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A review of trachoma history in China: research, prevention, and control

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Trachoma is one of the most widespread blinding eye diseases, which is harmful to human visual health. The efforts to prevent and control trachoma in China can be divided into three periods, i.e., highly epidemic period, research on pathogenesis and control of trachoma, and blinding trachoma elimination and epidemiological evaluation. In 1956, Prof. Feifan Tang and Xiaolou Zhang first discovered and isolated *Chlamydia trachomatis*, which clarified the cause of trachoma, and kick-started a fresh chapter in trachoma research, prevention, and control around the world. Although, the prevalence of trachoma differed in different areas, the average prevalence once exceeded 50% and was as high as 90% in some areas before and at early liberation of China. Therefore, the government-led efforts were made to comprehensively prevent and control trachoma, including development of National Plan for the Prevention and Control of Trachoma, nationwide screening and treatment of trachoma, implementation of National Patriotic Health Campaign and improvement of water supply and lavatories. After decades of effort, China reached the goal of eliminating blinding trachoma in 2015. China has gained remarkable achievements in the prevention and treatment of trachoma, making outstanding contributions toward the goal of eliminating trachoma worldwide. The research, prevention, and control of trachoma in China were reviewed in this paper.

Chlamydia, *Chlamydia trachomatis*, blinding trachoma

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INTRODUCTION

Trachoma, which is one kind of chronic infectious conjunctivitis, is caused by *Chlamydia trachomatis* infection. Patients have obvious symptoms, including eye pain, photophobia, tears, itching, and irritation, even vision loss. In addition to the clinical signs of palpebral conjunctiva, e.g., follicular and papillary hyperplasia, most patients usually suffer from conjunctival scarring, corneal pannus, and Herbert's pits typical performance. Repeated infection may cause enstrophe, trichiasis, ptosis, atretoblepharia, and even blindness by macular cornea at the end stage. The prevention and control of trachoma in China can be characterized by three periods as follows: highly epidemic period, comprehensive trachoma prevention and control period, and blinding trachoma elimination and evaluation period. The objective of this paper is to review studies concerning the prevention and control of trachoma in China.

HIGHLY EPIDEMIC PERIOD

Before liberation, trachoma was widespread in China owing to economic issues and poor sanitation. The average prevalence of trachoma was about 50%, with the prevalence rate of 30% in urban areas and as high as 80%–90% in remote rural areas was, resulting in the proverb that "nine out of ten

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were caught in trachoma" (Wang et al., 2015). In total, 25%–37% of blindness was caused by trachoma (Jin, 2006; Wang et al., 2015; Ji, 1944). Before 1955, the pathogenic mechanisms were not clear, and trachoma spread as a major cause of blindness worldwide for a long time. It was once called the "dark district of ophthalmology" for the lack of clear etiology (Jin, 2006). The mechanism underlying the early prevalence of trachoma was mainly unknown; thus, no targeted prevention or control measures could be taken. To identify certain microorganism as trachoma pathogen, Koch's postulates should be followed, which include the following requirements: (i) the organism must be isolated from the corresponding cases; (ii) to the microbe must be subcultured *in vitro*, separately; (iii) vaccination of the isolated microorganisms must produce lesions and symptoms in healthy hosts; (iv) the microbe must be isolated again from the vaccinated host.

Internationally, there were several theories about trachoma pathogens, including Koch's trachoma germ theory and Noguchi's trachoma particles *Escherichia coli* pathogen theory. However, most studies have failed to retain strains or to be confirmed by repeated experiments performed by other groups. Accordingly, they fail to meet the four principles of Koch's criteria; thus, it was not possible to determine the cause of trachoma. In the spring of 1929, Prof. Feifan Tang, a member of the first generation of Chinese microbiologists and virologists, started to work on identifying the trachoma pathogen. Using the conjunctival biopsies of 227 patients as sources, Prof. Feifan Tang and ophthalmologist Prof. Chenghu Zhou still failed to isolate bacillus particles by bacterial culture after hundreds of attempts from 1932 to 1935. Moreover, no infection appeared when the Noguchi bacillus strain particles were inoculated to the eyes of monkeys or 12 volunteers, including those of Feifan Tang. In an additional agglutination experiment and complement fixation experiment, there were no differences with respect to the use of particles as antigens in the results for patients with and without trachoma, thus rejecting Noguchi's theory (Tang and Zhou, 1936).

After the establishment of People's Republic of China, deadly infectious diseases were highly controlled; thus, the focus of epidemic prevention efforts shifted to multiple standard infectious diseases. In 1954, Prof. Feifan Tang, the director of Nation Vaccine & Serum Institute began to study trachoma pathogens in cooperation with Prof. Xiaolou Zhang, an ophthalmologist from Beijing Tongren Hospital.

Prof. Feifan Tang and Xiaolou Zhang's trachoma pathogen research included three main stages: trachoma inclusion studies, the inoculation of trachoma-positive inclusion material to monkeys, and pathogen separation experiments (Tang et al., 1956a, b, c, 1957a, b, 1958; Li et al., 1956, 1964; Zhang and Zhang, 1965; Chang et al., 1960). Based on an analysis of the successes and failures of predecessors in separating the "trachoma virus", Prof. Feifan Tang found that pathogen separation was mainly influenced by two factors: (i) the sensitivity of animals and appropriate route of infection and (ii) the control of bacterial breeding in specimens. After hundreds of thousands of experiments, they ultimately chose to vaccinate chicken embryonic yolk sacs with a "trachoma virus", and adjusted the specimens added to 1,000 units of streptomycin; these were maintained at 4°C for 4 h. In August of 1955, for the first time, they successfully isolated trachoma pathogenic agents: "*Chlamydia* TE55 standard strains" (Tang et al., 1956c, 1957a). In order to confirm the trachoma virus cultivated in the chicken embryo yolk sac as a trachoma pathogen, Feifan Tang and Xiaolou Zhang inoculated themselves in January of 1956. Based on daily observations and conjunctival smears, they finally found trachoma inclusions in the typical clinical signs and conjunctiva smears, and cultivated the "trachoma virus" separately several times.

The fact that the "trachoma virus" was separately cultivated in the chicken embryo strongly indicated that it was a trachoma pathogen (Zhang and Zhang, 1965; Li et al., 1964). In 1970, "trachoma virus" was formally renamed "*Chlamydia trachomatis*" during the international symposium on trachoma and related diseases caused by *Chlamydia*.

With over 50 years of intensive efforts, Chinese scientists finally isolated trachoma pathogens, which represented a major international advance in the fields of microbiology and ophthalmology. In 1957, medical delegations from the US and UK asked Prof. Feifan Tang for the separated strains TE8 and TE55 during their visit to China. Dr. Collier, director of the British trachoma team, vaccinated chicken embryos after recovery and cultivated *Chlamydia* with his teammates, validating the experimental results of Feifan Tang and others. In 1958, by following Feifan Tang's method, Collier and Sowa managed to isolate 1 strain in the western African country of Gambia, which was named trachoma strain G1. They also obtained positive results when the strain was inoculated to the eyes of monkeys and volunteers. In 1959 and later, Saudi Arabia, the United States, Israel, Egypt, Japan, and other countries successively isolated many strains of "trachoma virus". In 1960 and 1961, Lepine, chairman of the International Conference on Trachoma, highly praised China's effort in isolating *Chlamydia* and named the TE55 strain "Tang's strain", which could be used worldwide as the standard strain for trachoma research. Due to this unique contribution, Prof. Feifan Tang was awarded Trachoma Gold Medal by International Organization Against Trachoma.

RESEARCH ON PATHOGENESIS AND CONTROL OF TRACHOMA

The discovery of *Chlamydia* laid a foundation for the prevention and treatment of trachoma and Chlamydia, starting a new chapter in the study of the prevention and treatment of *Chlamydia trachomatis*. China carried out studies on typing, toxins, serological properties, pathogenic mechanism, local immunity, the transmission mode, treatment, development of vaccines and preventive measures from the perspective of clinical service and public health, and promoted SAFE (Surgery for Trichiasis, S; Antibiotic Treatment, A; Face Washing, F; and Environmental Improvements, E) strategy nationwide to comprehensively prevent and control trachoma.

Pathogenesis of trachoma

In 1956, Feifan Tang measured the *Chlamydia trachomatis* size as 0.13–0.2 μm (Tang et al., 1956c), while Xiaolou Zhang reported a size of 0.311–0.477 μm using an electron microscope (Zhang and Zhang, 1965). In 1973, Tao Hong studied the microstructure of *Chlamydia trachomatis*, and observed equal and unequal divisions (Hong et al., 1973). In 1956, using volunteer and monkey eye infection tests, Feifan Tang and Xiaolou Zhang confirmed that human and monkey eyes were sensitive to *Chlamydia trachomatis*, while rabbits, guinea pigs, dogs, sheep, and other animals were not susceptible (Tang et al., 1956b, c, 1957a). Typical trachoma inclusions were found when Feifan Tang and others injected *Chlamydia trachomatis* into chicken embryo yolk sac endodermal cells, human embryonic kidney cells, human embryo conjunctiva, and HeLa cells. Zihua Li and others isolated *Chlamydia trachomatis* from chicken embryo yolk sac endoderm and HeLa cells and maintained it passaging for five generations. These studies laid the foundation for cell cultures of trachoma (Tang et al., 1958; Li et al., 1963, 1964). In 1956, based on observations of trachoma inclusions, such as morphological classifications and effects on cell properties, Feifan Tang and others advanced the idea that the inclusions were trachoma and the initial colony form, or the reticulate body, was the source of infection of trachoma pathogens, and found it replicate after the initial infection (Tang et al., 1956a). Xiaolou Zhang and others found that the reproductive cycle of *Chlamydia trachomatis* is 48–72 h in duration (Zhang et al., 1965). In 1980, Youxun Zhang and others studied the ultrastructure of *Chlamydia trachomatis* and found that the splitting original body and large individual actually breed by binary fission, budding, multicenter germinal methods, and so on, clarifying the life cycle of trachoma (Zhang et al., 1980). Keqian Wang, Xiaolou Zhang, and others confirmed that *Chlamydia trachomatis* can produce toxins, which were antigenic and sensitive to temperature. Penicillin treatment could make *Chlamydia trachomatis* lose its chlamydial infection ability and maintain toxin activity, while immune serum could neutralize these toxins. These findings laid the basis for further studies on trachoma immunity (Wang and Zhang, 1966).

Xiaolou Zhang, among others, began serological studies of *Chlamydia trachomatis* in China since 1960 (Zhang and Zhang, 1965). In 1964, Keqian Wang found a significant antigen consistency among trachoma strains (Zhang et al., 1980; Wang and Huang, 1964). In 1966, Keqian Wang found that 46 strains of trachoma "virus" obtained from separation experiments in Beijing, Shanghai, Henan, and other places could be divided into two types, types I and II (Wang and Zhang, 1966). In 1991, Zhang Li and other researchers classified *Chlamydia trachomatis* discovered in northern China. They found that 78.1% and 21.9% sequence similarity between the isolates from northern China and type B and type C reference strains, verifying the idea of KeQian Wang that the type I *Chlamydia trachomatis* TF55 was type C (Zhang and Zhang, 1991). In 1992, Jun Fan and Wenhua Zhang used two kinds of synthetic primers to perform PCR amplification as a detection method for trachomatous specimens. This method enabled the rapid detection of eye infection by *Chlamydia trachomatis*, and indicated that the positive rate increased to 70.6% (Fan et al., 1992). In 2007, PCR-based gene classification was performed by Yumei Zhou and others, revealing that the major type in China was type B (Zhou et al., 2007), and the major genotype of patient in the clinical ophthalmology was still type B, representing 56%, while type C represented 25% and type D represented 19%. Types B and C showed high homology with the gene pool and trachoma of the same type spread in the endemic area of China, while type D showed certain differences (Zhou et al., 2013).

Based on the analysis of conjunctival cytology, follicular pathology, and *Chlamydia* Xiuying Jin, Xiaolou Zhang, and others further clarified the pathogenesis of trachoma (Jin et al., 1980; Wang et al., 1980), pointing out that recovery from the initial infection was possible, while repeated infection might cause a delayed hypersensitivity reaction. Additionally, an increasing number of repeated infections would cause more severe pathological injury, leading to higher morbidity and sequelae and ultimately inducing blindness. Hence, devoted efforts to treat acute trachoma, cut off transmission routes, and prevent super-infection were of great significance (Jin et al., 1980).

Drug studies

In 1956–1962, Feifan Tang, Xiaolou Zhang, Zhenxi Ma, and others discovered that while geomycin, terramycin, penicillin, chloromycetin, and sodium hyaluronate could inhibit trachoma, streptomycin could not. More than 100 various Chinese herbal medicines tested by Zhen Xi Ma and others limited the process of virus breeding (Tang et al., 1956c; Lu and Xu, 1955; Ma et al., 1962; Zhang and Jin, 1962a). The Ophthalmology Department at the No. 3 Hospital of Beijing University used an herbal pill named Huatiedan to treat trachoma and obtained a cure rate of 48.6% within two weeks in 1959 (Department of Ophthalmology, 1959). In 1972, Xiaolou Zhang and other researchers checked 220 herbal medicines and 19 local Chinese herbal eye drops, and found that these drugs could inhibit *Chlamydia trachomatis* using *in vitro* tests, but none were effective *in vivo* (Zhang et al., 1974). In 1962, Xiaolou Zhang and others prepared 0.1% rifampicin eye drops to treat trachomas. The cure rate reached 47.5% in four weeks and 88.1% in six weeks, suggesting the application of rifampicin eye drops for the treatment of trachoma in Chinese ophthalmology three years earlier than this strategy was adopted in foreign countries (Zhang, 1977).

Research on preventive measures

Results of studies on localized premunition of trachoma and vaccine use carried out by Xiaolou Zhang and Xiuying Jin in 1963–1964 indicated that a localized premunition existed in the internal ocular surface for a period within the post-healing time of trachoma. Though it failed to reduce high-dose virus, self-vaccine-injection could provide immunity to a certain degree, increasing resistance to natural infection and protecting the lateral eye from infection (Zhang et al., 1963; Chang et al., 1964). To adopt effective prevention methods and gain predictive control in pathophoresis, Xiaolou Zhang and Xiuying Jin carried out a series of studies in 1966, and found that heat sterilization was the most convenient and effective way to prevent trachoma transmission in homes and public areas. Due to its strongest inactivation ability against *Chlamydia trachomatis*, 75% ethanol was an effective disinfectant; it can be used by healthcare workers to disinfect their hands and dental instruments (Chang and Chin, 1962; Zhang and Jin, 1962b).

Promotion of SAFE strategy

Increased attention was paid to trachoma prevention by the new Chinese government. Specifically, the prevention and treatment of trachoma was included in the national development programe in 1956 and National Plan for the Prevention and Control of Trachoma; nationwide screening and treatment of trachoma as well as a campaign named "national prevention and treatment of trachoma through improvement of water supply and lavatories" were carried out in 1957–1959. As early as 1958, China put forward the strategy of combining the prevention and treatment of trachoma with National Patriotic Health Campaign and advocated preventive measures, such as one towel for each person, face washing with running water, refraining from eye rubbing with hands, use of clean water and comprehensive prevention and control of trachoma, which coincide with the SAFE strategy put forth by World Health Organization.

Meanwhile, the prevention and treatment of trachoma in China was tailored to its national conditions, as the Chinese government continuously increases investment in rural medical force development and rural medical insurance system to perfect the three-tiered medical network, relies on medical and health facilities at all levels, give full play to urban-rural medical network, emphasizes the publicity and education on health aimed at improving the health awareness of the general public in the prevention and treatment efforts. In the first nationwide survey in 1987, trachoma fell to the third leading cause of blindness, rather the leading cause, explaining approximately 10.87% of all causes of blindness (Zhang et al., 1992).

In May 1990, the World Health Organization (WHO) Collaborating Centre for the Prevention of Blindness in China (Beijing Institute of Ophthalmology, Beijing Tongren Hospital) held a training course on the simplified WHO trachoma grading system—for the first time in China. Prof. Baochen Sun invited WHO advisor Dr. Konyama to be the lead lecturer. In November 1991, Prof. Sun and Dr. Konyama carried out a survey of trachoma in Kunming, and continuously promoted simplified WHO trachoma grading system of the WHO.

In 1999, the team led by Prof. Baochen Sun obtained the written permission and funding from the WHO headquarters in Geneva and translated the four handbooks on trachoma control into Chinese. These books were published in January 2000 and were distributed to provinces, municipalities and autonomous regions in China. Since then, Prof. Baochen Sun and Prof. Ailian Hu organized training courses and promote the simplified WHO trachoma grading system and SAFE strategy by lecturing, showing videos or demonstrating. They made an outstanding contribution to trachoma prevention and control and the elimination of blinding trachoma in China.

In September 1999, the Chinese government signed the "VISION 2020" declaration initiated by WHO and the Non-governmental organizations (NGOs), and solemnly swore to eliminate avoidable blindness by 2020, indicating the start of a new period in the prevention and treatment of trachoma in China.

BLINDING TRACHOMA ELIMINATION AND EPIDEMIOLOGICAL EVALUATION

In November 1999, the WHO cooperated with National Health and Family Planning Commission of the People's Republic of China (NHFPC), performed by the National Institute of Hospital Administration, to hold a workshop on the assessment and management of trachoma in Kunming of Yunnan province, pointing out that about 6 million trichiasis patients might require surgery in China, which is of priority in the fight against trachoma in our country.

In 2003, on behalf of China, Prof. Ningli Wang attended the Seventh Meeting of the WHO Alliance for the Global Elimination of Blinding Trachoma, a meeting held at the WHO headquarters in Geneva. According to epidemiological data in China, the WHO assessed the prevalence of trachoma, pointing out that China was still a country with a large population of trachoma patients, with 26 million active trachoma patients (TF+TI) and three million trichiasis patients (TT) (Table 1 shows the simplified WHO trachoma grading system).

Currently, in the face of its reality, China's primary task in achieving the goals of "VISION 2020" and eliminating blinding trachoma in China was to evaluate the nationwide prevalence of trachoma.

To investigate the nationwide epidemiological status of trachoma and discuss China's strategy for prevention, Prof. Ningli Wang, and his team invited international officials specialized in blindness prevention, including Dr. Konyama, Dr. Mariotti, Dr. Resnikoff, Dr. Para and Pro. Taylor, to China for a short-term visit. Furthermore, they actively advocated the National Health and Family Planning Commission of the People's Republic of China (NHFPC, the former Ministry of Health), the China Disabled Persons' Federation (CDPF), international NGOs and Mr. Ronggen Tan, who was working in the Lions Clubs International, to work together.

In 2004, their efforts brought a program called "Eliminating Blinding Trachoma in China", a program financially and technically supported by the WHO, and they started preliminary experimental evaluations on the elimination of blinding trachoma in China. By reviewing the related literature, analyzing data, and seeking advice based on other useful information, they rapidly screened, treated, and evaluated children under the age of 10 and adults 50 years or older around provinces and areas with high suspected trachoma prevalence, such as Sichuan, Yunnan, Qinghai, Chongqing, Shanxi, Beijing, Guangdong, Heilongjiang, Inner Mongolia, Yunnan, Hainan, Hebei, Jilin, Jiangxi, Xinjiang, and Tibet. In the program, Prof. Ailian Hu and Prof. Tongtong Cui led the local medical forces specialized in blindness prevention to carry out the screening of trachoma among children, and 59,630 children were screened, and 559 positive cases of TF were detected, with a positive rate of 0.94%. Among them, the positive rate in 2004 was up to 3.89%, while the rates in 2005, 2006, and 2007 were 0.39%, 0.33%, and 1.22%, with no TT- and CO-positive cases. The rates in Shanxi and Chongqing were both above 5%, and the trachoma TF positive detection rate for children under age 10 in the country were all less than 1% in the other 13 prov inces, showing that trachoma was unevenly distributed (Hu et al., 2015).

According to the trachoma screening results in the population of individuals 50 years old and above, including a total of 82,434 people who were screened from 2004 to 2007, 284 cases were positive for TT, and the positive rate was 0.34%. These patients all acquired trachoma infection in the 20th century, when the disease was highly prevalent in China; thus, they were named "old trachoma patients". In the second nationwide survey in 2006, trachoma fell to the 11th leading cause of blindness (Hu et al., 2015). The rate of blindness caused by trachoma decreased considerably, therefore, trachoma is no longer a leading cause for blindness.

The above results contributed to the approval for project "Eliminating blinding trachoma in China before 2016". In September of 2012, together with the Lions Clubs International, NHFPC launched the third phase of "Vision First, China Action" project in Beijing, i.e., "Eliminating blinding trachoma in China before 2016". The office for "Vision First, China Action" project was set in National Institute of Hospital Administration, with both Prof. Jialiang Zhao and Prof. Ningli Wang as co-chairmen of the expert panel. A series of studies, including screening, treatment and evaluation on the effect of prevention and treatment efforts were carried out under the common effort by the expert panel, Dr. Resnikoff and Dr. Mariotti from WHO and other domestic ophthalmologists and blinding-prevention workers in 16 provinces with previously high incidences, covering 8,163 children under the age of nine in 130 schools and 87,924,355 residents over 15 years old in 55,679 villages.

All of the work was completed by the end of 2014, showing that the morbidity among 1–9 year olds was less than 5%, while the rate of trichiasis among adults was less than 1‰ (Hu et al., 2016), meeting the WHO standard of eliminating blinding trachoma, and fulfilling the task of eliminating blinding trachoma five years early, indicating that trachoma was no longer a public hygiene problem affecting vision health. On May 18, 2015, Bin Li, Minister of National Health and Family Planning commission of the PRC, made an announcement in a general speech on the 68th World Health Assembly that China met the WHO requirement of eliminating the blinding trachoma in 2014.

In order to determine whether there is biological variation between the current *Chlamydia trachomatis* and the previous pathogenic bacteria, and to evaluate the properties of the remaining sporadic trachoma, such as its pathogenicity, intensity, transmission routes, and so on, Prof. Ningli Wang and the medical team from the Beijing Institute of Ophthalmology made many trips to Qinghai in 2014–2015, conducting a broad range of trachoma prevention and treatment research in the medically underserved area, which is widely known as "the world of old, young, remote, and poor". Their surveys in rural primary schools of Dunhua, Huangyuan, and Huzhu in Qinghai Province identified sev-

Table 1 Simplified WHO trachoma grading system

Grade	Clinical signs
Trachomatous inflammation follicles (TF)	Five or more follicles of >0.5 mm on upper tarsal conjunctiva
Trachomatous inflammation intense (TI)	Inflammatory thickening obscuring more than half of the normal deep tarsal vessels
Trachomatous conjunctival scarring (TS)	The presence of easily visible scars in the tarsal conjunctiva
Trachomatous trichiasis (TT)	At least one eyelash rubbing on the eyeball or evidence of recent removal of in-turned eyelashes
Cornea opacity (CO)	Opacity of the cornea involving part of the pupil margin

eral cases of sporadic trachoma.

In May and December of 2015, they investigated the students in two boarding primary schools in Galeng District, Salar autonomous County, Haidong City of Qinghai Province and found 26 students with *Chlamydia trachomatis* among 322 students using RT-PCR detection. The *ompA* gene sequence of these 26 subjects had 99% similarity with the sequence of type B. By comparing the homology of *ompA* among 11 subjects, they also found a missense mutation occurring in the 2nd conserved region, where an adenine (A) was converted to a guanine (G) (ACT to GCT). As a result, the 91st amino acid changed from Thr to Ala. This missense mutation existed in all 26 subjects. Additionally, in the fourth variable region at the 887th site, a missense mutation occurred in which a thymine (T) was converted to a cytosine (C) (GCA to GTA), resulting in a change at the 296th amino acid from Ala to Val (A to V); four in 26 subjects presented this missense mutation. Compared with ATCC VR-573, six mutation sites were detected. These genes were divided into two groups according to the mutation at site 887, named CQZ-1 (Qinghai-1) and CQZ-2 (Qinghai-2).

The record of prevalence of trachoma can date back to thousands of years. China, once holding the largest population of trachoma patients (accounting 1/4–1/3 of the world's total), now have eliminated blinding trachoma in China after the unremitting efforts of several generations of researchers. China has gained remarkable achievements in the prevention and treatment of trachoma, making outstanding contributions toward the goal of eliminating trachoma worldwide.

Although China has reached the goal of eliminating blinding trachoma, it does not mean that China no longer has trachoma cases. Hence, further efforts need to be made to promote simplified WHO trachoma grading system, trachoma rapid assessment, and SAFE strategies at a broader scale to prevent the recurrence of trachoma (Wang et al., 2015).

Compliance and ethics *The author(s) declare that they have no conflict of interest.*

Chang, H., Chin, H., and Wang, K. (1964). Experimental studies on trachoma vaccine in monkeys. Chin Med J 83, 755–762.

Chang, H., and Chin, H. (1962). Studies on trachoma virus with various physical and chemical agents for prophylaxis. Chin Med J 81, 779–783.

Chang, H., Chin, H., and Wang, K. (1960). Experimental trachoma in human volunteers produced by cultured virus. Chin Med J 80, 214–221.

Cui, S., Ji, C., and Zhang, L. (2006). A national analysis of trachoma prevention and control among primary and high school students in 2000. Chin J Dis Contr Prevent 1, 60–61.

Department of Ophthalmology. (1959). Affiliated Hospital of Peking University Group A preliminary summary of the treatment of trachoma using Hua Tiedan. J Peking Univ: Health Sci 1, 138–141.

Fan, J., Zhang, W., and Wu, Y. (1992). The PCR method for detection of *Chlamydia trachomatis* eye infection. Ophthalmol China 1, 44–47.

Hong, T., Wang, S., Chen, L., Yu, W., Jin, X., and Ma, S. (1973). Study on the morphology of the trachoma virus by electron microscopy. Acta Microbiol Sin 2, 91–101.

Hu, A., Xiao, X., Qiao, L., Zhang, Y., Zhang, X., Sun, B., and Wang, N. (2015). Comparison of visual impairment caused by trachoma in China between 1978 and 2006. Chin J Ophthalmol 51,768–772.

Hu, A., Xiao, X., Qiao, L., Zhang, Y., Zhang, X., and Sun, B. (2015). The epidemiological characteristics changing of trachoma in recent sixty years in China. Chin J Practical Ophthalmol 33, 985–990.

Hu, A., Sun, B., Cui, T., Zhang, X., Sang, J., Zheng, Y., Yang, X., and Wang, N. (2016). Assessment of the prevalence of high incidence area of high of trachoma in China. Chin J Ophthalmol 52, 212–215.

Ji, X. (1944). A review on blindness of trachomatis. Nat Med J China 30, 66–75.

Jin, X. (2006). The research course and progression of *Chlamydia trachomatis*. Ophthalmol China 15, 145–150.

Jin, X., Zhang, X., Zhang, W., Wang, X., Sun, X., Zhao, W., and Luo, S. (1980). Pathogenesis of trachoma. Chin Med J 93, 827–834.

Li, Z., Shen, M., Zhou, Y., Guo, Y., Chen, F., Lin, F., Guo, B., and Wu, H. (1964). *In vitro* culture of the trachoma virus–separation and passage with endoderm cells chicken embryo. Acta Acad Med Primae Shanghai 2, 264.

Li, Z., Shen, M., and Zhou, Y. (1963). *In vitro* culture of the trachoma virus. Nat Med J China 49, 697–703.

Li, Z., Guo, Y., Shen, M., Chen, F., Zhou, Y., Zhang, Y., Guo, B., and Wu, H. (1964). Studies on the etiological agent of trachoma. Shanghai First Med College J, 121–125.

Li, Y., Lu, B., Zhang, X., and Tang, F. (1956). Study on the pathogen of trachoma III. Attempt to isolate the virus in the white mice. Acta Microbiol Sin 4, 26–32.

Lu, L., and Xu, W. (1955). The effect of chloramphenicol on trachoma. People's Military Surgeon 2, 57–59.

Liu, H., Ou, B., and Paxton, A. (2002). Rapid assessment of trachoma in Hainan Province, China: validation of the new World Health Organization methodology. Ophthalmic Epidemiol 9, 97–104.

Ma, Z., Zhan, S., and Ma, S. (1962). Experimental study on screening of anti-trachoma. Ophthalmology Academic Conference in Zheng zhou. Zheng zhou.

Su, X., Zheng, Y., and Sun, B. (1994). Epidemiological survey of the prevalence of trachoma in Miyun Beijing. Chin J Pract Ophthalmol 12, 251–252.

Tang, F., and Zhou, C. (1936). The study on trachomatis bacillus and trachomatis. Nat Med J China 22, 867–878.

Tang, F., Zhang, X., Li, Y., and Huang, Y. (1956a). The study on the etiological agent of trachoma I. The study on Lindner's initial body. Acta Microbiol Sin 1, 1–14.

Tang, F., Zhang, X., Li, Y., and Lu, S. (1956b). Study on the pathogen of trachoma II. Infection test in monkey body. Acta Microbiol Sin 4, 15–23.

Tang, F., Zhang, X., Huang, Y., and Wang, K. (1956c). Study on the pathogen of trachoma IV. Attempt to isolate the virus in the embryonated hens eggs. Acta Microbiol Sin 2, 189–210.

Tang, F., Chang, H., Huang, Y., and Wang, K. (1957a). Studies on the etiology of trachoma with special reference to isolation of the virus in chick embryo. Chin Med J 75, 429–447.

Tang, F., Zhang, X., and Huang, Y. (1957b). Study on the pathogen of trachoma V. Improved trachoma virus isolation technology. Nat Med J China 43, 81–86.

Tang, F., Huang, Y., Chang, H., and Wong, K. (1958). Further studies on the isolation of the trachoma virus. Acta Virol 2, 164–170.

Wang, N., Hu, A., and Taylor, H.R. (2015). Trachoma. (Beijing: People's Medical Publishing House, pp. 45–46.

Wang, N., and Hu, A. (2015). Enlightenment and thinking of blinding trachoma elimination in China. Chin J Ophthalmol 51, 484–486.

Wang, K., and Zhang, X. (1966). Experimental study on the classification of virus toxin and virus. Chin J Ophthalmol 13, 146–149.

Wang, K., and Huang, Y. (1964). Studies on the etiology of trachoma VII. Serological properties of trachoma virus and relationships to psittacosis-lymphogranuloma venereum (P-L) group of viruses. Acta Microbiol

Sin 10, 400–405.

Wang, K., Zhang, X., and Zhang, W. (1980). Study on the pathogenesis of trachoma. Nat Med J China 60, 259–262.

Wang, L., and Wei, K. (1992). Application of the WHO new *Chlamydia* classification method. Chin J Ophthalmol 28, 273–275.

Wei, J. (1992). Explore the feasibility of the new WHO trachoma grading standards using in China. Chin J Ophthalmol 28, 270–272.

Yu, C. (1942). Statistics on the blindness of the hospital in the past year of the Red Cross Society of Shanghai in China. Nat Med J China 16, 454.

Zhang, S., Zou, L., Gao, Y., Di, Y., Yu, X., and Wang, X. (1992). An epidemiological survey of blindness and low vision in China. Chin J Ophthalmol 5, 260–264.

Zhang, X., Jin, X., and Wang, K. (1960). Observation of human infection in the isolated culture of *Chlamydia trachomatis*. Nat Med J China 46, 25–32.

Zhang, X., and Zhang, E. (1965). Current situation of research and prevention and treatment of the trachoma virus in China. Chin Sci Bull 1, 47–55.

Zhang, Y., Meng, X., Zhang, L., Su, H., and Li, D. (1980). Study on membrane ultrastructure by *Chlamydia trachomatis*. Sci China 7, 712–717.

Zhang, X., and Jin, X. (1962a). Experimental study of trachoma infection range and drug sensitivity of animal. Nat Med J China 48, 418–423.

Zhang, X., Jin, X., and Wu, J. (1974). Trachoma therapeutic drug screening and clinical observations. Data Compil Beijing Tongren Hospital 7, 11–14.

Zhang, X. (1977). Recent advances in the study of trachoma. Int Rev Ophthalmol 2, 1–5.

Zhang, X., Jin, X., and Wang, K. (1963). Study on trachoma immunity problems. Nat Med J China 49, 751–758.

Zhang, X., and Jin, X. (1962b). Study on the preventive measures of trachoma. Nat Med J China 48, 775–777.

Zhang, L., and Zhang, X. (1991). Patients with trachoma endemic areas of North China anti-*Chlamydia trachomatis* antibody testing and typing. Chin J Ophthalmol 2, 67–70.

Zhou, C., and Deng, Y. (1930). The trachomatis in the north of China. Nat Med J China 16, 555–565.

Zhou, C., and Zhang, W. (1934). The comments on trachomatis in Shanghai. Nat Med J China 20, 775–873.

Zhou, Y., Wang, Z., and Sun X. (2007). Detection and genotyping of *Chlamydia trachomatis* in the primary school children of two districts of north China. Chin Ophthalmic Res 25, 465–468.

Zhou, Y., Wang Z., Li R., and Sun, X. (2013). Identification of genotype of chlamydia trachomatis from outpatients of trachoma. Chin J Exp Ophthalmol 31, 855–858.