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Holistic intelligence and smart organization affecting the performance of standard medical laboratory guidelines of medical technologists at community hospitals in Health Region 7

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ABSTRACT

Background: Medical laboratories are vital components of healthcare systems in community hospitals, serving as frontline facilities in public healthcare. The development of laboratory quality standards requires comprehensive improvement in personnel and organizational aspects to ensure public confidence and safety in service delivery.

Objective: This cross-sectional descriptive research aimed to study the effects of holistic intelligence and intelligent organization on medical laboratory standard practices among medical technologists in community hospitals within Health Region 7.

Materials and methods: The sample consisted of 187 medical technologists from community hospitals in Health Region 7, selected through stratified random sampling proportionally by province, followed by simple random sampling within each province. Data were collected between November 13-23, 2024, using an online questionnaire validated for content by three experts, with an overall reliability coefficient of 0.988. Data analysis employed descriptive statistics, Pearson's correlation coefficient, and stepwise multiple linear regression.

Results: The results revealed that overall holistic intelligence was at a high level (Mean=4.12, SD=0.45), overall intelligent organization was at a high level (Mean=3.80, SD=0.65), and overall adherence to medical laboratory standards was at a high level (Mean=4.27, SD=0.49). Both holistic intelligence and intelligent organization showed statistically significant moderate positive correlations with medical laboratory standard practices (r=0.599, p<0.001 and r=0.557, p<0.001, respectively). Predictive factor analysis identified organizational learning system co-creation (B=0.266), moral and ethical intelligence (B=0.262), and emotional intelligence (B=0.213) as significant predictors, collectively explaining 47.2% of the variance in medical laboratory standard practices (R^2adj=0.472).

Conclusion: Based on these findings, relevant agencies should develop organizational learning systems through the establishment of learning centers and mentoring systems, enhance moral and ethical intelligence through training and knowledge exchange, and improve personnel emotional management skills to elevate the quality and safety standards of medical laboratory operations in community hospitals.

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Introduction

The 20-Year National Strategy (2018-2037) encompasses strategic initiatives to create social opportunities and equality, address disparities, and ensure equitable access to quality healthcare services across all regions. It emphasizes a citizen-centric approach, prioritizing

responsive, efficient, and transparent service delivery.[1] Medical laboratories in community hospitals provide essential analytical services and facilitate specimen referrals for specialized testing to accredited external facilities. These laboratories play a crucial role in public health systems, generating vital data for diagnosis, treatment monitoring, and disease surveillance. Furthermore, their findings inform healthcare policy development and public health service planning. Quality and standardization in medical laboratory operations significantly enhance public health service system efficiency and outcomes. The 2019 Medical Laboratory Standards of the Ministry of Public Health comprise 12 critical evaluation domains.[2] The evolving healthcare landscape demands continuous improvement in medical laboratory standards, particularly in community hospitals serving as frontline healthcare facilities. This study examines how holistic intelligence and competent organization characteristics influence the implementation of medical laboratory standards in community hospitals within Health Region 7. Holistic intelligence represents an integrated approach to professional capability, encompassing multiple dimensions essential for comprehensive performance in modern healthcare settings. Simultaneously, smart organization characteristics reflect organizational capabilities necessary for maintaining high-quality standards in rapidly changing environments.

Recent studies indicate that maintaining medical laboratory standards requires individual competence and organizational support systems. However, the relationship between these factors and laboratory standards implementation, particularly in community hospital settings, remains understudied.

Holistic intelligence is key to achieving operational objectives, encompassing multiple components essential for comprehensive goal attainment. Successful performance requires more than singular competency, necessitating the development of diverse capabilities across six dimensions. First, Emotional intelligence emerges as a fundamental component in healthcare settings, particularly in laboratory environments where precision and stress management are crucial.[3] Emotional intelligence significantly influences decision-making accuracy and professional resilience in high-stakes medical environments. Second, moral and ethical Intelligence plays a vital role in medical laboratory operations, where decisions directly impact patient care and safety.[4] Third, adversity intelligence shows better adaptation to changing protocols and maintains performance standards even under resource constraints.[5] This capability becomes particularly relevant in community hospital settings where resources may be limited. Fourth, social intelligence contributes to effective knowledge sharing and professional networking, which are crucial elements in maintaining laboratory quality standards.[6] Fifth, creative intelligence facilitates the development of novel solutions to operational challenges and contributes to continuous quality improvement initiatives.[7] Lastly, digital intelligence has become increasingly critical in modern laboratory operations, particularly with the advancement of automated systems and digital record-keeping.[8] The concept of smart organization has emerged as crucial in the current era of rapid globalization and technological advancement. This organizational paradigm comprises five key dimensions: 1) shared vision creation has been identified as fundamental for aligning organizational efforts toward quality excellence, 2) human resource development significantly influences an organization's ability to maintain high operational standards and adapt to changing requirements, 3) operational process co-creation shows that collaborative process development leads to better implementation outcomes and sustained quality improvements, 4) organizational learning system development demonstrate that robust learning systems contribute significantly to maintaining high laboratory standards and fostering innovation, and 5) organizational culture formation provides the foundation for sustainable quality practices.[9] Research indicates that strong organizational cultures supporting quality and continuous improvement lead to better long-term outcomes in laboratory operations.

A survey of medical laboratories in Health Region 7, encompassing Kalasin, Khon Kaen, Maha Sarakham, and Roi Et Provinces, revealed 71 community hospitals employing 240 medical technologists.[10] Of these facilities, 23 have received Ministry of Public Health certification,[11] 17 have obtained Medical Technology Council quality accreditation,[12] and one has achieved ISO:15189 certification.[11] This represents a 57.75% accreditation rate, leaving 42.25% without formal certification, potentially affecting service quality and patient safety. Previous research has identified correlations between emotional intelligence and healthcare personnel performance and between organizational climate and medical technologists' work-life quality.[13,14] However, no direct studies have examined the relationship between holistic intelligence, smart organization, and medical laboratory standards implementation in this region. This study aims to identify factors that could enhance medical laboratory service standards in Health Region 7 and provide insights for future quality improvement initiatives.

The 20-Year National Strategy (2018-2037) emphasizes creating social opportunities and equality, ensuring equitable access to quality healthcare services across all regions through citizen-centric approaches prioritizing responsive and efficient service delivery.[1] Medical laboratories in community hospitals serve as essential components of public health systems, providing analytical services and facilitating specimen referrals for specialized testing. These laboratories generate vital data for diagnosis, treatment monitoring, and disease surveillance while informing healthcare policy development and public health service planning. Quality and standardization in medical laboratory operations significantly enhance public health service system efficiency and outcomes, with the 2019 Medical Laboratory Standards of the Ministry of Public Health comprising 12 critical evaluation domains.[2]

Successful laboratory operations require comprehensive

capabilities across multiple dimensions. Holistic intelligence represents a key factor in achieving operational objectives, encompassing six essential components: emotional intelligence,[3] focusing on self-awareness and relationship management; moral and ethical intelligence,[4] ensuring professional integrity and accountability, adversity intelligence,[5] enabling effective problem-solving under pressure; social intelligence[6], facilitating teamwork and communication; creative intelligence,[7] promoting innovative solutions; and digital intelligence,[8] supporting technological adaptation and data management.

In parallel, the concept of smart organization has emerged as crucial in the current era of rapid technological advancement. This organizational paradigm comprises five key dimensions: shared vision creation, establishing common goals and direction; human resource development, enhancing staff capabilities, operational process co-creation, optimizing workflow efficiency, organizational learning system development, facilitating knowledge transfer; and organizational culture formation, building sustainable quality practices.[9]

A survey of medical laboratories in Health Region 7, encompassing Kalasin, Khon Kaen, Maha Sarakham, and Roi Et provinces, revealed that among 71 community hospitals employing 240 medical technologists,[10] only 57.75% have achieved various forms of quality certification.[11,12] Previous research has identified correlations between emotional intelligence and healthcare personnel performance[13] and between organizational climate and medical technologists' work-life quality.[14] However, no direct studies have examined the relationship between holistic intelligence, smart organization, and medical laboratory standard compliance in this region. This study aims to identify factors that could enhance medical laboratory service standards in Health Region 7 and provide insights for future quality improvement initiatives. Figure 1 displays the conceptual framework.

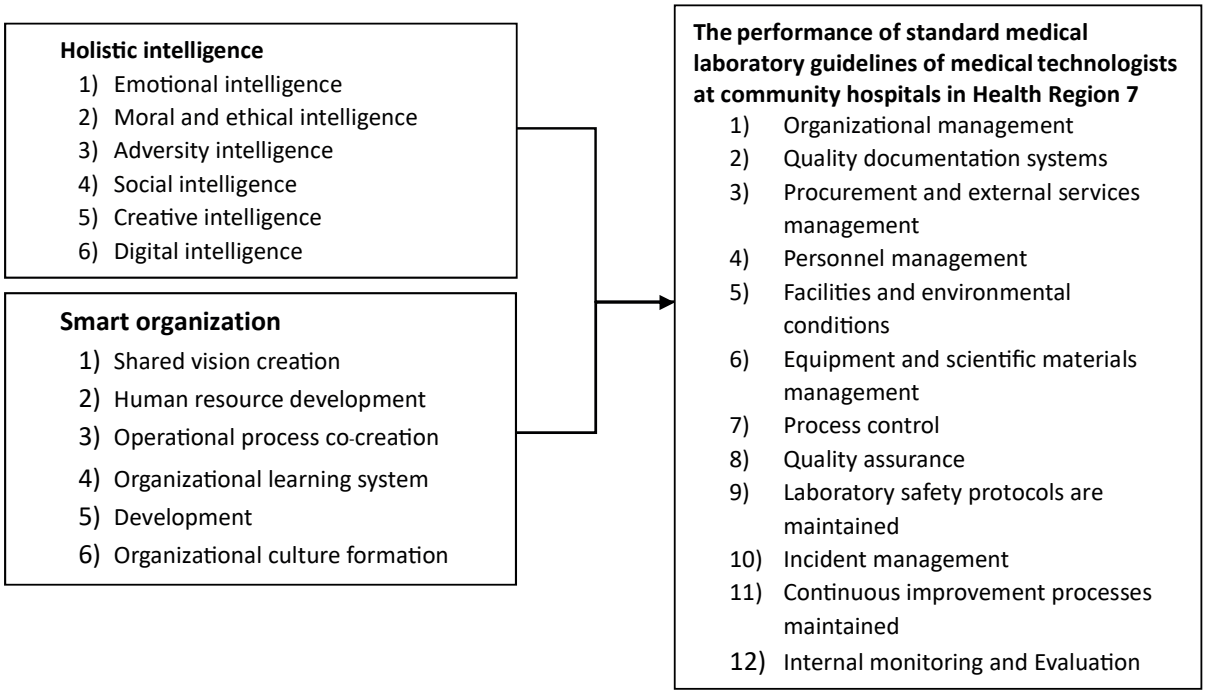

Figure 1. *The conceptual framework.*

Methodology

Research design and sample

This research employed a cross-sectional descriptive design to examine medical technologists working in community hospitals within Health Region 7. The sample size was determined using Cohen's formula[15] for stepwise multiple linear regression analysis, drawing from a previous study on personal characteristics and leadership aesthetics skills affecting physiotherapists' performance in Health Region 8.[16] This calculation yielded a required sample size of 187 participants.

The study utilized stratified random sampling to ensure proportional representation across the region's provinces.[17] This sampling method was selected to enhance the sample's representativeness by accounting for geographical distribution and organizational characteristics. The sampling framework encompassed four provinces within Health Region 7: Khon Kaen Province: 54 participants selected from a population of 70 medical technologists; Kalasin Province: 53 participants selected from a population of 69 medical technologists; Roi Et Province: 45 participants selected from a population of 57 medical technologists, Maha Sarakham Province: 35 participants selected from a population of 44 medical technologists

Research instruments

The research utilized a comprehensive questionnaire comprising four sections designed to gather data on medical technologists' characteristics, competencies, and operational practices. The first section focused on personal characteristics, incorporating eight key demographic and

professional items. These included gender, age, marital status, educational level, academic position, income, duration of service in community hospitals within Health Region 7, and participation in medical laboratory standards training. The second section assessed holistic intelligence through 30 items consisting of 1) emotional intelligence,[3] 2) moral and ethical intelligence,[4] 3) adversity intelligence,[5] 4) social intelligence,[6] 5) creative intelligence,[7] and 6) digital intelligence.[8] The third section evaluated smart organization characteristics using 25 items[9] consisting of 1) shared vision creation, 2) human resource development, 3) operational process co-creation, 4) organizational learning system development, and 5) organizational culture formation. The fourth and final section contained 60 items specifically addressing medical laboratory standards 1) organizational management, 2) quality documentation systems, 3) procurement and external services management, 4) personnel management, 5) facilities and environmental conditions, 6) equipment and scientific materials management, 7) process control, 8) quality assurance, 9) laboratory safety protocols maintained, 10) incident management, 11) continuous improvement processes maintained, and 12) internal monitoring and Evaluation.[8]

Instrument quality assessment

The development and validation of the research questionnaire followed a rigorous process to ensure both content validity and reliability. The instrument underwent comprehensive quality assessment through multiple stages of evaluation and refinement. Content validity was established through expert review by three qualified professionals. The Item Objective Congruence (IOC) assessment required scores exceeding 0.66 from at least 2 out of 3 qualified professionals to retain each item, confirming the questionnaire's content validity. This validation process ensured that each item appropriately measured its intended construct and aligned with the research objectives. Reliability testing was conducted through a pilot study with 30 medical technologists working in community hospitals within Health Region 8. This region was selected for the pilot study due to its similar operational environment and geographical proximity to the study area. The pilot sample provided valuable insights into the instrument's performance under real-world conditions. Statistical analysis using Cronbach's alpha coefficient demonstrated strong internal consistency across all questionnaire sections. The holistic intelligence section achieved a reliability coefficient of 0.962, while the smart organization section showed a reliability coefficient 0.979. The medical laboratory standards section demonstrated a reliability coefficient of 0.981. The overall questionnaire exhibited exceptional reliability with a coefficient of 0.988.

Data interpretation

The research employed a comprehensive scoring system to evaluate levels of holistic intelligence, smart organization characteristics, and implementation of medical laboratory standards. The interpretation framework was based on established guidelines for five-level rating scales.[18] The questionnaire utilized a five-point rating scale across all sections, measuring holistic intelligence, smart organization characteristics, and medical laboratory standards among medical technologists in community hospitals within Health Region 7. The rating scale assigned numerical values from 1 to 5, corresponding to performance levels from lowest to highest: highest performance (5 points), high performance (4 points), moderate performance (3 points), low performance (2 points), and lowest performance (1 point). Following standardized interpretation guidelines,[19] the mean scores were categorized into five distinct levels of performance: highest level: mean scores of 4.50-5.00; high level: mean scores of 3.50-4.49, moderate level: mean scores of 2.50-3.49, low level: mean scores of 1.50-2.49, lowest level: mean scores of 1.00-1.49.

For correlation analysis, the interpretation of Pearson's correlation coefficients (r) followed established guidelines with values ranging from -1 to +1.[20] The strength of relationships was classified as follows: no correlation (r=0), low correlation (r=±0.01 to±0.30), moderate correlation (r=±0.31 to ±0.70), high correlation (r=±0.71 to±0.99), and perfect correlation (r=±1).

Data collection and analysis

Data was collected through online questionnaires between November 13-23, 2024, after obtaining approval from the Khon Kaen University Human Research Ethics Committee. The process began with authorization from the Faculty of Public Health Dean, followed by coordination with Provincial Public Health Officers in Health Region 7 (Roi Et, Khon Kaen, Kalasin, and Maha Sarakham). Survey links were distributed to randomly selected participants through LINE network groups of provincial Medical Technology Professional Networks. Participant privacy and confidentiality were maintained throughout the data collection process, with a 15-day response window provided**.**

Data analysis employed both descriptive and inferential statistics. Descriptive statistics included frequency distributions, percentages, means, SD, and range values to summarize data characteristics. Pearson's correlation coefficient examined relationships between variables for inferential statistics, while stepwise multiple linear regression analysis identified significant predictors of medical laboratory standard implementation.

Ethical considerations

This study was approved by the Khon Kaen University Human Research Ethics Committee (Protocol No. HE672178, October 8, 2024). The research protected participant privacy by excluding personally identifiable information and using only aggregated data for analysis. Research data were securely stored, accessible only to the primary researcher, and will be destroyed one year after study completion.

Results

Personal characteristics of medical technologists in community hospitals, Health Region 7

The demographic analysis of medical technologists working in community hospitals within Health Region 7 revealed significant insights into the workforce composition. Female professionals constituted the majority of the sample, with 124 participants (66.31%). The age distribution showed a concentration in the 31-40 age bracket, comprising 102 participants (54.55%). The mean age was 36 years (SD=7.23), ranging from 24 to 60 years. Regarding marital status, single professionals formed the largest group, with 97 participants (51.87%). Educational attainment data showed that most participants held bachelor's degrees or equivalent qualifications, accounting for 160 individuals (85.56%). Regarding professional classification, medical technologists at the specialist level represented the largest segment, with 101 participants (54.01%). The financial analysis indicated an average monthly income of 34,062 Baht (SD=8,277). Professional experience metrics showed an average tenure of 11.15 years (SD=7.75), ranging from 1 to 41 years in service. Professional development data revealed that 118 participants (63.1%) had received training in medical laboratory standards, with most participants (104 individuals) having attended one to two training sessions as presents in Table 1.

Table 1. Percentage, mean, SD, median, minimum, and maximum personal characteristics of medical technologists in community hospitals, Health Region 7 (N=187).

Personal characteristics	frequency (N=187)	Percentage
Gender		
Male	63	33.69
Female	124	66.31
Age (years)		
21-30	46	24.60
31-40	102	54.55
41-50	30	16.04
51-60	9	4.81
Mean=36.25, SD=7.23, Minimum=24, Maximum=60		
Marital status		
Single	97	51.87
Married	84	44.92
Widowed/divorced/separated	6	3.21
Educational level		
Bachelor's degree or equivalent	160	85.56
Master's degree or higher	27	14.44
Academic position		
Medical technologist	25	13.37
Medical technologist practitioner level	61	32.62
Medical technologist professional level	101	54.01
Income (Baht)		
≤20,000	14	7.49
20,001-30,000	54	28.88
30,001-40,000	88	47.06
≥40,001	31	16.58
Mean=34,061, SD=8,277, Minimum=15,000, Maximum=56,000		
Duration of service in community hospitals with in Health Region 7 (years)		
1-10	108	57.75
11-20	57	30.48
≥21	22	11.16
Mean=11.15, SD=7.75, Median= 10, Minimum=1, Maximum= 41		
Participation in medical laboratory standards training		
No	69	36.90
Yes	118	63.10
Number of times participation in medical laboratory standards training (N=118)		
1-2	104	88.13
3-4	13	11.01
≥5	1	0.85

Holistic intelligence levels in medical laboratory standards operations

The analysis of holistic intelligence among medical technologists in community hospitals within Health Region 7 revealed consistently high levels across multiple dimensions. The overall holistic intelligence score achieved a mean of 4.12 (SD=0.44), indicating strong performance across the measured domains. Moral and ethical intelligence emerged as the most vigorous dimension, with a mean score of 4.31 (SD=0.49), demonstrating medical technologists' robust commitment to ethical practice and professional integrity. Social intelligence was followed closely by a mean score of 4.25 (SD=0.53), reflecting strong interpersonal capabilities within the professional environment. Emotional intelligence also showed strong results with a mean score of 4.14 (SD=0.50), indicating well-developed emotional awareness and management skills. The assessment of adversity intelligence revealed a mean score of 4.08 (SD=0.51), suggesting effective resilience and problem-solving capabilities among the practitioners. Digital intelligence and creative intelligence, while still achieving high-level ratings, showed slightly lower mean scores of 3.99 (SD=0.54) and 3.98 (SD=0.56), respectively, indicating potential areas for professional development (Table 2).

Table 2. Holistic intelligence levels in medical laboratory standards operations of medical technologists at community hospitals in Health Region 7 (N=187).

Holistic intelligence in medical laboratory standards operations of medical technologists at community hospitals in Health Region 7	Score	SD	Interpretation
1. Emotional intelligence	4.14	0.50	High
2. Moral and ethical intelligence	4.31	0.49	High
3. The assessment of adversity intelligence	4.08	0.51	High
4. Social intelligence	4.25	0.53	High
5. creative intelligence	3.98	0.56	High
6. Digital intelligence	3.99	0.54	High
Holistic intelligence overview	**4.12**	**0.44**	**High**

Smart organization levels in medical laboratory standards operations

The assessment of smart organization characteristics in community hospitals within Health Region 7 demonstrated strong organizational capabilities across multiple dimensions. The overall smart organization score achieved a mean score of 3.80 (SD=0.65), indicating robust institutional frameworks supporting medical laboratory operations. Operational process co-creation emerged as the most vigorous dimension, with a mean score of 3.87 (SD=0.74), reflecting practical collaborative approaches to developing and implementing laboratory procedures. Organizational culture formation followed closely with a mean score of 3.83 (SD=0.72), suggesting well-established shared values and professional practices within the institutions. Vision creation and alignment showed similarly strong performance with a mean score of 3.79 (SD=0.64), indicating clear strategic direction and purpose. The organizational learning system development achieved a mean score of 3.79 (D=0.69), while human resource development and support scored 3.73 (SD=0.71), as detailed in Table 3.

Table 3. Smart organization levels in medical laboratory standards operations of medical technologists at community hospitals in Health Region 7 (N=187).

Smart organization in medical laboratory standards operations of medical technologists at community hospitals in Health Region 7	Mean	SD	Interpretation
1. Shared vision creation	3.79	0.64	High
2. Human resource development	3.73	0.71	High
3. Operational process co-creation	3.87	0.74	High
4. Organizational learning system development	3.79	0.69	High
5. Organizational culture formation	3.83	0.72	High
Smart organization overview	**3.80**	**0.65**	**High**

Implementation of medical laboratory standards

The analysis of medical laboratory standards implementation among medical technologists in community hospitals within Health Region 7 revealed strong performance across all operational domains. The overall implementation level achieved a score of 4.28 (SD=0.49), indicating robust adherence to established standards. Organizational management emerged as the highest-performing area, with a mean score of 4.50 (SD=0.51), demonstrating effective administrative practices. Quality documentation systems followed closely with a mean score of 4.41 (SD=0.53), reflecting substantial documentation and record-keeping practices. Laboratory safety protocols maintained high standards with a mean score of 4.36 (SD=0.56), while equipment and scientific materials management achieved a mean score of 4.35 (SD=0.54). Process control and quality assurance demonstrated consistent performance with identical mean scores 4.30 (SD=0.53 and 0.58, respectively). Procurement and external services management showed strong implementation with a mean score of 4.28 (SD=0.61), followed by internal monitoring and evaluation at 4.26 (SD=0.62). Continuous improvement processes maintained a robust score of 4.22 (SD=0.59). Areas showing relatively lower scores while still maintaining high-performance levels included facilities and environmental conditions (Mean=4.09, SD=0.64), incident management (Mean=4.10, SD=0.70), and personnel management (Mean=4.15, SD=0.54), as detailed in Table 4.

Table 4. Levels in medical laboratory standards operations of medical technologists at community hospitals in Health Region 7 (N=187).

Medical laboratory standards operations of medical technologists at community hospitals in Health Region 7	Mean	SD	Interpretation
1. Organizational management	4.50	0.51	High
2. Quality documentation systems	4.41	0.53	High
3. Procurement and external services management	4.28	0.61	High
4. Personnel management	4.15	0.54	High
5. Facilities and environmental conditions	4.09	0.64	High
6. Equipment and scientific materials management	4.35	0.54	High
7. Process control	4.30	0.53	High
8. Quality assurance	4.30	0.58	High
9. Laboratory safety protocols maintained	4.36	0.56	High
10. Incident management	4.10	0.70	High
11. Continuous improvement processes maintained	4.22	0.59	High
12. Internal monitoring and Evaluation	4.26	0.62	High
Medical laboratory standards overview	**4.28**	**0.49**	**High**

Relationships between holistic intelligence, smart organization, and medical laboratory standards implementation

The analysis revealed significant moderate correlations between both holistic intelligence and smart organization characteristics with medical laboratory standards implementation. The overall holistic intelligence demonstrated a mild positive correlation (r=0.599, p<0.001), while smart organization showed a similar moderate positive relationship (r=0.557, p<0.001) with laboratory standards implementation.

Within the holistic intelligence dimensions, social intelligence emerged as the strongest correlate (r=0.570, p<0.001), closely followed by emotional intelligence (r=0.569, p<0.001). Moral and ethical intelligence also substantially correlated (r=0.537, p<0.001). Adversity intelligence (r=0.477, p<0.001) and creative intelligence (r=0.476, p<0.001) demonstrated similar moderate relationships, while digital intelligence showed the lowest, though still significant, correlation (r=0.450, p<0.001).

Regarding smart organization characteristics, the organizational learning system development showed the most substantial relationship with standards implementation (r=0.575, p<0.001). Operational process co-creation (r=0.547, p<0.001) and organizational culture formation (r=0.540, p<0.001) also demonstrated robust correlations. Vision creation and alignment (r=0.482, p<0.001) and human resource development (r=0.416, p<0.001) showed moderate positive relationships, as detailed in Table 5.

Table 5. Pearson's correlation coefficients between holistic intelligence, smart organization, and medical laboratory standards operations of medical technologists at community hospitals in Health Region 7 (N=187).

Holistic intelligence and smart organization	*Medical laboratory standards operations*		
	Correlation coefficient (r)	*p value*	*Relationship level*
Holistic intelligence overview	**0.599*** **	**<0.001**	**moderate**
Emotional intelligence	0.569***	<0.001	moderate
Moral and ethical intelligence	0.537***	<0.001	moderate
The assessment of adversity intelligence	0.477***	<0.001	moderate
Social intelligence	0.570***	<0.001	moderate
Creative intelligence	0.476***	<0.001	moderate
Digital intelligence	0.450***	<0.001	moderate
Smart organization overview	**0.557*** **	**<0.001**	**moderate**
Shared vision creation	0.482***	<0.001	moderate
Human resource development	0.416***	<0.001	moderate
Operational process co-creation	0.547***	<0.001	moderate
Organizational learning system development	0.575***	<0.001	moderate
Organizational culture formation	0.540***	<0.001	moderate

****Correlation is significant <0.001 level.*

Holistic intelligence and smart organization affecting medical laboratory standards implementation of medical technologists at community hospitals in Health Region 7

The study employed stepwise multiple regression analysis to examine the influence of holistic intelligence and smart organization characteristics on medical laboratory standards implementation among medical technologists in community hospitals within Health Region 7. Initial statistical assumptions were verified through rigorous testing procedures. The Kolmogorov-Smirnov test confirmed the normal distribution of subjective data (p=0.083), exceeding the established threshold of 0.05. The Durbin-Watson statistic of 1.541 confirmed the independence of residuals, which falls within the acceptable range of 1.50-2.50. The homoscedasticity assumption was met, indicating consistent variance in prediction errors across all predictor variables. Multicollinearity testing showed no concerning relationships between variables (tolerance=0.574-0.765, variance inflation factor (VIF)=1.307-1.742), meeting the regression analysis requirements where Tolerance should be greater than 0 but not exceeding 1, and VIF should be less than 10. These results confirmed that all statistical assumptions for multiple regression analysis were satisfied. As detailed in Table 6.

Table 6. A stepwise multiple regression analysis examining factors influencing medical laboratory standards implementation among medical technologists in community hospitals within Health Region 7 (N=187).

Factor	B	95%CI		SE	Beta	T	*p* value	R	R^2	R^2adj	R^2 change
		lower	Upper								
The organizational learning system co-creation	0.266	0.181	0.351	0.405	0.376	6.168	<0.001	0.575	0.330	0.327	-
Moral and ethical intelligence	0.262	0.122	0.402	0.366	0.259	3.680	<0.001	0.675	0.456	0.450	0.126
Emotional intelligence	0.213	0.170	0.357	0.358	0.220	2.938	0.004	0.693	0.480	0.472	0.024

***Note**: Constant 1.255, F=56.366, p<0.001, R=0.693, R^2=0.480, R^2adj=0.472.*

Discussion

The study findings demonstrate high overall adherence to medical laboratory standards among medical technologists (Mean=4.28, SD=0.49), with organizational management and administration emerging as the most substantial domain (Mean=4.49, SD=0.51). This exemplary performance reflects the successful implementation of Hospital Accreditation (HA) quality systems, which have established clear administrative structures and strategic development plans in community hospitals. However, facilities and environmental conditions received the lowest mean score (Mean=4.09, SD=0.64), highlighting significant infrastructural challenges. Community hospitals face constraints in upgrading aging facilities and maintaining appropriate environmental conditions due to budget limitations and increasing service demands. These findings align with previous research.[13,21,22]

Medical laboratory operations demand highly specialized knowledge and skills, making effective knowledge management systems essential for operational excellence. A robust organizational learning system enables personnel to efficiently access and apply critical knowledge while facilitating valuable knowledge transfer between staff members. This systematic approach to learning supports continuous knowledge development and innovation within the laboratory environment. The dynamic nature of laboratory standards, which evolve continuously with technological advancements, further emphasizes the importance of practical learning systems. These systems enable personnel to monitor standard modifications, adapt procedures promptly, and implement changes efficiently, thereby reducing operational errors and enhancing service quality. Previous research has demonstrated that effective organizational learning in medical settings significantly improves diagnostic accuracy and operational efficiency, particularly in high-precision environments like medical laboratories.[23] The collaborative nature of laboratory work underscores the value of organizational learning systems. These systems foster a shared understanding of operational standards and facilitate the exchange of best practices among team members, leading to comprehensive staff development.

Previous research has identified organizational learning systems as key drivers of medical laboratory standards implementation, enabling superior adaptation to change and maintenance of innovation standards.[13] Studies have consistently supported these findings. Research has shown that organizations with effective knowledge management systems achieve superior quality development outcomes, particularly in staff skill development and service innovation.[24] Additionally, evidence suggests that establishing a learning culture in healthcare organizations is crucial for service quality improvement, enabling continuous professional development and effective technological adaptation.[25] The strong correlation between organizational learning systems and laboratory standard implementation indicates that investing in knowledge management infrastructure yields significant operational quality and sustainability returns. This relationship suggests that medical laboratories should prioritize developing comprehensive learning systems to maintain high standards and adapt to evolving healthcare requirements.

Medical laboratory work's direct impact on patient health and lives underscores the critical importance of moral and ethical intelligence among medical technologists. This foundational aspect of professional competence ensures adherence to operational standards, accountability for analytical results, and unwavering focus on patient welfare. The laboratory environment demands exceptional integrity and reliability in all operations. Medical technologists with well-developed moral and ethical intelligence consistently demonstrate honesty in result reporting, maintain strict patient confidentiality, and adhere rigorously to professional ethics. Their commitment to compassionate care drives continuous quality improvement and maintains high service standards. Research has established strong positive correlations between moral intelligence and ethical work behaviors, directly affecting medical service quality.[26] The four fundamental dimensions of moral intelligence-integrity, responsibility, compassion, and forgiveness-align precisely with medical laboratory requirements, where precision, accountability, and patient-centered care are paramount.[27]

Previous research has demonstrated that moral intelligence correlates significantly with organizational commitment, enhancing operational efficiency and patient satisfaction.[28] Professionals exhibiting high moral intelligence consistently show more remarkable dedication to quality improvement and adherence to professional standards. Additional studies have identified positive relationships between administrative skills, work ethics, and intrinsic motivation.[29] The results suggest enhanced management capabilities strengthen ethical practice and operational standards. Laboratory professionals regularly encounter situations requiring complex ethical decision-making, from prioritizing urgent tests to managing limited resources and reporting errors. Strong moral and ethical intelligence enables appropriate decision-making that balances ethical principles, procedural accuracy, and patient benefit. This capacity becomes particularly crucial in challenging situations where standard protocols may not provide clear guidance.

In medical laboratory operations, emotional intelligence is critical in maintaining professional standards under high-pressure conditions. Medical technologists face multiple pressures, including high workload volumes, urgent reporting deadlines, and expectations for precise analytical results. High emotional intelligence enables these professionals to effectively manage these pressures while maintaining the focus and attention to detail essential for laboratory work. Previous research demonstrates that healthcare personnel with developed emotional intelligence show improved work efficiency, particularly in service delivery and quality assurance.[30] This improvement stems from enhanced stress management capabilities, leading to better concentration and methodical adherence to

established standards. Supporting these findings, previous research reveals that emotional intelligence development enhances communication skills and interprofessional collaboration, critical elements in maintaining laboratory standards through effective coordination and information exchange.[31] The impact of emotional intelligence extends beyond individual performance. Previous research found that personnel with high emotional intelligence consistently deliver superior service quality with fewer operational errors, attributing this to better emotional regulation and stress management.[32] This directly influences adherence to laboratory safety and quality standards. Moreover, research indicates that emotional intelligence correlates strongly with learning ability and self-development capacity, essential qualities for adapting to evolving laboratory standards and continuous quality improvement initiatives.[33]

Implementing holistic intelligence and smart organization concepts in medical laboratories encounters several significant challenges that require systematic consideration and strategic solutions. Understanding these challenges and developing appropriate mitigation strategies is crucial for successful implementation. Resource and financial constraints represent fundamental obstacles in implementing quality improvement initiatives. Budget limitations frequently affect the acquisition of new technologies and staff training programs in community hospitals. Research indicates that successful quality improvement initiatives typically require 2-5% of total operating budgets for effective implementation.[23,24] A phased implementation approach, prioritizing low-cost, high-impact activities and establishing educational institution partnerships, has been identified as an effective strategy for resource optimization.[25] Organizational resistance to change presents a significant behavioral challenge in implementation efforts. Studies have documented consistent staff concerns regarding increased workload and systemic changes. Organizational culture transformation typically requires 3-5 years and sustained executive support.[26,27] Effective change management strategies emphasize comprehensive stakeholder engagement, transparent communication channels, and well-structured incentive systems.[28]

Personnel expertise limitations significantly impact quality development initiatives. The scarcity of professionals with technical expertise and mentoring capabilities has been identified as a critical implementation barrier.[29] Successful approaches include developing multi-tiered mentoring systems, implementing technology-supported learning platforms, and establishing inter-institutional collaboration networks.[30] Inter-departmental coordination complexity presents substantial systemic challenges to implementation efforts. Successful implementation requires coordinated efforts across all organizational sectors.[31] Effective solutions include establishing clear governance structures, implementing regular progress monitoring mechanisms, and developing standardized reporting systems.[32] Future research directions should focus on qualitative investigations to understand context-specific barriers and enabling factors. This includes examining successful implementation cases, evaluating strategy effectiveness, and monitoring the long-term sustainability of quality improvement initiatives.[33] Developing successful medical laboratory standards requires comprehensive planning that addresses resource constraints, change management processes, personnel development strategies, and inter-departmental coordination mechanisms. Understanding these implementation challenges enables organizations to develop context-appropriate strategies that promote efficient and sustainable laboratory standards development.

Based on the research findings, three key factors—organizational learning systems, moral and ethical intelligence, and emotional intelligence—significantly influence the implementation of medical laboratory standards. At the policy level, the Ministry of Public Health should establish learning centers at the regional level and develop mentoring systems to facilitate knowledge transfer among medical technologists. These centers would serve as hubs for operational standard exchange and professional development across community hospitals. Institutions should implement comprehensive knowledge management systems and ethical consultation mechanisms for organizational development. Healthcare facilities should establish emotional support structures and foster an organizational culture that promotes staff well-being. Performance monitoring systems should be developed to evaluate and maintain the implementation of medical laboratory standards, with indicators encompassing learning systems, ethical practice, and emotional management competencies. Professional development initiatives should focus on continuing education programs that enhance laboratory standards implementation. The Medical Technology Council should create clear career paths linked to medical laboratory standards implementation capabilities and increase medical technologists involvement in policy development. These systematic developments at both organizational and professional levels will strengthen medical laboratory standards implementation and enhance healthcare service quality in community hospitals

At the hospital administration level, organizational learning system development requires systematic implementation. Hospital administrators should establish digital knowledge repositories designed explicitly for medical technologists, containing standardized operating procedures, case studies, and best practices that can be easily accessed and updated. To enhance knowledge transfer and professional development, structured mentoring programs should pair experienced medical technologists with newer staff members. Additionally, hospitals should implement regular professional development programs focusing on moral, ethical, and emotional intelligence through monthly ethics case discussions, emotional intelligence workshops, and professional supervision sessions. Resource allocation should prioritize staff development through dedicated annual budgets for training programs, conference

attendance, and continuing education opportunities.

We recommend establishing Regional Learning Centers within Health Region 7 for policymakers and healthcare authorities to serve as hubs for knowledge exchange, professional development, and quality improvement initiatives. These centers should have simulation facilities, digital learning resources, and expert facilitators to support continuous professional development. A comprehensive standard competency framework should be developed, integrating technical skills with holistic intelligence components to guide career progression and professional development planning. Furthermore, a unified quality monitoring system should be implemented across the region, incorporating traditional quality metrics and newer indicators related to organizational learning and staff development.

Educational and training institutions are crucial in developing comprehensive curricula integrating technical competencies with holistic intelligence development. These programs should include practical modules on emotional intelligence, ethical decision-making, and organizational development, emphasizing case-based learning methods to connect theoretical knowledge with practical application. Professional development courses should have flexible delivery modes, including online and face-to-face components, and precise assessment criteria aligned with workplace requirements. Formal collaborative partnerships between training institutions and hospitals should be established through memoranda of understanding to ensure continuous alignment between educational content and workplace needs.

Through this comprehensive approach, with clearly defined roles for each stakeholder group, we can create a sustainable framework for enhancing medical laboratory standards while developing individual capabilities and organizational effectiveness.

Limitation

This study faced several methodological limitations that warrant consideration. The primary constraint was the cross-sectional design, which collected data simultaneously, limiting our ability to establish causal relationships between variables. While the study revealed significant associations between holistic intelligence, smart organization characteristics, and laboratory standards implementation, the temporal nature of data collection prevents definitive conclusions about cause-and-effect relationships. Another notable limitation concerns our statistical approach using stepwise multiple regression, which may have inherent limitations, including potential overfitting and model instability. While widely used, this method could potentially exclude essential predictor variables and may not fully capture the complex interrelationships among our study variables. The study's geographical scope, confined to Health Region 7's community hospitals, may limit generalizability to other regions.

Additionally, our reliance on self-reported questionnaire data, though validated and reliable, may be subject to response bias. While employing a cross-sectional design provided valuable insights, it restricted our ability to establish causal relationships between variables, and our regression model's explanatory power (R^2adj=0.472) indicated that approximately 52.8% of the variance in medical laboratory standards implementation remains unexplained. Future research would benefit from employing more robust statistical methods, such as hierarchical regression or structural equation modeling (SEM), alongside longitudinal or experimental designs to provide more substantial evidence of relationships between variables and confirm the stability of our findings.

Conclusion

Implementing medical laboratory standards among medical technologists in community hospitals within Health Region 7 is significantly influenced by three main components: collaborative organizational learning system development, moral and ethical intelligence, and emotional intelligence. These components necessitate integrated development across multiple levels.

Research findings support the development of a comprehensive capacity-building system at the policy level through the establishment of essential competency frameworks, integrated care system development, and sustainable resource allocation. At the regional and provincial health levels, emphasis should be placed on developing training curricula, mentoring systems, and efficient information systems. Meanwhile, community hospitals should prioritize the development of context-appropriate care systems and practical guidelines.

Implementation at the organizational level should emphasize personnel participation and strengthening professional networks. Operational strategies should be adapted to align with the resources and capabilities of each area, along with the development of effective monitoring and evaluation systems to ensure continuous operational improvement and growth. This approach will strengthen and sustain medical laboratory standards in Thailand, enabling efficient response to public health needs.

Conflict of interest

The authors declare no potential conflict of interest.

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