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The development of forensic science standards in China

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ABSTRACT

Forensic science standards are specifications and procedures that would greatly help to ensure a scientific, reliable and accurate result of the forensic process. The development of forensic science standards in China has been carried for more than 30 years and has its own development characteristics. Many forensic science standards have been widely used in forensic analysis and interpretation for the purposes of presenting conclusions to the court, effectively improving the performance of forensic science in China. This paper reviews the history and current situation of forensic science standards in China, including the standard development organization, standard supply, standardization system, standard implementation and review. This paper also introduces the characteristics and challenges of forensic science standardization in China and discusses the future trends, which would help to enhance the understanding of China's forensic science standardization and provide a Chinese reference for the global forensic science community.

1. Introduction

The standardization of forensic science is an important way to ensure the scientific, reliable and accurate results of the forensic process, and minimize the risk of errors. Standardization has become the consensus of the international forensic science community and there has been a strong call internationally for the development of relevant forensic standards [1,2]. A number of countries around the world have set up corresponding standardization organizations to develop and manage forensic science standards. For example, Standards Australia (SA) has established a forensic-based committee CH-041 and published AS 5239-2011 Examination of ignitable liquids in fire debris [3,4], AS 5388 Forensic Analysis standards [5,6], and many standards developed by SA have also been adopted as international standards. The European Committee for Standardization (CEN) has established the CEN/TC 419 project committee and is developing the standards in a joint collaboration with ISO [7]. The British Standards Institution (BSI) is the national standards body in the United Kingdom and has established the FSM/1 Forensic Science Processes mirror committee. The Forensic Science Regulator is responsible for identifying the requirement for new or improved quality standards and leading on the development of new standards where necessary in UK [8]. In the United States, the Organization of Scientific Area Committees (OSAC) for Forensic Science has a total of 25 registry approved standards, and more than 200 standards are in the process of approval registration [9]. From an international perspective, the International Organization for Standardization (ISO) is one of the world's largest and most important organizations that develops international standards [10]. ISO/TC 272 is currently the main technical committee devoted to developing international standards of forensic science. The predecessor of ISO/TC 272 was the ISO project committee established in April 2013 under the leadership of SA [2], responsible for the development of ISO 18385-2016 Minimizing the risk of human DNA contamination in products used to collect, store and analyze biological material for forensic purposes — Requirements [11] that is an international standard for DNA products. In December 2015, the project committee was formally turned into a technical committee and began to develop a wider range of forensic science standards, such as ISO 21043–1:2018 Forensic sciences — Part 1: Terms and definitions [12] and ISO 21043–2:2018 Forensic sciences — Part 2: Recognition, recording, collecting, transport and storage of items [13]. Standards still under development include ISO 21043-3, ISO 21043-4, and ISO 21043-5. At present, ISO/TC 272 has 25 participating members and 19 observation members and the secretariat is located in Australia [14].

Unlike the market-led system where the standard development organization (SDO) is the main standard-setting body in Britain and the United States, the development of standards in China is mainly

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led by the government. The Standardization Administration of China (SAC) is responsible for unified management, supervision and overall coordination of standardization work in China. In China, according to SAC's classification principles, standard is one type of normative document. According to different issuing agencies, standards can be divided into national standards (issued by SAC, also known as GB standards), industry standards (issued by relevant administrative departments and submitted to SAC for registration, known as GA standards in public security field), provincial standards (issued by local government and submitted to SAC for registration, also known as DB standards), association standards (issued by associations, also known as TB standards) and company standards (issued by company, also known as QB standards). The national standards are classified into mandatory standards and voluntary standards. Mandatory national standards are developed to address technical requirements for ensuring people's health and the security of their lives and property, safeguarding national and eco-environmental security, and meeting the basic need of economic and social management. According to the newly revised "Standardization Law of the People's Republic of China", the products and services that do not meet mandatory standards shall not be manufactured, sold, imported or provided. A statistical analysis and report system is established to monitor the implementation of mandatory standards. Most of the industry standards and provincial standards are voluntary standards. For the industry standards in forensic science, they can be divided into three types according to their objects: the basic standards are mainly documents about terminology, graphic symbols and IT related issues; the management standards are mainly about quality management in laboratory; the technical standards focus on testing and inspection in the forensic process. As for the accreditation standards, China National Accreditation Service for Conformity Assessment (CNAS) is responsible for developing accreditation standards for the laboratory accreditation activities against ISO/IEC 17025 and ISO/IEC 17020. This paper mainly focuses on the current situation of GB standards and GA standards for forensic science in China.

In the past decades, China has been striving to explore forensic science standardization. The development of forensic science standards in China can be traced back to the quality control research carried out in the field of forensic toxicology in the 1980s. In 1987, Liu Yao, the academic of the Chinese Academy of Engineering, proposed that toxicological analysis should carefully establish a set of standardized procedures, corresponding quality requirements and standardized methods from the collection, storage, transportation, and analysis method of items, and determine the best standard operating procedures to standardize the methods [15]. Standardization is an activity, which mainly involves the development, implementation, and reviewing of standards as a cycle. This cycle repeats and each time the cycle is completed, the level of standardization would be elevated [16]. In 1990, the Supreme People's Court, the Supreme People's Procuratorate, the Ministry of Public Security, and the Ministry of Justice issued the "Standards for assessing minor bodily injuries (for Trial Implementation)" and the "Standards for assessing serious bodily injuries", which were of significance in the standardization process of forensic medicine. In 1991, GA 8–1991 "Illegal and criminal information management" was published, which was the first forensic science standard in the public security industry with formal standard codes. In the same year, the National Technical Committee on Forensic Science of Standardization Administration of China (SAC/TC 179) was established as the government nominated body responsible for developing forensic science standards in China. In 1993, GA 55–1993 "General labeling of physical evidence" was released, which was the first mandatory standard in forensic science. In 1995, GA/T 116–1995 "Crime scene photography and video documentation standard Framework" was published, which was the first standard system issued in forensic science. By the end of 1999, there had been a total of 59 issued forensic science standards, including 27 forensic toxicology standards. The industry standards issued in the fields of forensic imaging, forensic medicine, fingerprints, and information technology (IT) also accounted for a considerable proportion. In 2003, the GB/T 19267.1–19267.12 "Physical and chemical examination of trace evidence" were approved to be the first series of national forensic standards. In 2018, 11 national standards including the "Specification for parentage testing" proposed by the Ministry of Justice were approved for publication [17].

This paper introduces the current situation of the development of forensic science standards in China in terms of the standard development organization, standard supply, standardization system, standard application and review, taking the current valid 502 national and industry forensic standards in China as the analysis data. The aim of the review is to share the information on the practice of forensic science standardization in China and propose relevant views for the future development of forensic science standards, which would be favorable for contributing Chinese experience in standardization to the global forensic community.

2. Standard development organization—SAC/TC 179

SAC/TC 179 is currently the only government recognized standard development organization on forensic science in China that is jointly administered by the Standardization Administration of China and the Ministry of Public Security. The organization structure of SAC/TC 179 is shown in Fig. 1, which consists of 10 subcommittees (SC) and 3 working groups (WG). The secretariat for SAC/TC 179 is held by the Institute of Forensic Science, Ministry of Public Security. In 1991, SAC/TC 179 was established and became an important organization for developing forensic science standards, which consisted of 6 subcommittees on forensic toxicology, criminal information technology, fingerprints, physical and chemical examination, forensic imaging, and forensic medicine. In 2009, SAC/TC 179 established 4 new subcommittees on digital evidence, forensic products, prints, impressions & markings, and document examination. In 2012, two working groups on standardization of DNA and voice technology were founded. In 2019, the working group on standardization of police dog technology was established. The scientific areas of forensic science standards continues to expand. There are currently 56 members in SAC/TC 179 board who come from the police, procuratorate, court, judicial agency, medical and health system, the military security department, academia, industry, and research institutes. Among them, 66% are from public sectors. Each of the SAC/TC 179 board members normally serves for a five-year term.

3. Standard supply

The development of forensic science standards in China is mainly government-driven, instead of market behavior. In the forensic science field, China currently has published 40 national standards (GB Standards) and 462 industry standards (GA Standards), while 43 national standards and 256 industry standards are still under development. By February 2020, a total of 1052 standard projects have been initiated under SAC/TC 179.566 of those projects have been issued and become national or industry standards, and 491 standards are currently valid. The annual change of the quantity of initiated standard projects and published standards developed under SAC/TC 179 was shown in Fig. 2. It is worth mentioning that the demand for the standardization of criminal information technology in forensic science was highlighted from 2007. The

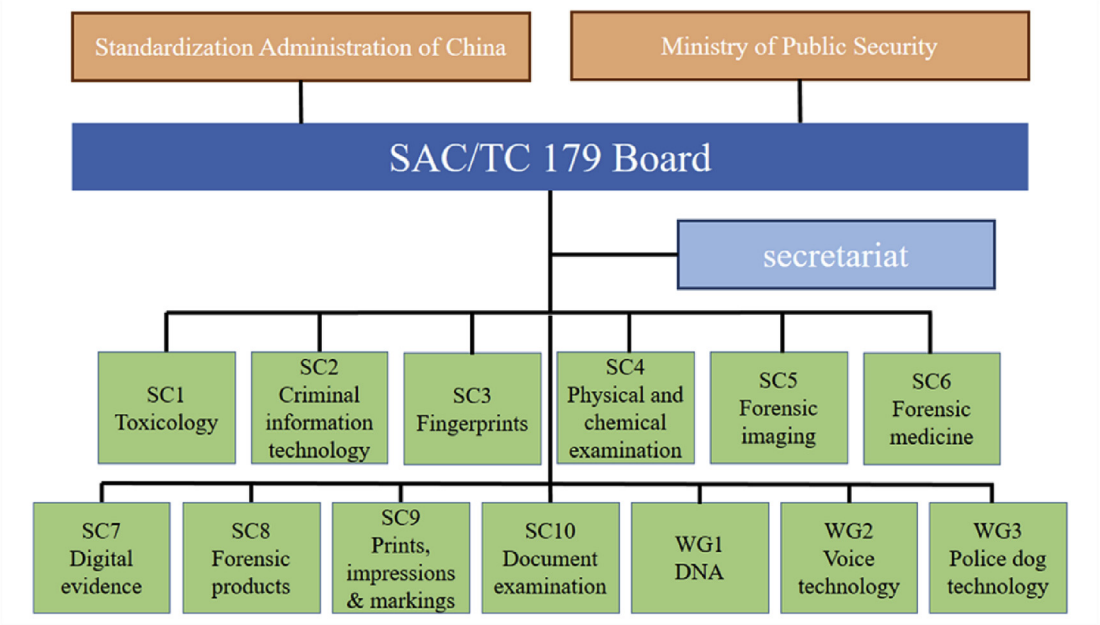

Fig. 1. The organization structure of SAC/TC 179.

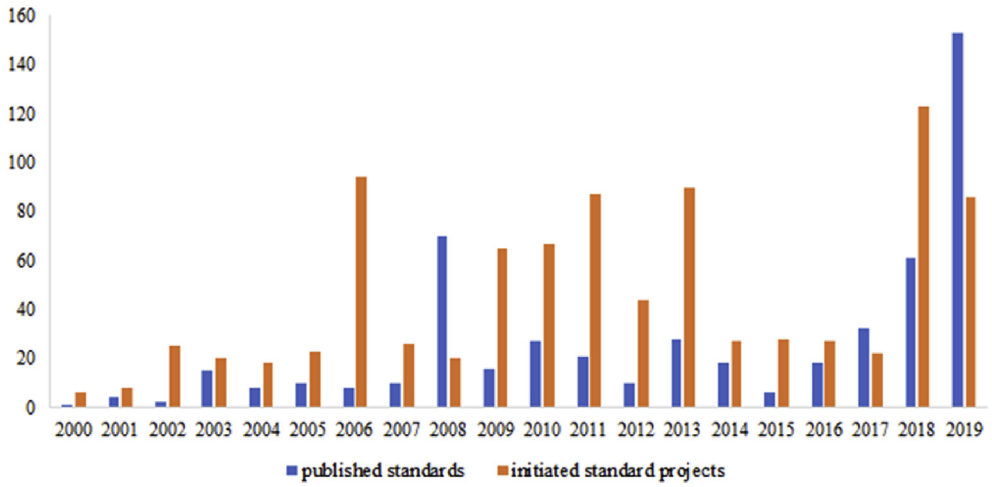

Fig. 2. The annual change of the quantity of initiated standard projects and published standards developed under SAC/TC 179.

number of information technology standards, e.g. fingerprint data acquisition, processing, and Automated Fingerprint Identification System (AFIS) building, increased rapidly. From 2018 to 2019, in order to meet the increasing demand for forensic science standards, a special research program on developing key forensic science standards was launched, proposing 137 industry standard projects and 16 national standard projects. In 2019, 153 standards developed under SAC/TC 179 were approved and published.

The Academy of Forensic Science under the supervision of the Ministry of Justice is another important standard development organization in China. At present, it has initiated 12 standard projects and 11 of them have been approved and published [18]. The Ministry of Justice has developed normative documents "Technical specifications for forensic science" since 2010 [19], which provide guidance for the standardization of rapidly changing technical fields in the form of agreed specifications. By February 2020, a total of 118 technical specifications have been published in various branches of forensic science (93 of them are still valid).

In addition, there are a number of normative documents, local standards, association standards and non-standard methods developed by government, court, agencies or forensic laboratories. The Supreme People's Court has issued some regulatory documents for the identification of criminals who can't take care of themselves [20]. Supreme People's Procuratorate has issued documents for forensic medical work and judicial accounting work [21]. Some of China's provinces, e.g. Sichuan, Shanghai, Tianjin, Jiangsu, Fujian, and a few municipalities have developed local standards such as DB51/T 2200 "Technical Guidelines for Identification of Personal Injuries Caused by Electric Shock", DB31/T 1076 "Regulations on clinical forensic expertise service" (DB stands for local standards). The newly revised "Standardization Law of the People's Republic of China" in 2018 has clarified the legal status of association standards. The Shanghai Association of Forensic Science and other associations have developed association standards such as the "Guideline to the assessment of legal competences in forensic psychiatry", which are adopted by the members of relevant associations and

provided for voluntary use in the forensic science community.

A statistical analysis of the composition of standard drafting committee based on the current valid 502 standards was conducted. As show in Fig. 3, police departments and research institutes were the main participating bodies when forming a standard drafting committee, which accounted for 39% and 41%, respectively. Colleges accounted for 15%, and judicial organizations accounted for 3%. In terms of the number of participating bodies in the standard drafting committees, 69% of the standards were drafted by two or more bodies, and 31% were drafted by only one body. Although most of the standards were drafted jointly, nearly one-third of the standards were drafted by one single body. SAC/TC 179 is striving for improvement of the consistency, coordination and representativeness of the standards. More diverse participants and peer-recognized approach would be involved into the development of standards.

4. Standardization system

China has attached great importance to the standard framework, as the top-level design of forensic science standardization system, in order to reduce duplication, overlap and conflicts between standards and TCs. Since the establishment of SAC/TC 179, the corresponding standard framework has been formulated, and it has been constantly modified with the improvement of technology and management. In 2019, the latest standard framework GA/Z 1600–2019 "Forensic Science Standard Architecture" was released, as shown in Fig. 4. The subcommittees and working groups of SAC/TC 179 have also developed their discipline-specific frameworks in accordance with GA/Z 1600–2019, including a hierarchy of standards and a detailed list of existing and planned standards, which help to pave the way in the standard development. The standard framework provides a guide and roadmap for standard development, implementation, review and management.

At present, forensic science standards in China are divided into

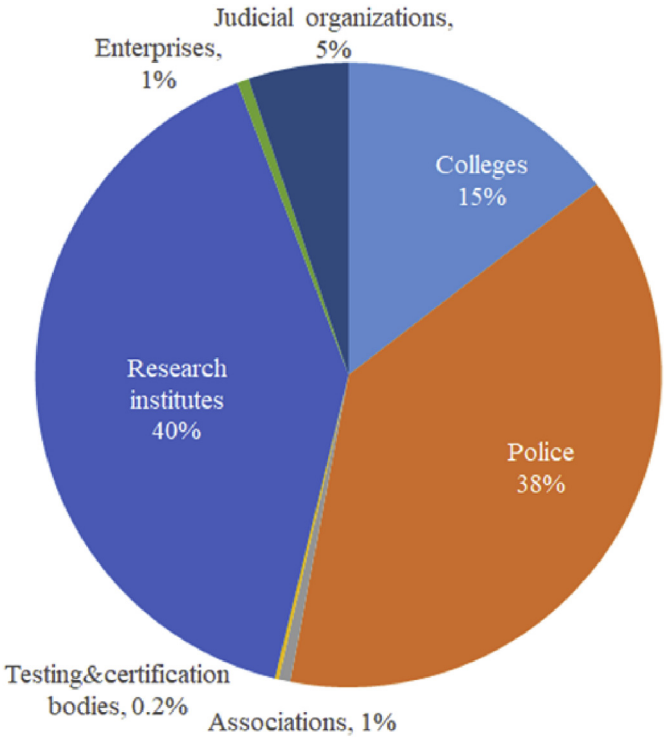

Fig. 3. The distribution of participating bodies in standard drafting committees.

basic standards, technical standards and management standards. Among the currently valid forensic science standards, the ratio of basic, technical and management standards is approximately 2:15:1, with technical standards accounting for the largest proportion. Among the forensic science standards published from 2000 to 2015, the number of voluntary standards accounted for 73% of the total [21], most of which were product standards and IT standards. After an evaluation and review of the mandatory standards in 2016, only one mandatory standard (forensic product standard) was left and all of the rest became voluntary standards. According to standardization principles and international experience, the transition from mandatory standards to voluntary standards is reasonable and it is also conducive to the development of standards.

According to standard framework, the first level includes 13 disciplines in the field of forensic science, e.g. toxicology, fingerprints, forensic medicine, video/image analysis, digital evidence and document examination. 1064 standards in the stage of valid, drafted, abolished, withdrawal or merged for all the disciplines are analyzed, as shown in Fig. 5. Due to different technological progress, the number of standards in different disciplines varies greatly. Among all the disciplines, forensic toxicology has the largest number of valid and drafted standards. The number of under-development standards for toxicology, voiceprint, police dog technology, and psychological testing is greater than that of the current valid standards, which means that the standard supply in these disciplines would continue to increase. The withdrawn standards exceed 15% of the published standards in the disciplines of fingerprints, physical and chemical examination and forensic medicine, which indicate that the technological progress and standard updating in these fields is fast. There are only a few basic and management standards that could be applied in the entire forensic process, including the standards on the evidence packaging and a small number of general standards for forensic products. It would be difficult to develop basic standards across the whole forensic process due to the large discipline spans. Therefore, it is more reasonable and feasible for each discipline to develop its own terms, symbols and classification standards to satisfy the diversified needs. However, IT or database standards have become a new trend in all disciplines recently that needs to be promoted as a whole. As for the management standards, the standards of quality control and method validation are also developed in respective disciplines based on ISO/IEC 17025 and ISO/IEC 17020. For example, the subcommittees on forensic toxicology (SC1) and prints, impressions & marks (SC9) of SAC/TC 179 have developed GA/T 1649–2019 "Specifications for validation of examination methods for toxicants" and GA/T 1674–2019 "Specifications for validation of morphological comparative methods for trace examination", respectively. The working group on DNA (WG1) has also published GA/T 1704–2019 "Specifications for quality control of DNA laboratories".

5. Standard implementation and review

At present, the full text of Chinese national standards for forensic science can be accessed for free, while the industry standards can be purchased online and will open access soon. The promotion and implementation of forensic science standards were generally organized by the technical committees and the public sectors. Training and meetings were the main forms of standards implementation. The police departments and the technical committees carried out special promotion and training on standard development ~3 to 5 times a year, generally 50 to 200 persons per time, targeted at the relevant forensic service providers. The Ministry of Justice has set up a group of national and provincial judicial

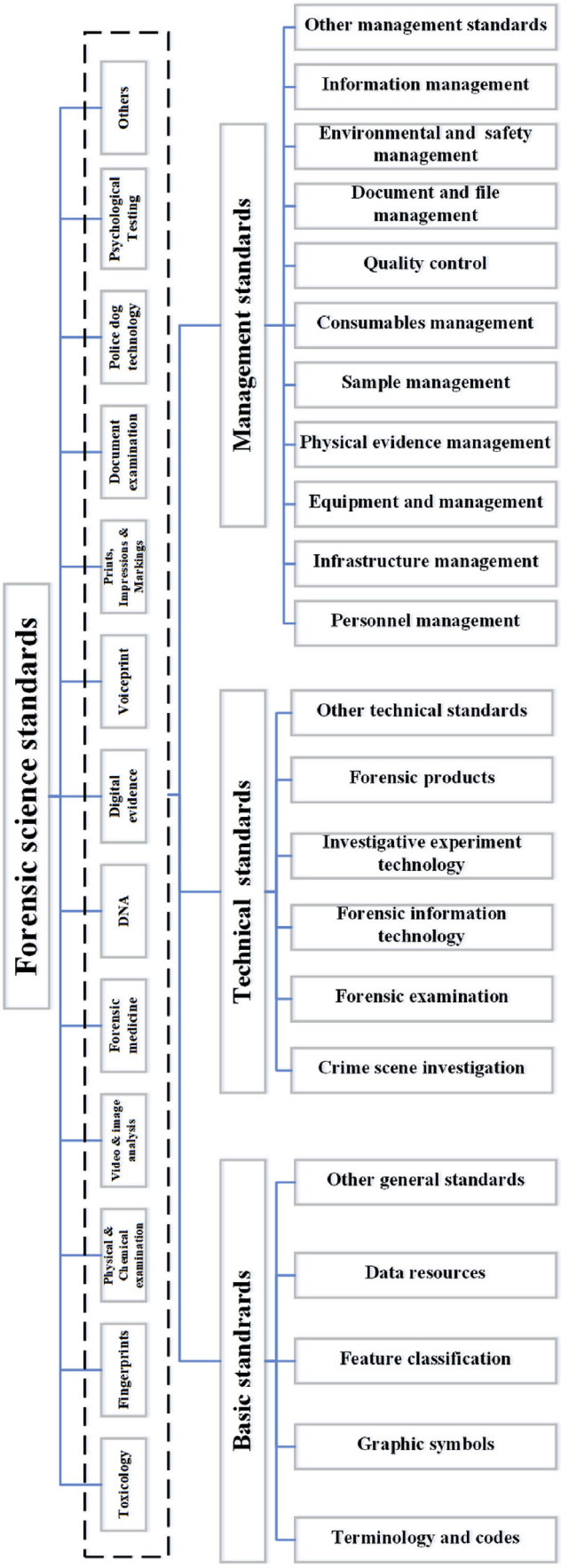

Fig. 4. Forensic science standard framework of China.

forensic continuing education and training courses at certain forensic science institutes and colleges, and especially carried out systematic and standardized trainings on the standards for assessing the extent of bodily injuries [22]. The professional training was one of the important aspects in the certification of forensic practitioners. In addition, SAC/TC 179 has established a standardization coordination mechanism to coordinate the positions of the forensic laboratories in different regions of China, which turns out to be conducive to further strengthening standards implementation and supervision.

Standards can be used in the accreditation of forensic laboratories or facilities and in the certification of products and services [2]. Both the accreditation and certification require the adoption of standards and the technical activities be carried out in accordance with the standards. A number of organizations around the world have developed corresponding standards based on their respective understanding of forensic science work in the accreditation and certification, but these standards cannot fully meet the needs of China's practical work, e.g. backlogs have become a problem for the forensic analysis and few of these standards mentioned time of report production or turnaround time. In China, CNAS has developed a series of accreditation standards in order to conduct accreditation activities, e.g. CNAS-CL08:2018 "Accreditation criteria for the competence of forensic units", which is based on ISO/IEC 17025 and supplemented by ISO/IEC 17020 and ILAC G19:08/2014 requirements. The level of standardization in various forensic service providers can be evaluated by means of accreditation and it would be helpful to reinforce the standard implementation in the accreditation. The development of personnel certification standard programs are still under discussion. With the combination of certification, accreditation and standardization (quality triangle) [23,24], standardization runs through the entire process of the quality control system and spirals up with the PDCA (plan–do–check–act) cycle. Nowadays the Chinese forensic experts are paying more and more attention to the quality management standards for the laboratory's record control, personnel certification, proficiency testing, method validation and chain of custody when conducting accreditations.

The implementation of standards promotes the performance of forensic science in China. Two examples are given to illustrate the implementation and effectiveness of forensic science standards. The Chinese accreditation standards based on ISO/IEC 17025 and ISO/IEC 17020 have been promoted and implemented in more than 500 forensic laboratories nationwide through accreditation activities, accounting for approximately 10% of the total number of forensic laboratories in China. Before 2005, no laboratory in China had been accredited, but now it has grown to over 500, indicating that the Chinese forensic science community attaches great importance to laboratory quality management. At the same time, China has also established its own mandatory quality management system for forensic laboratories, called qualification accreditation. Currently, around 70% of the forensic laboratories in China have been accredited through qualification accreditation or CNAS laboratory accreditation, and the remaining laboratories have also been required by the government to seek corresponding accreditation within two years. Due to the combined effect of qualification accreditation and CNAS laboratory accreditation, GA standards have been widely adopted by Chinese forensic laboratories. When the forensic experts testify in court, they need to explain the standards used in the forensic process. Standards greatly help the laboratory to establish an effective quality management system and improve the reliability of results. The other example is the standards for forensic DNA testing laboratories. The laboratory construction standard provides guidance to the design, layout and equipment installation of DNA testing laboratory, which effectively reduces the

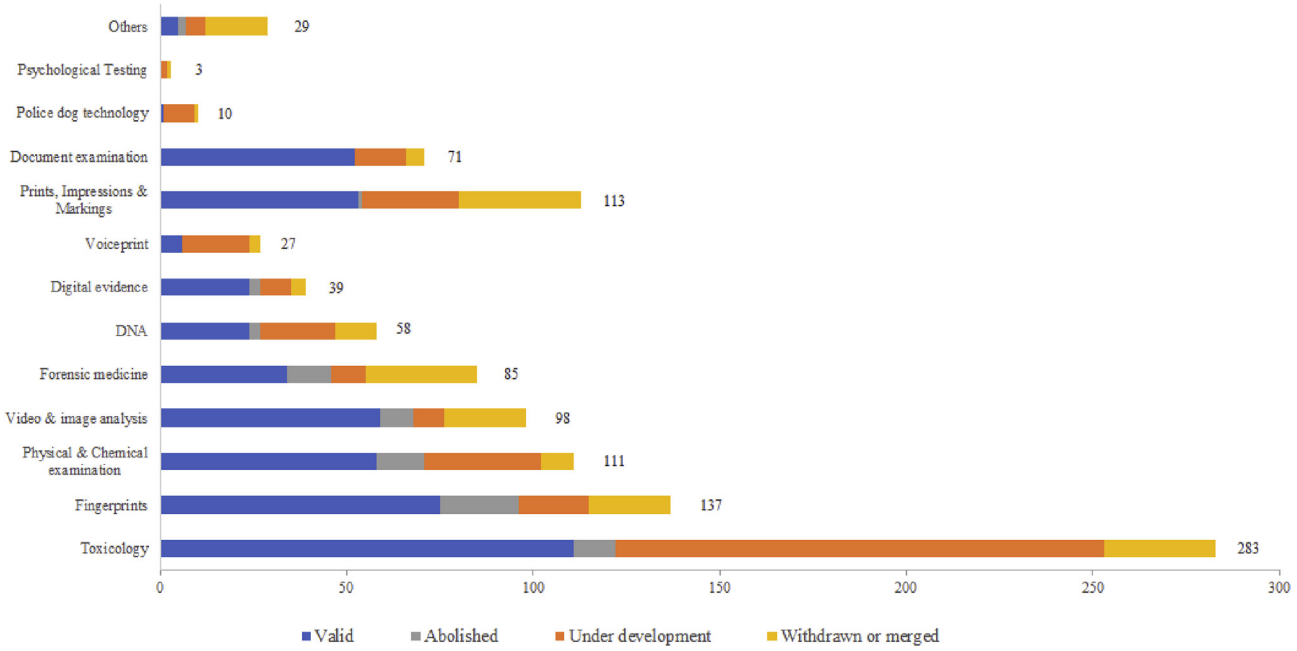

Fig. 5. Distribution of forensic science standards by disciplines.

risk of contamination. The implementation of DNA testing method standards has improved the laboratory performance in DNA testing. For example, low copy number (LCN) analysis has been widely used across the country, and a number of small forensic service providers are able to carry out LCN analysis.

The forensic science standards in China are generally reviewed every five years. The regular review promotes updating and optimizing of standards and ensures the standards meet the needs of rapid technological progress. In 2016, SAC/TC 179 organized a wide range review for 648 standards and 146 of them have been withdrawn, abolished or revised, accounting for 22.5% of all the reviewed standards.

6. Discussion and conclusions

The development of forensic science standards in China has been carried out for more than 30 years, and it has been widely used in law enforcement and judicial practice, effectively improving the standardization of forensic science. Through the introduction and analysis of the current situation of the development of forensic science standards in China, it can be seen that the forensic science community in China has experienced a gradually deepening understanding of the role of standards. Forensic science standards in China present unique characteristics and development paths. Chinese forensic practitioners focus on the development of standards from a technology-oriented perspective, which means that the standards for specific technical methods are developed, accelerating the promotion and application of the technical methods. Therefore, it produces a large number of technical standards, while the number of basic standards and management standards is relatively small. However, forensic practitioners in western countries such as Australia, Europe and the United States tend to view standards from a quality-oriented perspective, with more emphasis on basic standards and management standards. However, in recent years, forensic science standards in China have been more aligned with international standardization work. Standards are not only considered as standard operating procedures (SOPs) to ensure the result of a specific method, but also regarded as an important quality control tool, e.g. the forensic experts are now paying more attentions to the examination sequence and the physical evidence circulation procedures in various disciplines.

The government-led and market-led standardization have their own advantages and disadvantages. The government-led mechanism leads to a more efficient procedure for developing standards and the relevant funding can be guaranteed. However, sometimes the standards might be deviated from the actual needs, leading to a limited implementation. In contrast, the market-led mechanism takes more time to develop a standard but enables a more effective implementation. In recent years, many countries have begun to change. For example, the United States has established OSAC to strengthen the unified management of forensic science standards. China has revised the Standardization Law and encourages the associations and other social organizations to coordinate with relevant market stakeholders in jointly developing association standards that meet market and innovation requirements.

The forensic science standardization in China has become more active due to the participation of more public and private organizations, which continuously increase China's forensic science standards supply. The social groups are encouraged to develop association standards that are different from the national or industry standards developed by the government, which would meet the diversified needs of the market for voluntary choice and increase the effective supply of standards. On the other hand, it may also lead to the problems of duplication, overlap and conflicts between standards. It would be helpful for China to participate in international standardization actively and adopt international standards based on the actual conditions in China, promoting the consistency between Chinese forensic science standards and international standards such as ISO/IEC.

In the future, the development of forensic science standards in China will not only focus on developing standards at the in-lab analysis stage, but also consider the pre-lab (e.g. evidence collection and handling at the crime scene), post-lab (e.g. interpretation of the results and their applications in the investigations or courts) standards and the connections between different stages. In addition, there is urgent need for developing forensic IT standards on

building, maintaining and managing forensic databases. Furthermore, forensic analysis or interpretation may require using technologies comprehensively in various fields of forensic science and cooperating with various professions. Instead of pursuing the optimization of one single standard, it is promising to develop "interface standards" and explore comprehensive standards across disciplines, because one single standard may not be able to meet the diversified needs in increasingly complicated forensic practices. Finally, it is also necessary to strengthen the scientific validation and verification of forensic science standards, ensuring the quality of the standard supply, and jointly achieve the best overall effect.

Declaration of competing interest

There is no conflict of interest.

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