การพัฒนาเครือข่ายห้องปฏิบัติการนิติวิทยาศาสตร์เพื่อการรับรองมาตรฐานสากล*

Development of forensic laboratory networks for international standard accreditation*

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บทคัดย่อ

การรับรองมาตรฐานสากลสำหรับห้องปฏิบัติการนิติวิทยาศาสตร์สามารถดำเนินการผ่านการเตรียมความพร้อม การตรวจสอบและการประเมินโดยอาศัยหน่วยงานภายในที่สนับสนุนและจากเครือข่ายพันธมิตรร่วมภารกิจเดียวกัน เมื่อกรอบมาตรฐานและการปฏิบัติตามเกณฑ์เข้ามามีบทบาทการทำงานร่วมกันภายใต้เครือข่ายนิติวิทยาศาสตร์จึงเป็นสิ่งสำคัญ การวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาระดับการมีส่วนร่วมและการพัฒนาเครือข่ายการทำงานร่วมกันของห้องปฏิบัติการนิติวิทยาศาสตร์ เป็นการวิจัยเชิงคุณภาพด้วยการสัมภาษณ์เชิงลึกเจ้าหน้าที่ทางนิติวิทยาศาสตร์และสาขาที่เกี่ยวข้อง แบ่งผู้ให้ข้อมูลสำคัญเป็น 3 กลุ่ม ได้แก่ เจ้าหน้าที่นิติวิทยาศาสตร์ นักวิชาการและผู้มีส่วนได้ส่วนเสียกับห้องปฏิบัติการจากทั้งภาครัฐและเอกชน รวมทั้งสิ้น 19 คน ผลการวิจัย พบว่า (1) การมีส่วนร่วมของเครือข่ายห้องปฏิบัติการนิติวิทยาศาสตร์มี 4 ระดับ ได้แก่ ระดับการให้คำแนะนำและการบริการวิชาการ การมีส่วนร่วมในการวิจัย การมีส่วนร่วมในการให้บริการตรวจพิสูจน์และการมีส่วนร่วมในการเป็นคณะกรรมการและที่ปรึกษา และยังพบว่า

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(2) แนวทางการพัฒนาเครือข่ายความร่วมมือห้องปฏิบัติการนิติวิทยาศาสตร์ เป็น 2 ระยะ คือ ระยะที่ 1 ระยะสั้น คือการจัดการด้านการจัดเตรียมอุปกรณ์เครื่องมือและการฝึกอบรมประเมินความสามารถผู้ปฏิบัติงาน สำหรับระยะที่ 2 การพัฒนาระยะยาว โดยเครือข่ายความร่วมมือดำเนินกระบวนการที่เกี่ยวข้องกับการกำกับดูแลและหลักเกณฑ์ของห้องปฏิบัติการขยายขอบเขตการตรวจพิสูจน์และมาตรการดำเนินงาน และการแบ่งแยกหน่วยงานธุรการจากห้องปฏิบัติการ ซึ่งการดำเนินกลยุทธ์ระยะยาวนี้ต้องอาศัยการสนับสนุนจากความร่วมมือระหว่างองค์กรภายใต้แนวทางในระยะสั้น งานวิจัยนี้จึงเสนอแบบจำลองกระบวนการเพื่อเป็นแนวทางการรับรองมาตรฐาน สามารถสรุปได้ว่า ห้องปฏิบัติการนิติวิทยาศาสตร์ต้องได้รับการส่งเสริมให้ประเมินระดับการมีส่วนร่วมและการทำงานผ่านเกณฑ์ การรับรองมาตรฐานสามารถเกิดขึ้นได้ภายใต้เครือข่ายห้องปฏิบัติการนิติวิทยาศาสตร์และการมีส่วนร่วมตามแนวทางของแบบจำลองที่เสนอ

คำสำคัญ : การมีส่วนร่วม, ห้องปฏิบัติการนิติวิทยาศาสตร์, เครือข่าย, การรับรองมาตรฐาน

Abstract

The feasibility of international standard accreditation for forensic laboratories can be aligned through the process of preparation, audition and evaluation among internal supporting units and alliances with communal duties. Collaboration within forensic networks becomes more important when the standard guide and operation are involved. The participation level and development of forensic laboratory collaboration were examined as the research objectives. A qualitative study of officers who were engaged in forensic operations and related fields was performed via in-depth interviews. Three groups of key informants, a forensic officer, an academic researcher, and stakeholders from both the government and private sector for 19 persons in total, were interviewed and analyzed. It was found that (1) the participation level of the forensic laboratory collaboration were 4 levels which are academic and service consultation level, academic forming level, examination service level and committee and advised placation level; and (2) action guideline for the development of forensic laboratory collaborative network consists of 2 phases; Phase 1 which is short-term management of well-prepared equipment and competent-based training for the staffs and Phase 2, long-term development. Processes of the collaborative network for the long-term development involve participation in the regulatory and basis of the laboratory, enhancement on forensic examination scopes and measures, and separation of the unit administration

from the laboratory facility. The strategy for long-term phase must be supported by interorganizational collaboration under the short-term management. Thus, the process model for standard accreditation guidelines was proposed. In summary, forensic laboratory is encouraged once the participation level and operations are evaluated and qualified. The standard accreditation can be achieved under forensic laboratory network and the participation based on the proposed model.

Keywords: Participation/ Forensic Laboratory/ Network/ Standard Accreditation

Introduction

A well-organized management system serves for effective administration and can be applied as a guideline for standard operations in a variety of units and organizations including crime prevention agencies. The drives of law and legislation applied for official operation, forensic development, and standard accreditation to fulfill and support law enforcement agencies and the justice system have been continuously proposed based on the constitution of Thailand. Forensic operation plays a more important role and offers an effective process of justice. Therefore, guidelines, regulations and standard monitoring must be maintained. The standard operation procedure used by forensic scientists and law enforcement agencies must be consistent, as the examination results are accurate, precise, and globally accepted (Amornthap Phonrasuek et al., 2020). However, the current scheme for forensic examination, including operations in ASEAN countries, has not been well defined because of its dynamic role and cooperation. Several forensic laboratories have not been approved for international standard accreditation which is important for unit reputation and trust (Patchara Sinloyma, 2015). International standards are key factors for operational efficiency and cooperation. In terms of unit capacity and efficiency, policy planning and operational collaboration can be classified into three categories as follows (Chaichan Chairangsinant, 2016).

1) Human Resources: Knowledge and competence for staff must be regularly developed and approved according to international standard guidelines.

2) Laboratory and Equipment: The laboratory, tools and methods must be accredited by practical international standards, for example, the International Organization for Standardization, e.g., ISO/IEC 17025, the National Association of Testing Authorities (NATA) or the American

Society of Crime Laboratory Directors (ASCLD/LAB).

3) Process: The operation, working instructions and overall process must be prepared, followed by the manual and steps of operation, such as sample preparation, testing, analysis, recording, reporting, and document control. Processes can be monitored and traced back for transparency.

It can be inferred that collaboration from forensic officers and facilities is necessary for the standard accreditation of forensic laboratories. The collaboration can be expanded to academics, universities, institutes, research centers, service providers and stakeholders under the government and private sector. Academic and research collaboration will support forensic science development through ASEAN countries and at the international level. Knowledge, experiences, innovation, and mutual exchanges will help to integrate each unit of research system for the most explicit outcome in the justice system (Waraporn Promwikorn, 2020). Thedeveloping strategy of national policy is to support the national forensic agency in terms of the guidelines on collaborative networks for international standard accreditation especially for law enforcement agency in Thailand. In this work, the development of network for forensic laboratory to meet international standard accreditation is focused. The Royal Police Cadet Academy (RPCA) forensic laboratory was used as a model of the service unit by law enforcement academy in Thailand. The procedures and interdisciplinary organizations relevant to the laboratory system and infrastructure can be applied to this research. Possibility and potential guidelines can be achieved and contributed to the ongoing plan and workflow which are benefit to the laboratory management and standard system among forensic units.

Objectives

The aims of this research are to study collaboration as well as network development in forensic laboratories. Guidelines for forensic laboratory accreditation using network development are of interest and to be proposed.

Literature Review

Forensic science is considered the application of all fields of scientific knowledge to the justice system. This includes evidence collection and examination in a forensic laboratory (Saferstein, 2009). Collaborative networks, which include educational institutions, forensic science institutions, and related private sectors, are involved in the development of forensic

laboratories (Naiyana Wattanasri et al., 2010). For example, materials for scientific examination could be delivered, participation in organizing activities could be organized, observed activities could be planned, or knowledge or personnel could be exchanged to implement the standard of forensic laboratory collaboration. For successful development, cooperation and approaches from many stakeholders are generally needed. The next step in strengthening and expanding standard accreditation is participation, which allows laboratory networks to contribute to and be parted in the regulation, policy, process, and decision-making for implementation.

To be able to involve personnel participation in this development with flexible and feasible approaches, the quality system must be accepted within an organization where every person has a desire to be reasonably treated and accepted by others. As a result, participation can be achieved in network common activities. People should participate and benefit from development. It implies the association of people with goal setting, planning, formulating, implementing, and evaluating development. People's participation includes participation in decision-making and participation in program implementation and evaluation (Cohen & Uphoff, 1980). Participation is a strategy for people who are powerless to determine how they perceive and share information. People's participation, as a term of people's power, denotes a redistribution level. The classification in Arnstein's ladder principle reflects the amount of people's power in the benefit of society. The level of public participation can be divided into a total of 8 levels (Arnstein, 1969). The participation network in development of forensic laboratories refers to individuals or groups of people with knowledge and various activities in the forensic laboratory. Since the network is the group that impacts the laboratory's operations, it will lead to mutual agreement to drive the laboratory in a certain direction.

Forensic science standards consist of standard definitions or rules that are relevant to the policies, operating regulations, and principled practices of forensic science (Wilson-Wilde, 2018). Moreover, there are several definitions of the standard term. The standard specifications also include methods, ability designs, and various safety protocol as well as experiment; analysis; inspection (such as weighing, dosing, and measurements related to the materials, equipment, and products). In addition, regulations, and procedures for requesting accreditation in forensic science tasks must be consistent and appropriate in the context of service providers with

international standards in other countries. Many countries provide accreditation of the ISO/IEC 17025 standard system as a general requirement for laboratory testing, certified by the International Organization for ISO standards. The purpose of this standard is to identify general requirements for the laboratory's ability to perform tests and calibration. The sampling principle is based on principles and laboratory verification methods. The organization that provides this laboratory verification service must implement procedures that follow international accreditation bodies, such as the International Laboratory Accreditation Cooperation (ILAC), which is an international cooperative organization for scientific laboratory accreditation and promotes operational verification. Moreover, the ILAC also has a guideline for the forensic laboratory to apply ISO/IEC 17025 standards(Chaichan Chairangsinant, 2016). The United Kingdom Accreditation Service (UKAS) has been developed to provide a comprehensive certification standard in the field of crime scene investigation according to the ISO/IEC 17020 standard system. This is to improve the crime scene investigation in terms of evidence collection and evidence handling procedures before submitting to the laboratory. However, the standard that UKAS has developed to cover the field of crime scene inspection according to ISO/IEC 17020 does not cover the use of electronic evidence verification. Nevertheless, UKAS has developed the ISO/IEC 27037 standard to verify the laboratory's competence in obtaining electronic evidence. There is information about security and practice guidelines for collecting evidence, as well as the use of tools and electronic evidence retention. This approach can be considered a standard for forensic examination by which the UKAS was developed to cover the laboratory, for crime scene investigation, and for electronic evidence examination. Forensic science cooperation in Europe plays an important role in solving problems related to crime and terrorism across borders. The subject of laboratory accreditation was established to ensure that operators are certified according to ISO/IEC 17025 by issuing an enforced act at every step of the investigation in the forensic laboratory. Consider the European countries, it is powered by the European Network of Forensic Science Institutes (ENFSI), which has been recognized as an expert in the field. The ENFSI aims to improve the quality of forensic work across Europe and has published an operating manual to encourage laboratories to follow necessary standards in accordance with practice under standard quality assurance (Wilson-Wilde, 2018). The National Association of Testing Authorities (NATA) has set laboratory

standards in Australia. NATA accredits ISO/IEC 17025 and developed the Field Application Document (FAD) for use in standard forensic applications in the laboratory. The ISO/IEC 17025 standard was applied to the FAD in forensic laboratory. However, specific standards, such as sample collection at the scene, a safe and secure sample conveying process, issuing an evidence examination report, and expressing opinions of experts on evidence, have not been determined in forensic application. International standards in forensic science are not limited to the known ISO system; however, there are standard systems that have been established by organizations in different countries particularly specific to forensic science, such as the U.S. ASCLD/LAB or NATA of Australia. Each standard system that a particular country has established mostly depends on the context of their own needs. However, the overview of all the systems is based on similar principles with reference to ISO/IEC 17025, and the requirements have been adjusted according to the operation of each organization (Chaichan Chairangsinant, 2016). Not only ISO accreditation but also the factors of budget, personnel, equipment, tools, safety, knowledge, and the accuracy of the laboratory results to drive standard procedure achievement are involved in international standard criteria. In addition, staff and personnel in the system are required to be assessed in accordance with the accreditation. This confirmed that their examination and performance were reliable. This approach can reduce unnecessary resources, increase personnel capacity and competency, and enhance accurate examination under standard criteria. Consequently, the forensic investigation process will be accepted internationally and worldwide. Since target groups, such as stakeholders, executives, and operation staff, play an important role in further organizational development, the opinions of the targets are extremely important for the laboratory improvement to meet the standard.

Royal Police Cadet Academy (RPCA) is the main agency responsible for both teaching and academic services. RPCA forensic laboratory is established for application of science in the justice process in various contexts. It serves for RPCA cadet student, graduate student in Master of Science program in Forensic Science, academic and research collaboration among universities, law enforcement agencies, and community in Thailand Scientific Equipment Center Network. For laboratory duties and activities, executives and chief officers have provided observations and the policy announcement, emphasizing standard operation procedures to serve

as models for both internal and external agencies. In this research, the target groups participated in decision-making and conclusive opinions on development of the RPCA forensic laboratory to meet the international standards are mainly focused.

Research Methodology

1. Method: Qualitative research was carried out via in-depth interviews of samples about the development of forensic laboratory covering guidelines, collaboration, ability strengthening and cooperative working scheme using semi structured interview. This is meant to elevate the quality of RPCA forensic laboratories and to be a role model for relevant forensic laboratories and networks to meet international standards. The scopes of interview are (1) exploring and evaluating collaborative levels, (2) generating collaborative guidelines by interviews under the scope of policy and operation for forensic laboratory development, and (3) initiating collaborative forensic science networks within the country and worldwide.

2. Population: Key informants were 19 people in total selected from the personnel involved in forensic science based on the applied inclusion criteria. They were divided into 3 groups; officers with at least 3 years of working experience, academic or researcher who has been working in the field and published at least 3 articles, and stakeholders under the forensic laboratory service.

3. Data Collection: Data were obtained via (1) face-to-face interviews, (2) video call interviews or (3) online meetings following the COVID-19 protection measures. This research was reviewed and certified by the Institutional Review Board (IRB) from the Faculty of Forensic Science, RPCA with Certification No. 630626-009.

4. Data analysis: Data were extracted, reviewed, and analyzed by descriptive statistics in accordance with the records and objectives of the research. Theory and documents were referred to and supported by the content for comparison and summarization of the forensic laboratory collaborative network as a role model for the Royal Thai Police and interorganizational agency.

Results

1. Participation level in the development of the forensic laboratory

1.1 Data from the interviews showed that the participation of forensic laboratories was subsidized by exchanges among staff, equipment and academics. These can be classified as participation in Level 1 - Manipulation, Level 3 - Informing, Level 4 -

Consultation and Level 5 - Placation (Arnstein, 1969). Participation in the Benefits step is consistent with the basis and secure participation level (Cohen & Uphoff, 1980). The RPCA forensic laboratory requests cooperation to participate in forensic laboratory activities or to participate in the form of committees, advisors in the research or other projects of the forensic laboratory or related science by dividing the level of participation in the manipulation stage. The interview data revealed that the laboratory consistently cooperate with different departments, such as the Central Institute of Forensic Science under the Ministry of Justice, the Central Police Forensic Science Division under the Office of Police Forensic Science, the Institute of Forensic Medicine under the Police General Hospital, and departments from the university or educational institute. Results from cooperation are highlighted on the cooperation in consulting and preparing for the Memorandum of Understanding (MOU) on knowledge development, personnel productivity, creation of innovation and forensic science research. For example, the MOU and forum for academic cooperation on environment and forensic science with the Pollution Control Department. The MOU was signed by RPCA and universities majoring in forensic science to encourage academic cooperation and interlaboratory networks.

1.2 Participation in research and being a lecturer are cooperation Level 2 - Therapy, 3 - Informing, 5 - Placation (Arnstein, 1969) whereas this step can also related to the Benefits in the reported concept (Cohen & Uphoff, 1980). At the above level, the Faculty of Forensic Science of the Royal Police Cadet Academy invited key informants to join as researchers and to be speakers to educate police cadets and master's degree students. The key informants in group 1 said that most of them were invited to participate as researchers and were the most targeted group in the research. Most of the executives were invited as speakers to educate students. The key informants in Group 2 were the most likely participants to be speakers, to educate students, to become researchers, and to constitute a target group in descending order. The key informants in Group 3 were service recipients or stakeholders, most of whom were members of the research sample and were willing to cooperate.

1.3 Participation in a summit to examination can be classified as Level 3 (Informing), Level 4 (Consultation) according to the ladder of citizen participation (Arnstein, 1969). Also, Level 1 (Analysis), Level 3 (Implementation), and Level 4 (Benefits) can be inferred from the concept (Cohen & Uphoff, 1980). Accordingly, most of the materials used to examine under this topic were from

Group 3 (recipients or stakeholders), which are companies and partnerships that have previously submitted samples to the laboratory for specific examination. All key informants experienced to the RPCA forensic laboratory for metal contamination in water based on pollution analysis.

1.4 Participation in consulting and boarding is in Level 3 (Informing), Level 4 (Consultation) of the participation ladder (Arnstein, 1969)as well as Level 5 - Evaluation (Cohen & Uphoff , 1980). From the interview, it was found that the informants at the executive level in Group 1 and Group 2 were invited to join as course committees and the quality system examination of the laboratory to provide the consult, propose useful opinions on laboratory development guidelines, control the safety of the laboratory. These processes can ensure quality, correctness, and accuracy that will substantially meet the standard criteria.

2. Guidelines for the development in forensic laboratory.

2.1 Short-term phase This refers to the development of existing resources with efficiency and capacity. The target groups have proposed to develop in 3 schemes as follows:

2.1.1 Equipment and tools for the examination: more scientific equipment and tools must be provided. The key informant groups said that it is not compulsory to be fully equipped with all examination disciplines, but that is important to the scope and application of important examinations which cover a wide range of forensic separation and sample analysis. Advanced techniques such as structural analysis instruments with high accuracy and sensitivity should be installed.

2.1.2 Personnel: personnel development must be prioritized to staff knowledge, expertise, and experience in criminalistics and crime scene investigation. The practice of theoretical and practical examination is required to be eligible for the qualified expert. Once training and tests are established, the staff of the laboratory will be able to examine the evidence accurately and consistently. The key informants said that personnel who are responsible for the electronic evidence, information technology criminalistics and digital material evidence examination are important to gain specific knowledge and training to pass a competency test. Continuous training both at home and abroad can be an option to learn from research, projects, and media because information technology (IT) is dynamic and continuously updated. Improving the effectiveness of IT examinations according to international standards will maintain trust in those involved in the justice process and public.

2.1.3 Public relations: it is needed to prioritize and disseminate the public relation matter. News, research, and the

ability of forensic laboratory must be known to related departments and stakeholders. To be professional and qualified, the forensic laboratory must be recognized as a good reputation for crime solving agency and reliable scientific research unit within and beyond the nation.

2.2 Long-term phase

Scheme 1: Participation in the formulation of regulations and standards. The key informants reveled that the laboratory must be certified by ISO/IEC 17025:2005 to cover other quality system certifications related to ISO 9001:2008, such as alcohol content analysis, explosive substance testing, medicine analysis, drug analysis, fiber analysis, and ion analysis in explosive substances. Moreover, international standards related to forensic science are under several accreditation organizations and systems, such as ASCLD: American Society of Crime Laboratory Directors, ENFSI: European Network of Forensic Science Institutes, FAD: Field Application Document, NATA: National Association of Testing Authorities, and UKAS: United Kingdom Accreditation Service.

Scheme 2: Examination readiness. The equipment and scope of the examination should be expanded and covered, including document examination, firearm, trace analysis, anonymous body and missing person identification, forensic pathology analysis, forensic clinical examination, forensic psychiatric analysis, genetic material identification and analysis, chemical analysis (drugs, toxic substances, narcotics, chemicals), and digital forensic evidence. This is to service and support future trends of crime and illegal incidents efficiently.

Scheme 3: Separation of forensic laboratory management from the organizational administration. This is to ensure flexible management together with sufficient personnel and budget. Also, substantial knowledge of forensic science can be effectively provided without redundant tasks.

Conclusion and Discussion

The participants in the three networks were forensic science practitioners, academics or researchers, and service recipients or stakeholders from government departments, private sectors, and universities. There are 4 levels of participation: (1) Agreement to exchange knowledge on personnel, academic work, and tools; to consult and discuss the development of knowledge and personnel production; and to create innovation and research in forensic science. (2) Participation in research, knowledge exchange and lecturing, (3) Participation in the examination and

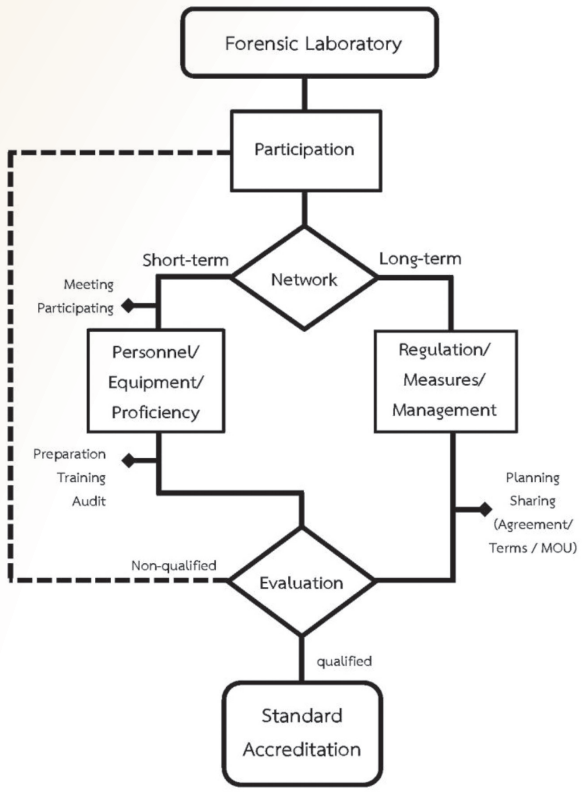
(4) Involvement as an advisor and board member, which is consistent with the concepts of participation's place in development (Cohen & Uphoff,1980), ladder of citizen participation (Arnstein, 1969) and previous study of forensic science standard accreditation (Chaichan Chairangsinant, 2016). These 4 levels are the collaborative steps leading to operational success and common goals. All institutes gain mutual benefits in forensic laboratory development as forensic science involves institutes in both public and private sectors with application of case investigation, environmental examination, or chemical testing laboratory. The results of the examination must be correct, accurate, and reliable, and service fees are acceptable for the service recipients. In addition, the development of forensic work must be coordinated with the network to expand the strength of participation, such as signing a memorandum of understanding (MOU) between institutes for academic cooperation, work in forensic science, and laboratory quality system. Moreover, technology and facility to support for learning skills of practitioners for maximum efficiency must be successfully developed by equipment, tools, and content, consistent with the previous research of the optimal model of private service in Thailand (Sasiwimon Thongklom, & Thamavit Terdudomtham, 2020). It was reported that co-operating network support for participation and reduce workload of the government sector, resulting in more reliable and qualified for standard accreditation.

Guidelines for participating in the development of forensic science laboratories suggest that the development framework involves 2 phases. (1) Short-term: it is emphasized that the laboratory must be qualified for tools and equipment along with personnel development in terms of knowledge, expertise, experience in criminals, crime scene investigation, and training on specific examination. There are both theoretical and practical assessment tests as well as public relations, published news, research, and the ability of the laboratory to various institutes to realize the importance of forensic science in addition to solving crimes, agreed with research done by Phonrasuek's group (Amornthap Phonrasuek et al., 2020). These findings demonstrate that knowledge of all fields of forensic examination should be carried out following internationalstandards at the highest level of importance, which is consistent to the results of previous work about the study on scope of forensic science in Thailand (Akkakorn Chaiyapong et al., 2022). The establishment of international examination standards results in reliable performance is of the

most priority. Providing information on the preparation of international standards for forensic examination is necessary at the highest level. The model of cooperation in the development of forensic science is focused on promoting cooperation in 3 areas: standard development, management, and personnel development. The organization should be encouraged to upgrade toward international standards. Management must be focused on organizational achievement. Production factors and processes such as personnel, money, budgets, and tools will stimulate personnel to develop their competence. (2) Long term: this includes participation in forensic laboratory regulations and standards, well-prepared equipment with all necessary examinations, and suitable forensic laboratory management. Long-term operation requires cooperation from various departments, and supporting budgets received in the short-term plan. This can enhance the forensic laboratory to get accreditation covering all aspects. In the beginning, there was no accredited standard for evidence collection at crime scenes. Consequently, laboratory examination is not valid. Therefore, international standard development must be used in crime scene investigations as a system and procedure to collect evidence before transferring to the laboratory. It will result in correct evidence collection without contamination prior to the laboratory. The standard that has been developed by UKAS covers the field of crime scene examination according to ISO/IEC 17020. However, it is not yet used to examine electronic evidence. UKAS has developed the ISO/IEC 27037 standard to certify the laboratory's competence for electronic evidence. There are details about security and practice guidelines for collecting evidence, as well as the use of tools and the retention of electronic evidence. This approach is regarded as the forensic science standard that UKAS has developed to cover the laboratory, crime scene investigation, and electronic evidence examination (Wilson-Wilde, 2018). This approach allows laboratories in the region to be recognized internationally, such as the European Union. The standard process helps to emphasize the correct and accurate examination report, traceability, validity, and regulatory process used as a model for further regional laboratory development (Sakolkrit Akejakrawan, & Navapat Narongsak, 2022). In conclusion, the direction for driving forensic laboratory to be accredited by the collaborative network is based on the implementation of strategy planning in both short-term and long-term phases. This must be carried out under the participation in laboratory development. The guidelines and procedure can be summarized and demonstrated in Figure 1. This proposed

model for laboratory standard accreditation can be used as a role model for forensic laboratory within the organization and distributed to relevant laboratory for interlaboratory review among collaborative networks. Hence, this proposed model can be practically applied as a guideline for overall operation to meet the standard criteria and accreditation for the laboratory unit.

Figure 1 *Proposed model for standard accreditation of the forensic laboratory network.*



summarized and proposed by the research author.

Based on the proposed model as demonstrated in Figure 1, participation among networks will determine the status of qualified laboratory. If one laboratory starts the accreditation process without any planning, personnel training and facility maintenance, the short-term evaluation cannot be qualified. The possibility of success in accreditation can be enhanced by laboratory meetings regarding participation, training, and internal audit. These processes result in practical progress and concrete

outcomes. Moreover, in accordance with planning and sharing of regulations and measures among forensic laboratories and stakeholders, overall process can be accumulated to common agreement and mutual goal to be qualified for standard accreditation via long-term pathway. Budget and support managed during the short-term pathway can be represented as the checks and balances to each standard criteria for the forensic laboratory. Hence, participation and evaluation in both short-term and long-term phases are necessary and can be adapted as a guideline for related laboratories and research centers.

Suggestion

1. This research highlights the high possibility of developing forensic laboratories through collaborative networks in both the public and private sectors. Further expansion must be carried out by collaborating with institutes, volunteers, and the main network. Objectives and tangible results that institutes themselves can benefit from network collaboration by their strong bonding.

2. All institutional networks involved in forensic laboratory development are equally important, but their roles and abilities may differ. Therefore, in further network development, these elements should be considered: common perception for clear roles and concrete operational guidelines, common vision for the goal, mutual interests for values and incentives, stakeholders' participation as membership, complementary relationship for activities and benefits, interdependence in all case supporting and directing, and interaction to promote the forensic work for effective results and international standards.

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