

Vital Surveillances

Thirty Years of Experience of Acute Flaccid Paralysis Surveillance for Polio — China, 1993–2022

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ABSTRACT

Introduction: Detecting poliovirus infections proves to be highly challenging due to their asymptomatic nature and infectious potential, highlighting the crucial importance of effective detection methods in the context of polio eradication efforts. In many countries, including China, the primary approach for identifying polio outbreaks has been through acute flaccid paralysis (AFP) surveillance. In this study, we conducted an evaluation spanning three decades (1993–2022) to assess the effectiveness of AFP surveillance in China.

Methods: Data on all AFP cases identified since 1993 and national-level AFP surveillance system quality indicators aligned with the World Health Organization (WHO) standards were collected for analysis. The quality indicators assess surveillance sensitivity, completeness, timeliness of detection notification, case investigation, and laboratory workup. Surveillance sensitivity is determined by the non-polio AFP (NPAFP) detection rate among children under 15 years of age.

Results: Between 1993 and 2022, a total of 150,779 AFP cases were identified and reported. Within this pool, surveillance identified 95 cases of wild poliovirus (WPV) and 24 cases due to vaccine-derived poliovirus. From 1995 onwards, the detection rate of NPAFP cases consistently adhered to the WHO and national standards of ≥ 1 case per 100,000, falling between 1.38 and 2.76. Starting in 1997, all timeliness indicators consistently achieved the criteria of 80%, apart from the consistency in meeting standards set for the rate of positive specimens sent to the national laboratory.

Conclusions: AFP surveillance has been instrumental in China's accomplishment of maintaining a polio-free status. The ongoing adherence to key performance indicators, ensuring sensitivity and

prompt specimen collection, demonstrates that AFP surveillance is proficient in detecting poliovirus in China. As we move into the post-eradication phase, AFP surveillance remains crucial for the sustained absence of polioviruses in the long term.

In 1988, the World Health Assembly endorsed a resolution aimed at the global eradication of polio, leading to the establishment of the Global Polio Eradication Initiative (GPEI). In 2014, the World Health Organization (WHO) designated the international spread of wild poliovirus (WPV) as a Public Health Emergency of International Concern, a status that has been consistently maintained ever since. GPEI has made significant advancements towards the eradication of polio, with the successful elimination of WPV types 2 and 3 in 2015 and 2019, respectively. Furthermore, five out of the six WHO regions have been recognized as polio-free (*1*). China, along with all countries in the Western Pacific region, was accredited as polio-free in October 2000 and has successfully maintained this status to date.

Poliovirus infection typically presents asymptotically and only results in paralysis in less than 1% of infected individuals (*1*). The strategy for eradicating polio involves maintaining a high level of population immunity to the virus, promptly detecting polio outbreaks through identifying infected individuals, and executing substantial outbreak responses. Identifying every child affected by poliovirus is crucial, as a single case can signify an outbreak, potentially indicating numerous asymptomatic infections that are contagious.

Since the initiation of the GPEI, the surveillance of acute flaccid paralysis (AFP) has been instrumental in the detection of polio cases. AFP surveillance helps to identify children with paralysis, who are subsequently assessed for poliovirus infection. In the event of a polio

diagnosis, public health authorities initiate an investigation and implement response measures, such as vaccination campaigns, to halt the transmission of the poliovirus.

The sensitivity of AFP surveillance is of utmost importance and is objectively evaluated by determining if the annual AFP detection rate per 100,000 children under 15 years of age is at or above a specified threshold (one case). Detection rates surpassing this threshold offer reassurance of adequate sensitivity for detecting cases of paralytic polio.

In 1991, China established a dedicated AFP surveillance system aimed at polio eradication, following the development of guidelines in 1992 (2–3). By 1993, all provincial-level administrative divisions (PLADs), except the Xizang (Tibet) Autonomous Region, had adopted standardized national surveillance protocols that encompassed active AFP surveillance, case investigations, and stool specimen collection for poliovirus detection. The sensitivity and quality indicators of AFP surveillance have consistently remained at high levels, with sensitivity showing a gradual increase over time (4–6). While there have been epidemiological studies and case reports documenting AFP surveillance activities (5,7–8), a comprehensive overview of the overall progress of AFP surveillance in China has yet to be provided.

Data regarding all cases of AFP identified in China since 1993, and reports of surveillance system quality indicators were obtained. We conducted an evaluation and description of AFP surveillance in China over a 30-year period (1993–2022), assessing aspects such as incidence rates, epidemiological and laboratory investigations, clinical diagnoses, and the effectiveness and quality of the surveillance system.

METHODS

In China, real-time AFP surveillance is a mandatory initiative overseen by China CDC, with the annual submission of results to the WHO Regional Committee. The identification of AFP cases depends on both passive reporting from hospitals and active surveillance conducted by staff at county CDC. Since the inception of a nationwide infectious disease surveillance system in 1991, virtually all hospitals at or above the county level have been reporting AFP cases. County CDC personnel thoroughly investigate each AFP case, gathering stool specimens that are later transported to provincial laboratories for virus

isolation. Positive isolates are subsequently forwarded to the National Poliovirus Laboratory at China CDC, recognized as a WHO regional reference laboratory, for intratypic differentiation and genome sequencing. All data are meticulously recorded in the AFP Surveillance Information Reporting and Management System.

Assessment of AFP Surveillance Quality

Annually, quality indicators are computed at the national level and juxtaposed with WHO criteria. These indicators assess the sensitivity, comprehensiveness, and promptness of notification, investigation, and laboratory examinations.

The sensitive threshold for AFP surveillance set by the WHO aligns with China's AFP surveillance guidelines, requiring the detection of at least one AFP case per 100,000 individuals under 15 years per year. Adherence to the WHO protocol for sample collection, necessitating the retrieval of two adequate stool samples within a 14-day period, stands at 80% efficiency (1). In accordance with China's AFP surveillance guidelines, key criteria include an 80% rate for prompt investigation within 48 hours of case identification, timely receipt of stool samples within seven days, availability of poliovirus isolation results within 30 days, and the swift shipment of poliovirus-positive specimens to the national laboratory within a 30-day window.

Definitions

Clinically compatible polio cases are defined as AFP cases lacking stool specimens or having inadequate stool specimens without detection of WPV or vaccine-derived poliovirus (VDPV). These cases cannot be definitively ruled out for polio by provincial expert diagnostic teams, irrespective of residual paralysis, death, or loss of follow-up.

Excluded polio cases refer to AFP cases falling into one of two categories: 1) cases presenting with eligible stool specimens wherein neither WPV nor VDPV are identified; 2) cases lacking suitable stool specimens or presenting with inadequate specimens, with no detection of WPV or VDPV, yet conclusively ruled out as polio cases by regional expert diagnostic teams, irrespective of any residual paralysis, mortality, or loss of follow-up.

Statistical Analysis

Descriptive statistics were utilized to summarize the

demographic characteristics of AFP cases. Data on non-polio AFP (NPAFP) detections and population statistics were sourced from the China CDC information system. The analysis was performed using Microsoft Excel (version 2019, Microsoft, Redmond, USA).

Ethical Review

Individual-level, case-based AFP surveillance is required and is not subject to ethical review.

RESULTS

Detection of AFP and Demographic Variables

Table 1 illustrates the results of AFP surveillance and sensitivity indicator values over the 30-year study duration. A total of 150,779 AFP cases were identified and reported, with 149,386 cases (99%) occurring in children under the age of 15. The annual reported

TABLE 1. AFP cases and surveillance sensitivity indicators in China, 1993–2022.

Year	No. of AFP cases	No. of WPV cases	<15 NPAFP	<15 NPAFP detection rate	No. of clinically compatible polio cases	No. of discarded polio cases	No. of VDPV cases
1993	1,879	63	1,226	0.37	653	–	–
1994	3,142	6	2,790	0.88	307	–	–
1995	4,801	1 (imported)	4,615	1.49	168	–	–
1996	4,372	3 (imported)	4,171	1.38	201	4,171	–
1997	4,730	0	4,730	1.59	42	4,688	–
1998	5,009	0	5,009	1.72	44	4,965	–
1999	5,079	1 (imported)	5,078	1.76	33	5,045	–
2000	5,332	0	5,332	1.85	17	5,315	–
2001	5,395	0	5,395	1.88	19	5,376	0
2002	5,415	0	5,415	1.89	20	5,395	1
2003	5,107	0	5,107	1.79	21	5,086	0
2004	5,285	0	5,285	1.86	19	5,266	2
2005	5,425	0	5,425	1.94	16	5,409	1
2006	5,635	0	5,635	2.02	10	5,625	1
2007	4,986	0	4,986	1.79	1	4,985	2
2008	5,154	0	5,154	1.91	3	5,151	0
2009	4,961	0	4,961	1.79	8	4,948	0
2010	5,285	0	5,285	1.91	3	5,282	1
2011	6,205	21	6,205	2.49	30	6,152	2
2012	6,172	0	6,172	2.76	2	6,168	2
2013	5,623	0	5,623	2.51	1	5,621	1
2014	5,758	0	5,758	2.56	0	5,756	2
2015	5,217	0	5,217	2.31	1	5,216	0
2016	5,691	0	5,691	2.52	0	5,690	1
2017	5,278	0	5,278	2.33	0	5,276	2
2018	5,292	0	5,292	2.31	0	5,292	1
2019	5,183	0	5,183	2.23	0	5,183	2
2020	4,369	0	4,369	1.85	0	4,369	2
2021	4,771	0	4,771	2.02	0	4,771	1
2022	4,228	0	4,228	1.79	0	4,228	0
Total	150,779	–	149,386	–	1619	140,429	24

Note: “–” means not applicable.

Abbreviation: AFP=acute flaccid paralysis; WPV=wild poliovirus; NPAFP=non-polio acute flaccid paralysis; VDPV=vaccine-derived poliovirus.

cases of AFP varied from 1,879 in 1993 to 6,205 in 2011.

During the surveillance period, AFP surveillance identified 63 cases of WPV in 1993 and six in 1994. Additionally, five imported WPV cases were reported in 1995, 1996, and 1999. In 2011, Xinjiang reported 21 cases of WPV associated with AFP. No other instances of paralytic WPV infection were documented throughout the study period.

Among cases of AFP in individuals under 15 years of age, 140,429 (94%) were diagnosed as non-polio, 1,619 (1.1%) were clinically compatible cases that tested negative for poliovirus, and 24 cases were identified as VDPV cases. Eighty-two percent of clinically compatible cases were reported before 2000. The number of clinically compatible polio cases declined from 307 in 1994 to 42 in 1997, further dropping to fewer than 10 cases in 2007, and reaching zero in 2016, with no reported cases since, except for a slight increase in 2011 in Xinjiang attributed to enhanced AFP surveillance during an outbreak.

The surveillance sensitivity indicator for detecting NPAFP among children under 15 years of age showed an increase over the study period, rising from 0.37 cases per 100,000 in 1993 to 2.76 per 100,000 in 2012. The NPAFP detection rate in children under 15 surpassed the criterion of 1 per 100,000 for 28 consecutive years (1995–2022) and exceeded 2 per 100,000 for eleven of those years.

Of the 140,429 cases of NPAFP identified, 55,634 (40%) received definitive diagnoses. Among these, 9,505 cases were attributed to Guillain-Barré syndrome (GBS), 3,024 to non-polio enterovirus (NPEV) infection, 1,158 to transverse myelitis, and 1,116 to traumatic neuritis. The most prevalent category was

classified as “others,” underscoring the diverse range of factors contributing to AFP in pediatric cases (Figure 1).

Timeliness

Two indicator definitions remained consistent throughout the study period: investigating within 48 hours and collecting an adequate stool sample within 14 days of paralysis. Both indicators have an established criterion of 80%. Investigation timeliness has consistently met or exceeded the 80% target annually since 1995, while stool sample timeliness achieved the 80% target in 1996 and has been maintained at over 80% ever since.

Definitions for three indicators were modified over the study period. The timeframe for receipt of stool samples by provincial CDCs was adjusted from ten days in 1993 to seven days in 1995. Similarly, the timeline for isolation results being available at provincial CDC laboratories was altered from 45 days in 1993 to 30 days in 1995, then to 28 days in 2003, and finally to 14 days in 2015. Despite more stringent criteria, China's AFP surveillance system achieved and maintained 80% targets in 1996 and 1997. The indicator tracking poliovirus-positive specimens shipped to the national polio laboratory (NPL) fluctuated between 35% and 100%, with the timeframe changing from 30 days in 1997 to 14 days in 2003 (Figure 2).

DISCUSSION

Since 1995, China's AFP surveillance system has consistently met both the WHO and national sensitivity criteria. From 1993 to 2022, the system

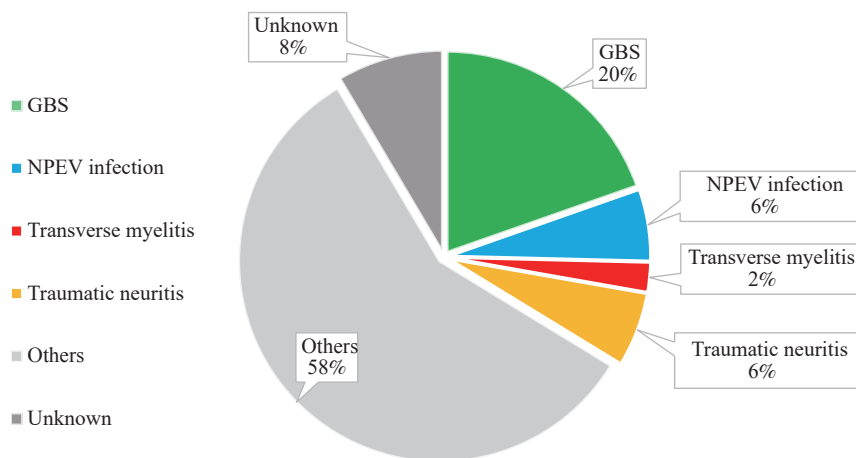


FIGURE 1. Final diagnosis of NPAFP cases <15 years old in China, 1993–2022.

Abbreviation: GBS=Guillain-Barré syndrome; NPEV=Non-polio enterovirus; NPAFP=non-polio acute flaccid paralysis.

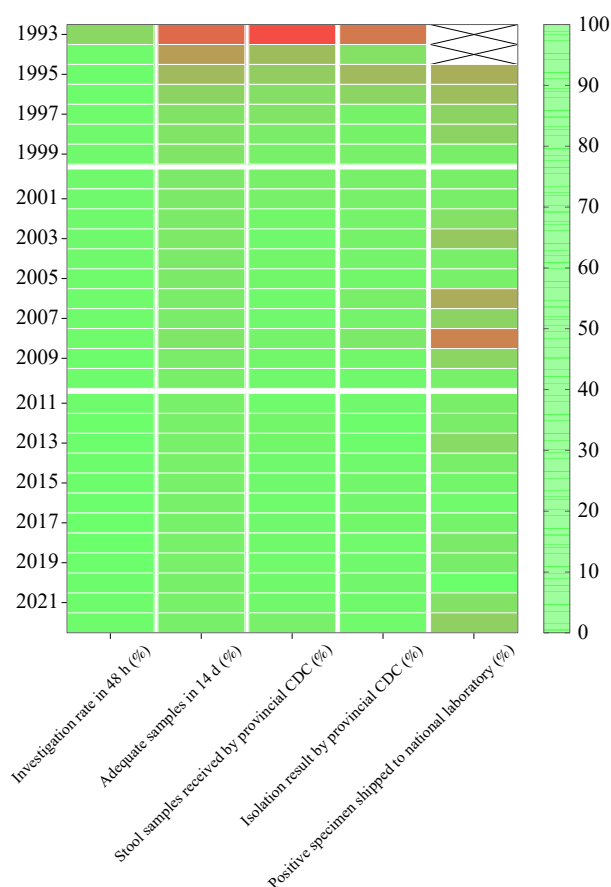


FIGURE 2. Timeliness indicators of AFP surveillance in China, 1993–2022.

identified 95 cases of WPV and 24 cases of vaccine-derived poliovirus among over 150,000 AFP cases. Through thorough investigations, these cases were found not to be polio-related. Maintaining accurate and sensitive polio surveillance is crucial for preserving a polio-free status in both pre- and post-global polio eradication efforts. This study represents the initial account of the results generated by the AFP surveillance system over the years leading up to China's polio-free certification in 2000 and the subsequent years thereafter.

The AFP surveillance system's detections of WPV have been crucial for upholding the polio-free status. For instance, in Xinjiang in 2012, AFP surveillance identified 21 WPV cases, which, through subsequent investigations, were determined to be import-related with evidence of local transmission. The prompt detection facilitated a swift response that safeguarded China's polio-free status (9).

AFP surveillance identified 24 VDPV cases, some of which were previously documented (10–11). Following WHO recommendations, response measures were implemented for each VDPV case. Given the continued use of live poliovirus vaccines, the

emergence of VDPVs capable of transmission and causing paralysis is expected, underscoring the importance of AFP surveillance in identifying paralytic cases indicative of VDPV outbreaks. As the global eradication of polio progresses, AFP surveillance will play a pivotal role as an essential element of a robust polio surveillance system.

AFP surveillance, although critical, may not suffice for comprehensive poliovirus detection, as it lacks the ability to identify polioviruses in asymptomatic children. An incident in Shanghai during 2020–2021 illustrated this limitation, where two circulating VDPV (cVDPV) type 3 were detected in a non-paralyzed child and an environmental sample, which genetic analysis revealed genetically linked (12). Despite the evidence of poliovirus circulation, no paralysis cases were reported. Similarly, a child diagnosed with a primary immunodeficiency (PID) without paralysis was found to harbor an VDPV, namely iVDPV, in stool samples (13). Silent infections like these are beyond the scope of detection by AFP surveillance; however, they can contribute to poliovirus transmission. Therefore, supplementary surveillance methods are imperative, including environmental (wastewater) surveillance and poliovirus monitoring in children newly diagnosed with PID. The evolution of AFP surveillance into an integrated disease surveillance system holds promise for sustained polio control and may yield benefits in managing other infectious diseases (14).

In order to enhance quality assurance, our AFP surveillance system underwent enhancements and modernizations concurrent with advancements in surveillance practices and program development. Initially, from 1991 to 1993, AFP cases were documented on paper and in written correspondence. Subsequently, spanning the years 1994 to 2003, case data for AFP were managed at the local level before being transmitted to China CDC via monthly email communications. Between 2004 and 2011, AFP surveillance transitioned to a client-server Internet platform that facilitated data analysis, with provincial CDC personnel submitting case details on a monthly basis. By 2012, the AFP surveillance mechanism had been integrated into China's national disease reporting framework, operating as a real-time online system (4).

The evaluation of AFP surveillance quality relies on two key performance indicators: the NPAFP detection rate and the percentage of AFP cases with adequate stool specimens. A NPAFP rate of $\geq 1/100,000$ is deemed sufficiently sensitive for poliovirus detection. The benchmark for AFP cases with adequate stool specimens is set at $\geq 80\%$. Our research reveals a swift and

sustained enhancement in surveillance indicators. Amid the COVID-19 lockdown from 2020 to 2022, certain timeliness indicators may have been adversely affected in selected PLADs; nonetheless, national annual indicators consistently met the 80% benchmark. The rapid decline in polio-compatible cases early on signifies improvements in stool sample collection and laboratory diagnosis procedures, signaling the need for continued enhancements. Despite unchanged surveillance guidance since 2006, there persists a subset of AFP cases lacking specific diagnoses or final classifications. The fluctuating proportion of positive samples forwarded to the NPL throughout the study period underscores the necessity for ongoing refinements.

Our study is constrained by the fact that definitions for VDPV cases were modified in 2016, likely resulting in potential underestimation of VDPV cases prior to the alteration. Furthermore, the relatively low counts of “No. of AFP cases” and “<15 NPAFP” in 1993 could be attributable to the nascent stage of the AFP surveillance system at that time.

In conclusion, AFP surveillance has been pivotal in China's effort to attain and uphold polio-free status, identifying 119 polio cases among 150,000 AFP cases over a 30-year period. The significance of AFP surveillance remains paramount, even post global polio eradication. Key performance indicators, such as the NPAFP rate and the proportion of AFP cases with sufficient stool specimens, have consistently met both WHO and national standards, demonstrating the effectiveness of China's AFP surveillance system in detecting polioviruses. Given the ongoing risks associated with WPV and cVDPV importation and transmission, maintaining a highly sensitive and timely AFP surveillance system will be essential to upholding polio eradication efforts in China and worldwide (15).

Conflicts of interest: No conflicts of interest.

Acknowledgements: All provincial and local Centers for Disease Control and Prevention in China.

Funding: Supported by the public health emergency response mechanism operated by the Chinese Center for Disease Control and Prevention (No. 102393220020010000017).

doi: 10.46234/ccdcw2024.065

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Submitted: December 06, 2023; Accepted: March 26, 2024

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