

## **Current Status of Forensic DNA Laboratory in Bangkok Thailand**

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### **Introduction**

DNA evidence plays an increasingly important role in criminal investigation, paternity cases, and missing persons [1-5]. Biological traces containing DNA can be collected and examined to provide scientific proof of transfer to the court. The fact that DNA is unique to each individual, except identical twins, DNA-based technology is widely accepted and used in the legal system nowadays. technology and it is widely accepted in the legal system. The quality of forensic examinations performed in the forensic science laboratories is one of the major concern not only for the forensic community but the whole judicial system. The interpretation and evaluation of evidence would be presented in court to non-experts. It is essential to ensure and maintain the highest standards of in forensic science [2].

The demand for rigorous quality control for all laboratories handling routine casework resulted from the obvious lack of standards and failures to present conclusive evidence in the early days of forensic DNA analysis. Hence, quality assurance of forensic laboratory work was considered. Firstly, the internal quality assurance system, which is the major element for quality assurance, is recommended by all scientific bodies. The second important element is the participation in external proficiency testing exercises. This is to obtain the necessary competence for carrying out research as well as for routine casework. There are numbers of proficiency trial schemes for DNA laboratories both for paternity analysis as well as for forensic identity testing. In addition, competency certificates will be issued to participating laboratories passing the tests. Such exercises also provide insights into potential sources of human and technical errors. In which these may help to educate the participants and offer support to develop strategies for avoiding these errors in their future work. For routine casework laboratories, rigorous quality assurance as well as international accreditation became a prerequisite for accepting\_casework samples [6].

The Technical Working Group on DNA Analysis Methods (TWGDAM) issued guidelines for quality control and quality assessment in 1991 [7]. It is suggested that personnel who perform DNA tests must have appropriate education and sufficient experience. In addition, the forensic DNA analyst must be familiar and understand the principles, uses and limits of the DNA typing methods and all related procedures connected forensic DNA testing. Forensic DNA laboratories must be equipped according to determined criteria, which must include reagents and all procedures. Reagents must be stored appropriately and regularly monitored in the same way as

laboratory equipment. Procedures for analysis must be generally accepted and supported by publication. New procedures and technical solutions may be used in routine work only when they have been well-tested and when we are aware of their limitations. All DNA laboratories must regularly participate in external professional assessments which confirm the correctness of results and simultaneously the qualification of the personnel who perform the analyses [8].

The most common standard is the ISO/IEC 17025. It covers general requirements for the competency of any test and/or calibration laboratory, issued by International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) [1,9-12].

In this study, the current situation of the forensic DNA Laboratories in Bangkok, Thailand, was evaluated. The information generated would benefit the preparation of the organization in order to apply for accreditations according to the International Organization for Standardization or International Accreditation Bodies. Detail of these can also be used as an informative guideline for setting up a new forensic DNA laboratory in Thailand.

## **Objectives**

To obtain and evaluate the current situation of the forensic DNA Laboratories in Bangkok Thailand, in terms of laboratory's capacity (manpower, Instrumentation, Workload), and International Standards (ISO 17025:2005).

## **Materials and Methods**

### ***Data collection and analysis***

There are 6 government-supported DNA laboratories in the Bangkok area, which all participated in this study. These laboratories are located in Chulalongkorn hospital, Ramathibodi hospital, Siriraj hospital, Central Institute of Forensic Science, Royal Thai Police Office of Forensic Science, and the General Police hospital. All of these laboratories work on forensic samples, such as specimens collected from crime scene and paternity cases. Information was collected by observation, interview and questionnaires. Criteria and questions were set up for interviewing based on the standard as ISO/IEC 17025 : 2005 and DNA Advisory Board [13], including the following issues: management system, status/expected date of accreditation, name of accreditation standard/accreditation bodies, number of staff , number of instruments and number of cases examined per year. A questionnaire was sent out to each of these laboratories. Appointments were made with administrative staff or manager laboratories for the visit and interview. Regarding to the agreement of issues concerned by laboratories, their names and addresses are not published in the result, conclusion and discussions.

Data collected by all means were then compiled and analyzed in terms of manpower, instrumentation, workload, and laboratory's management system. Where appropriate, computer software, such as Microsoft Excel data sheets, was used for calculations and presentation of figures.

## Results

In 2007, there are a total number of 7 forensic DNA laboratories in Thailand, in which 6 are located in Bangkok and only one laboratory is located outside Bangkok. All 6 forensic DNA laboratories in Bangkok participated in this study. According to the information consent agreed upon before the study, alphabetical letters "A" to "F" are designated to the six laboratories.

Five out of the six DNA laboratories in Bangkok operate the entire process for the analysis of DNA evidence from the biological sample collection and recovery to the court. Occasionally, officers of the forensic DNA laboratories were requested to collect evidence at crime scene. There is one laboratory out of the six, which provides service restricted only to laboratory work. After the genotyping result was obtained, they will immediately return the test result for interpretation, and completing the downstream process.

The result will be presented in two major parts; the first part is the evaluation of DNA testing capacity and the second part is the laboratory standard. Details are as following.

The current status of the DNA testing capacity of each laboratory was evaluated based upon the members of staff, major equipments, and the number of DNA tests which were run within one year. Details of resources in each DNA laboratory is shown in **table 1**. The number of staffs varies from 2 to 18. According to the number of staffs, the laboratories can be divided into 3 groups; less than 5 (small), 5-10 (medium) and more than 10 (large) members of staffs. Staffs in all laboratories hold qualifications in science and medical science, with experience working in forensic DNA analysis from 6 months to 26 years. Major equipments, which are thermalcyclers and DNA sequencers, are available in every laboratory. However, bottle neck in the laboratory process is demonstrated in two laboratories (laboratory A and laboratory F). The capacity to carry out PCR amplification is approximately 16-times (laboratory A) and 4-times (laboratory F) lower than capacity of the laboratory to carry out fragment analysis. The capability of these two laboratories to type DNA samples was then limited by the amplification capacity. Considering the number of DNA samples typed in 2006, a total of 11,000 DNA samples from criminal cases and paternity testing were analyzed. The number of samples being typed in each laboratory varies from 400 – 5,000 samples per year, implicating that a budget of approximately 546,000 to 6,825,000 baht were supported for chemicals and consumables to maintain the laboratory work. By comparing the number of submitted samples and the DNA typing capacity of each laboratory, it is shown that the maximum capacity of instruments has not yet been reached.

Questionnaires with detailed questions according to the ISO 17025:2005 criteria were sent out to all 6 laboratories. A summary of laboratory's self-evaluation is shown in **table 2**. It is shown that 2 laboratories scored a total of 90% compliance to the ISO 17025:2005 requirements. The percentages of laboratory compliance to the management requirements are higher than the technical requirements. There is only one requirement that none of the laboratories self-evaluated complete score is technical requirement for result reporting. Considering the specific requirements for forensic DNA laboratory based on the American Society of Crime Laboratory Directors/Laboratory Accredited Board (ASCLD/LAB) and Federal Bureau of Investigation DNA Advisory Board [13], these include requirements for analyst regarding experience and competency in handling and successfully analyzed forensic samples typically encountered in routine casework prior handling independent casework; training program in which presentation of evidence to the court is also included; detailed specific laboratory requirements concerning areas and procedures for secure storage, handling, evidence examination, DNA extraction, quantification, PCR setup, typing, disposition of samples, and the implementation of protocols ; the integrity of chain of custody; laboratory document; environmental health and safety program. There are two laboratories which absolutely comply with these requirements (laboratory B and E). The training in the presentation of evidence in court is not done in two laboratories (laboratory D and F). In addition, the quantification of human DNA in samples is not done in two laboratories (laboratory C and F), and one laboratory do not have and follow a document environmental health and safety program in one laboratory (laboratory A). The percentage of compliance to the requirements of the DNA advisory Board is presented in **table 3**.

**Table 1** Laboratory Resources.

Lab	No. of staff	Amplification capacity	Fragment analysis capacity	Max. Typing capacity in 24 hr	No. of forensic samples analysed in 2006	Estimated cost of consumables in 2006 (baht/year)
<b>A</b>	12	48	816	48	5,000	6,825,000.00
<b>B</b>	18	960	928	928	2,500	3,412,500.00
<b>C</b>	7	576	1056	1056	1,000	1,365,000.00
<b>D</b>	8	768	240	240	1,200	1,638,000.00
<b>E</b>	5	432	240	240	1,000	1,365,000.00
<b>F</b>	2	192	768	192	400	546,000.00

**Note:** - The amplification capacity was estimated based upon the specification of thermalcyclers in each laboratory, and the assumption that the polymerase chain reactions would be carried out within the working hours per day.  
 - The fragment analysis capacity was estimated based upon the specification of the DNA sequencers in each laboratory.

**Table 2** ISO 17025:2005 compliance self-evaluated by all 6 laboratories in Bangkok

ISO 17025:2005 Requirements	Percentage (%) which the requirements were complied by each laboratory.					
	A	B	C	D	E	F
<b>1. Management Requirements</b>						
1.1 Organization	60	87	100	100	100	87
1.2 Management system	18	100	100	100	100	64
1.3 Document control	9	91	55	100	100	91
1.4 Review of request, tenders and contracts	0	100	29	100	57	57
1.5 Subcontracting of test and calibrations	NA	NA	NA	100	100	NA
1.6 Purchasing services and supplies	25	100	50	100	100	100
1.7 Service to the customer	50	100	50	100	100	100
1.8 Complaints	0	100	0	100	100	100
1.9 Control of nonconforming	14	100	28	100	0	43
1.10 Improvement	0	100	0	100	100	100
1.11 Corrective action	17	100	33	100	100	100
1.12 Preventive action	0	100	50	100	100	50
1.13 Control of records	57	100	71	100	100	100
1.14 Internal audits	25	100	50	100	100	100
1.15 Management reviews	0	100	100	100	100	100
Total (%)	19.6	98.4	51.1	100	90.5	85.1
<b>2. Technical requirements</b>						
2.1 General	33	100	100	100	100	100
2.2 Personnel	93	100	93	92	100	38
2.3 Accommodation and environmental conditions	63	100	75	100	100	88
2.4 Test and calibration method validation	38	100	82	85	100	77
2.5 Equipment	39	94	100	100	100	61
2.6 Measurement traceability	18	100	100	100	100	82
2.7 Sampling	0	100	75	50	100	0
2.8 Handling of test and calibration items	72	100	82	100	100	100
2.9 Assuring the quality of test and calibration results	25	100	100	100	100	100
2.10 Reporting the results	67	94	82	94	97	62
Total (%)	44.8	98.8	88.9	92.1	99.7	70.8
<b>Total % laboratory compliance</b>	<b>30.1</b>	<b>98.6</b>	<b>66.9</b>	<b>96.8</b>	<b>94.1</b>	<b>79.2</b>

**Table 3** Laboratory compliance to requirements according to the DNA advisory board, self-evaluated by the 6 laboratories in Bangkok.

DNA Advisory Board requirements	Laboratory					
	A	B	C	D	E	F
% compliance	88.9	100	88.9	88.9	100	77.8

## Discussions

An operating forensic DNA laboratory requires a large amount of budget to maintain the laboratory activities at the acceptable standard. From this study, we estimate that at least 136,500 baht per 100 reactions would have to be supported for consumables to maintain the routine laboratory work. This estimation does not include instrument parts and maintenance, staff salary, etc. For an operating forensic DNA laboratory to be up and running effectively, not only the numbers and qualifications of staffs should be considered. Competency of staffs to carry out the assigned task must also be evaluated. Moreover, staffs having a minimal of bachelor degree should be persuaded to continue higher education or special training in forensic DNA analysis, including evidence interpretation, evaluation, and presentation of evidence in court. Therefore, issues regarding the workload must consider not only the numbers of staffs, but also their competency in parallel. Major factors affecting the laboratory capacity to carry out DNA testing depends upon personnel and instruments in the work flow. Capacity of each major instrument should be considered in order to make the work flow through. From the study, most laboratories perform PCR during the working hours, hence, amplification can be set up twice a day. In contrast, the DNA sequencer is run only once a day if it is full-loaded; often that the DNA sequencer is left to run overnight. The capacity of thermalcycler to carry out the polymerase chain reaction will be the bottle neck of the work flow if two laboratories will have to work at their maximum capacity. When the capacity of the thermalcycler was compared to the DNA analyzer, the ratio was greater than 1:2.

Data obtained in this study were based on the interview and questionnaires answered by each laboratory, in which bias is not excluded from this self-evaluation. Although the most common standard use for guideline in forensic DNA laboratories [1, 12] is the ISO/IEC 17025. It is shown that all 6 laboratories are not yet accredited. Based on the information provided, it is likely that at least 50% of the laboratories are very close to fulfill all requirements of ISO 17025:2005. It is noted that all laboratories are aware of the importance of standards and accreditations as prerequisites in accepting casework. To date, none are accredited in the area of forensic science. A number of standards and accreditation bodies were mentioned throughout the study, such as hospital accreditation (HA), ISO 15189:2003, ISO 9001:2000, standard and ethics complying with requirements and good practice suggested by The Royal Collage of Pathologist of Thailand. However, these are not accounted as accreditation for forensic science laboratory. By comparing those with ISO 17025:2005, and the requirements of the DNA advisory board, there is a similarity in the management requirements, but not in the technical requirement part. In addition, the

recommendations of the DNA advisory board have specific details emphasizing specific technical issues concerning forensic aspects of the DNA typing process, evidence collection and preservation and storage, competency and chain of custody.

Out of the 6 laboratories in Bangkok, 4 of these are located in hospitals that are part of government-supported agencies and meet the HA standards. Thus, laboratories located in accredited hospitals, laboratories which are ISO9001:2000 and/or ISO 15189:2003 accredited would then have the advantage over the others because the management requirements, which are similar to the part in ISO 17025:2005, were fulfilled. The other 2 laboratories are part of government agencies which deal with case work routinely. All laboratories are positive towards the achievement of standards and accreditation in the forensic DNA area; 66.67% of the laboratories set a time frame to achieve accreditation within 3 years, while one laboratory is uncertain and one has not yet considered due to the major organization's policy.

## **Conclusions and Suggestions**

Currently, neither of the 6 forensic DNA laboratories in Bangkok is accredited for forensic DNA analysis by international accreditation bodies nor ISO17025:2005. However, out of the 6 DNA laboratories, one laboratory is ISO 15189:2003 accredited and one is ISO 9001:2000 accredited for the management system. All of the 6 laboratories are equipped with essential instruments sufficient for carrying out forensic DNA analysis, though a need to balance the capacity of major instruments to reach it's full capacity. To strengthen the competency of staffs, special training regarding forensic issues must be provided. All 6 laboratories have positive attitude towards standards and accreditation as prerequisite to carry out forensic case work. Over 66.67% of the DNA laboratories aim for being ISO17025:2005 accredited within 3 years. However, in order to process for the accreditation, the main organization must have a clear supporting policy. An external auditor may be appointed as a part of the auditing team to provide a broader view to the laboratory, as well as demonstrating clarity of the quality assurance process. In the beginning of this year, 2007, the Bureau of Laboratory Quality Standards, Ministry of Public Health, Thailand has launched an accreditation program based on ISO/IEC 17025:2005 for forensic science laboratories. This is would help support Thai forensic laboratories to meet the quality and international standards in the very near future.

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