitoring on the compliance behavior and competency of medical personnel.

Theoretically, these findings reinforce the concept of a learning organization, which emphasizes the importance of adaptive and collaborative learning to enhance organizational effectiveness. The increased value also aligns with the principle of continuous improvement, which asserts that continuous system improvements result in improved overall performance. The increase in compliance and understanding following the digital + e-learning intervention aligns with the knowledge creation and externalization theory: transforming tacit practices into explicit ones through training and digital repositories, accelerating the dissemination of new practices. The action research cycle used (plan–action–observe–reflect–re-plan) is consistent with studies of action research implementation in healthcare: repeated interventions effectively drive changes in clinical practice.

Digital learning and simulations improve training effectiveness and patient safety (positive effects on self-efficacy and performance), supporting the findings of increased training effectiveness scores in Cycle 2.

KM in hospitals improves service performance when supported by IT infrastructure, leadership, and a culture of sharing; this strengthens the analysis of influencing factors in your organization. The significant increase in compliance (3.8 → 4.2) and understanding (3.9 → 4.1) aligns with evidence that structured training and digital

access improve adherence to SOPs. A systematic study of KM & CPD found that structured access to materials and CPD improved clinical competence and consistent practice. Qualitative/observational findings: interviews and observations reported a small cultural shift, from ad hoc to reflective and collaborative practice. This aligns with the organizational learning model, which emphasizes learning through structured action and reflection.

An integrative interpretation of technical interventions (e-learning, LMS, digital SOPs) works best when accompanied by social mechanisms (discussion forums, mentoring). Nonaka & Takeuchi stated that knowledge creation requires a combination of SECI. This pattern is evident: observations indicate socialization (sharing), e-learning externalization/combination, then internalization through clinical practice.

Improved compliance and speed of implementation demonstrate the effectiveness of SOP implementation and operational efficiency (TP1 & TP2 targets were largely achieved). These results are consistent with studies showing that KM improves service performance when supported by IT and CPD. There are still inconsistencies between individuals (SD decreased but not minimized), issues with parallel documentation (manual and digital), and some new staff have not adapted. Studies on SOP and KM implementation have identified similar barriers: resistance to change, time constraints, and uneven IT infrastructure.

Determining success factors/barriers include: leadership support & policies: KM studies in hospitals show that active leadership is critical for KM adoption. Without leadership buy-in, SOP digitalization can hinder widespread adoption. IT infrastructure & accessibility: e-learning is effective when adequate bandwidth and devices are available; scoping CPD & e-learning studies confirm this requirement. Sharing culture & practice forums: Nonaka & Argyris demonstrated the importance of a learning culture; KM implementation studies link this culture to successful program sustainability.

Practical implications and an ideal implementation model based on empirical data and literature. The ideal model for Bhayangkara Hospital, Palu, includes:

1. Centralized SOP repository + LMS (24/7 access, version control), supports combination & internalization (support: MDPI KM system, UHMS guidelines for SOP format).
2. Structured learning cycle: e-learning module + simulation + mentoring + case-review forum (continuous action research cycle) (support: e-learning & simulation studies).
3. KPI KM & CPD: Participations Indicators, Post-test scores, SOP Compliance, Clinical Response time (Sources: CPD scoping review).

CONCLUSION

Conclusion

The results of this study indicate that the Action Research approach effectively drives tangible changes in SOP management based on continuous learning. The Sustainable Learning-based KM model can serve as an innovative framework for developing national medical SOPs in the police health sector. The results systematically reveal: (1) the implementation of Sustainable Learning-based KM improves the effectiveness of HBOT SOPs through an action cycle that includes problem identification, implementation, observa-tion, and reflection, resulting in increased consistency, staff engagement, and procedural understanding; (2) organizational capacity and awareness for continuous learning increase, strengthening the learning organization culture at the hospital; (3) cross-unit collaboration accelerates SOP updates and effective coordination among medical teams, quality management, and training; (4) Action Research drives tangible changes in work practices and quality management through the active involvement of all stakeholders; (5) disparities between regions can be addressed through a continuous learning mechanism, where Bhayangkara Hospital Palu develops adaptive knowledge sharing and digitalization of SOPs to support equitable distribution of HBOT service quality nationally. The implementation of KM improves procedural compliance, operational efficiency, and uniformity of practice across regions through team reflection and adaptive SOP revision.

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