Vaccine 37 (2019) 2394–2400

Contents lists available at ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine

Successful switch (tOPV to bOPV) in India: Tribute to a resilient health system

Rajib Dasgupta [a], Shweta Sharma [b], Nisha Sharma [b], K. Banerjee [a], E.G.P. Haran [a], J.P. Muliyel [a], Subhash Salunke [a], Muneer Ahmad Masoodi [a], Pradeep Haldar [c], Sunil Bahl [d], Pankaj Bhatnagar [e], Sudhir Joshi [e], Narendra K. Arora [a,*]

[a] National Certification Committee for Polio Eradication, New Delhi, India
[b] National Certification Committee for Polio Eradication Secretariat, New Delhi, India
[c] Ministry of Health and Family Welfare, New Delhi, India
[d] SEARO WHO, New Delhi, India
[e] National Polio Surveillance Project, New Delhi, India

ARTICLE INFO

Article history:
Received 26 July 2018
Received in revised form 14 February 2019
Accepted 18 February 2019
Available online 14 March 2019

Keywords:
Switch strategy
Validation
bOPV
tOPV

ABSTRACT

In accordance with the end game strategies for polio eradication a synchronized switch plan from tOPV to bOPV was implemented globally in 2016. The National Committee for Polio Eradication (NCCPE) validated the switch activities in India. An expert group of 104 academics conducted field visits in 25 states and 2 Union territories for independent verification (after an initial round of verification by the National Polio Surveillance Project [NPSP]). The objectives were to validate withdrawal and disposal of tOPV by screening cold chain points in public and private sector health facilities in both rural and urban areas; additionally, availability of bOPV and IPV was also documented. 34 filled tOPV and 5 empty vials were detected inside cold chain equipment and 17 outside. The disposal mechanism was found to be reasonably adequate. The key strategies -- 'throttling' of vaccine supplies well ahead of the switch date while preventing stock outs at various immunization points, simultaneously working with the regulators to delicense the tOPV on the switch date and helping manufacturers to calibrate vaccine production according to national timelines, and strong and persistent advocacy with professional associations to align with national bOPV and IPV policy facilitated successful accomplishment of the switch process. Effective implementation of the switch strategy in India also bears testimony to the resilience of the health system operating under diverse and heterogeneous governance.

1. Background

India is committed to phased withdrawal of oral polio vaccines as per the polio-eradication endgame strategy [1]. The World Health Assembly (WHA) endorsed the Strategic Advisory Group of Experts (SAGE) on Immunization recommendation for a synchronized plan to switch from the trivalent oral polio vaccine (tOPV) to the bivalent oral polio vaccine (bOPV) in all 156 countries and regions using the oral polio vaccine (OPV) during the two weeks of April 2016 [2]. India, as a member-state was also required to undertake this task; the national switch date was scheduled on 25 April 2016. The Global Polio Eradication Initiative (GPEI) of the World Health Organization (WHO) envisaged a National Validation Committee, independent from implementation activities, to provide monitoring oversight and validation of the switch activities; the National Committee for Certification of Polio Eradication (NCCPE) performed this function in India.

The switch exercise was a highly complex coordinated process that entailed nation-wide replacement of trivalent Oral Polio Vaccine (tOPV) by the bivalent Oral Polio Vaccine (bOPV) on a single day. It was a globally coordinated process, the initial planning for which commenced in the first quarter of 2015. Switch coordination committees at national and sub-national levels provided management and operational oversight of its implementation. It required thoughtful preparation well ahead of the actual date across institutions and actors ranging from regulators, vaccine producers to frontline workers and health providers in both public and private sectors. Soon after the switch, the Immunization Division of the national Ministry of Health and Family Welfare (MoHFW) and the National Polio Surveillance Project (NPSP) conducted a nation-

* Corresponding author at: NCCPE, F-1/5, Second Floor, Okhla Industrial Area Phase I, New Delhi 110020, India.
E-mail address: nkarora@inclentrust.org (N.K. Arora).

https://doi.org/10.1016/j.vaccine.2019.02.038
0264-410X/

wide sweep covering all public sector facilities and some private sector cold chain points during May 2016. This paper presents the independent evaluation lead by the NCCPE-India that was designed to validate the effectiveness of the switch implementation and determine and detect failures, if any. The validation exercise also offered learning of methodological challenges of planning and organizing a nationwide exercise.

2. Switch strategies

The GPEI reviewed the switch preparations in October 2015 and decided to conduct the switch operation during the low season of polio transmission in April 2016. The switch had to be globally synchronized to prevent emergence of circulating Vaccine Derived Polioviruses (cVDPVs) in all OPV using countries between a two week window during 17 April and 1 May 2016. Accordingly, India decided the National Switch date as 25th April 2016. To assure the operational feasibility of the switch, a dry run was conducted by the MoHFW in May 2015 in two states (Assam and Uttar Pradesh) to field test and pilot the switch [3]. The country's preparation for OPV2 withdrawal was as per criteria laid down by the WHO Strategic Advisory Group of Experts [SAGE]) on Immunization [4]. A 'throttling strategy' was designed to ensure that supply of tOPV was reduced to the stores at regional, state and district levels in a calibrated manner. Manufacturing licenses of the vaccine manufacturers were also canceled ahead of the switch date. In effect, relatively small quantities of tOPV were available on or around the switch date. Simultaneously, the supply of bOPV was enhanced to minimize the possibility of stock-outs particularly at Community Health Centers (CHC) and Primary Health Centers (PHC) across the country. As these preparations were made, the MOHFW organized a series of advocacy meetings with key stakeholders particularly the Indian Academy of Pediatrics and Indian Medical Association to communicate to their membership for supporting cessation of tOPV after the switch date.

The key activities on Switch Day entailed: (i) removal of all opened and unopened tOPV vials from cold chain at all levels; (ii) placing tOPV vials in a bag or container and label as 'waste'; and, (iii) sending these tOPV vials for disposal. In order to ensure a smooth switch, the Ministry of Health & Family Welfare undertook a judicious mix of three strategies: (a) 'push exchange', to deliver bOPV to facilities and pick up tOPV simultaneously; (b) 'pull exchange', facilities collect bOPV from the district level and surrender tOPV; and, (c) 'preposition', deliver bOPV to health facilities just before the switch date [3].

Attention was paid to boost immunity to type 2 polioviruses preceding the switch to prevent cVDPV2 emergence or spread after the switch. To achieve this, additional tOPV supplemental immunization activities (SIAs) were relied upon. The country had undergone the regular two National Immunization Day (NID) campaigns with tOPV in January and February 2016. Mission Indradhanush (an intensive catch-up round) was conducted with tOPV in April 2016 in 201 high risk districts [4].

3. Objectives of switch validation exercise

The objectives were to:(a) develop a validation strategy, with the highest probability of detecting failure; (b) to validate withdrawal and disposal of tOPV by screening cold chain points in public and private sector health facilities/vaccine storage points in both urban and rural areas; (c) validate disposal of tOPV; and, (d) assess availability of bOPV and inactivated polio vaccine (IPV) in the vaccine chain.

4. Methods

The NCCPE met in February and April 2016to deliberate on and finalize the validation methodology. In conformity with the GPEI's guidelines, risk based purposive sampling of districts was adopted in order to identify areas and institutions with the highest probability of detecting the gaps in switch implementation and detection of active tOPV vials in the health facilities. Confidentiality was maintained for all respondents and administrative immunity was sought for, in case lapses were detected anywhere.

Timeline of activities: The preparation of switch validation by the NCCPE-India started in January 2016; fieldwork was done during 16th to 18th May 2016. The NCCPE submitted its report to the Immunization Division, MoHFW-Government of India, the WHO-India office and the SEARO, WHO on 20th May 2016.

4.1. Selection of districts

Districts were selected by following a set of broad governance, institutional and functional indicators to categorize states and then the districts to develop a study population frame. Within a district, cold chain vaccine delivery points were sampled from rural and urban areas as well as including both public and private sectors.

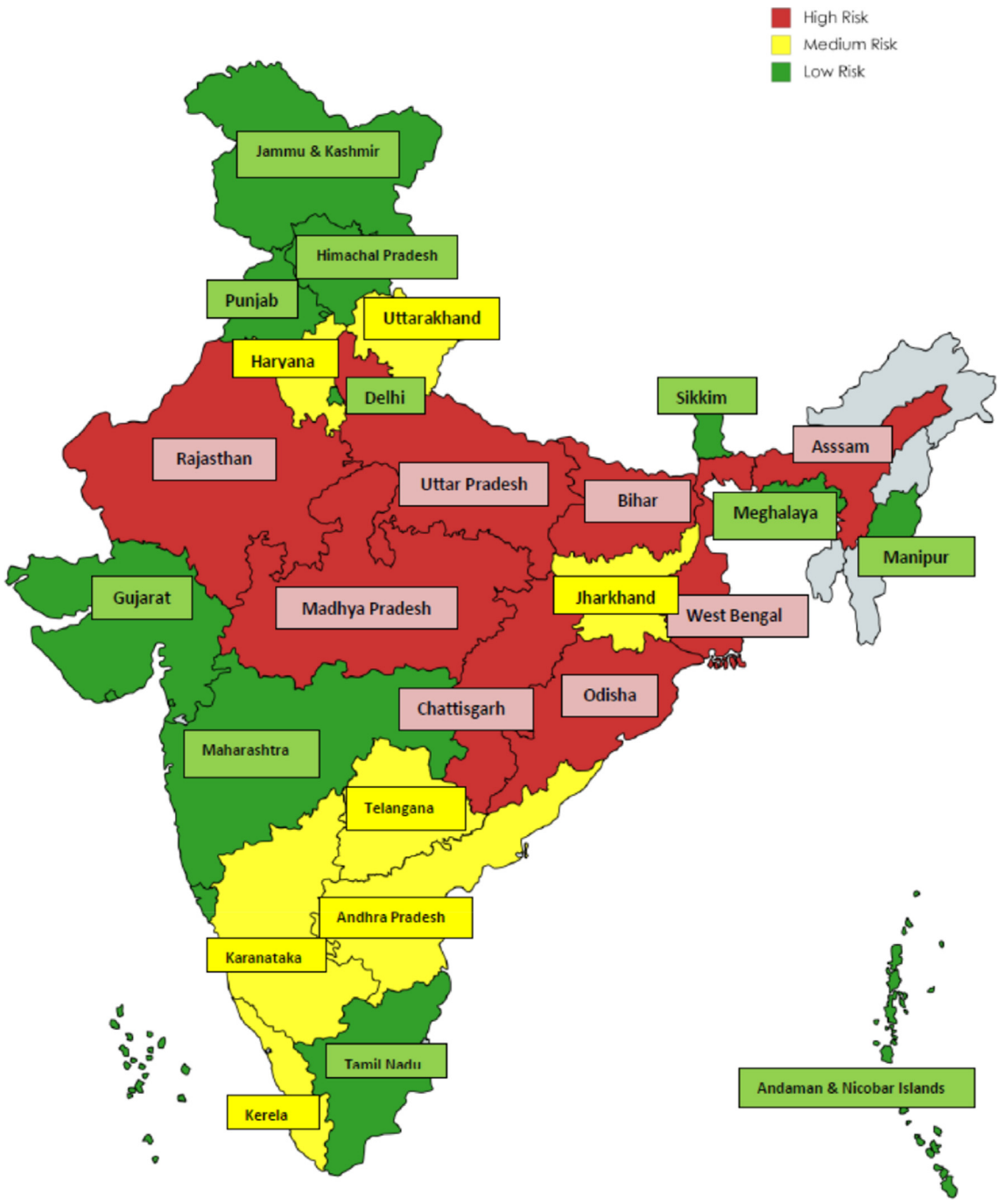
The ranking of states and districts computed by the Independent Commission of Health (ICH) was used. A set of infrastructure indicators (human resource, supply chain logistics) and performance indicators (reproductive and child health programs) were taken in to account to compute two sets of composite indices: SIS (Staff, Infrastructure and Supply) Index and Performance Index [5]. The SIS index closely represented strengths and weaknesses of vaccine supply logistics. Based on the SIS Index, the ICH 2008 had characterized a 'red belt' of five states. Within each state, red districts represented the lowest scores (weakest) and green district the highest (strongest). The National Institute of Public Finance and Policy (NIPFP) conducted a study in 2012 and ranked 19 major states with a broader set of governance indicators [6]; ranking was a fair match of the ranking of the states in the ICH 2008 report.

The study team therefore adopted the SIS index for the purpose of sampling the districts. We also added the eight poor governance states identified by the NIPFP ranked as the highest risk category, which finally comprised of eight states. They were therefore less likely to default. Poor SIS scores of districts *within* each state represented a higher risk. Fourteen districts with high SIS scores were also sampled as there was a possibility of complacence in these areas with much of the focus of the program managers on low SIS scores districts. Overall, 48 districts spread over 25 states and 2 union territories were identified for the evaluation exercise (Map 1; Table 1).

4.1.1. Selection of health facilities at district level

In 2010, the National Health Systems Resource Centre (NHSRC) compiled inaccessibility status (classified as: inaccessible, most difficult, and difficult) of health facilities in 27 major states [7]. Health facilities *within* the chosen district were sampled from the list of 'inaccessible' and 'most difficult' facilities. For each district, two most inaccessible Primary Health Centers (PHCs) and one Community Health Center (CHC) or Sub-district Hospital was selected (Table 2).

Though the proportion of immunizations in the private sector had been substantially lower than that in the public sector and generally located/clustered in urban areas, the regulatory framework and controls over tOPV/bOPV supplies were weak. During the MoHFW and NPSP sweep of May 2016 the proportion of government to private sector vaccine storage points scanned was 15,385 and 5,060 respectively. Thus, the NCCPE-India team decided



Map 1. Selected districts and union territories.

to visit and evaluate vaccine distributor(s) cold chain points catering to private sector in all the districts selected for the switch validation exercise (see Table 3).

4.2. Tools

Three observation tools prepared for assessing different levels of health facilities and monitoring cold chain points were used for rapid appraisal. The tools were adapted from the WHO's switch plan templates [2]. The fourth tool recorded the summary observations of assessors.

Tool 1 (For Primary Care Facilities): This tool was designed to record data from CHCs, urban dispensaries, PHCs, immunization sessions (at the outpatient or outreach sessions) and private practitioners. The tool was designed to keep count of facilities, cold chain points and cold chain equipment; it also recorded detection of tOPV vials both inside and outside the cold chain. The verification of the disposal of tOPV vials was recorded through systematic scrutiny of relevant registers and documents since the switch date. Availability of bOPV and IPV was also recorded.

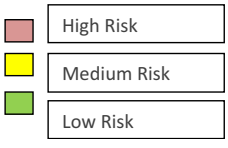
Tool 2 (For Secondary & Tertiary Care Facilities) recorded the same data from medical colleges, district hospitals and private hospitals.

Tool 3 (For District level cold chain points in government and private sector) was designed to capture cold chain related data from government district stores and private dealers.

Table 1
NCCPE tOPV-bOPV switch validation: Selected states and districts.

State/ Union Territory	Higher Risk	Lower Risk
Delhi		East Delhi
Bihar	Bhojpur	Saran
	Samastipur	
Chhattisgarh	Dhamtari	Durg
	Mahasamund	
Madhya Pradesh	Dindori	Gwalior
	Panna	
Uttar Pradesh	Mathura	Raebareli
	Bareilly	
Jharkhand	Hazaribagh	Gumla
Assam	Dhemaji	Sonitpur
	Morigaon	
West Bengal	Malda	Darjeeling
	South Dinajpur	
Odisha	Jagatsinghpur	Ganjam
	Nayagarh	
Rajasthan	Dungarpur	Dausa
	Alwar	
Himachal Pradesh		Una
Meghalaya		West Garo Hills
Manipur		Imphal East
Sikkim		East Sikkim
Andhra Pradesh	Vishakhapatnam	East Godavari
Karnataka	Udupi	Uttar Kanada
Jammu & Kashmir	Kargil	
Uttarakhand	Almora	Haridwar
Haryana	Jhajjhar	Kurukshetra
Telangana	Nizamabad	Khammam
Punjab		Patiala
Kerala	Ernakulam	Palakkad
Gujarat	Rajkot	
Maharashtra	Gondia	
Tamil Nadu	Thiruvannamalai	
Chandigarh		Chandigarh
(Union Territory)		
Andaman & Nicobar (Union Territory)		Andaman & Nicobar

Source: NCCPE, India



Tool 4 summarized the expert assessment (jointly by the two experts visiting a district) and addressed the following questions (elaborating on the reasons):

- Was throttling of tOPV achieved?
- Was all remaining stocks of tOPV removed from the stores and safely disposed?
- Was bOPV pre-positioned in the district (assessment of the adequacy of stocks)?
- Was IPV available in the district (assessment of the adequacy of stocks)?

Table 2
NCCPE tOPV-bOPV switch validation: Selection strategy of cold chain points in every district.

District Town	
• Medical college (if any in the district)	1
• District hospital	1
• District store	1
• Private distributor/store	(1–2)
• Private hospital: 1 (if there is only 1 private distributor)	1
• Private practitioner	1
• (Medical College and Private distributor were replaced with private facilities if **None** in the district)	
Sub-district levels	
• Sub-district hospital or CHC	1
• PHC	2
o PHCs were randomly chosen from among the storage sites in each district. As far as possible two sites were selected from among the NHSRC list of Inaccessible, Most Difficult and Difficult (for the respective districts)	
• Private hospital (or Nursing Home)	1
• Private Practitioners	2

Source: NCCPE, India.

Based on the above four key questions, the two experts were required to provide an overall assessment of the study district and jointly sign the Tool 4 (Tools 1 to 3 were filled up by either of the experts assessing the respective health facilities).

Based on the analysis of the data from the sampled districts, the National Switch Validation Report was collated and submitted by the NCCPE in Form 3 of the GPEI's switch monitoring form to the RCCPE (through the national Ministry of Health & Family Welfare).

4.3. Teams

The NCCPE was supported by an Expert Group comprising of 104 academics (from the disciplines of pediatrics and public health) drawn from across 70 institutions (medical colleges, universities and research institutions).

4.4. Cold-chain search strategies

Search strategies included: (i) inspection of all available cold chain spaces at the health facilities including domestic refrigerators and ice-boxes; (ii) thorough searching of all shelves and contents of the cold chain space; (iii) checking at various non-conventional spaces where tOPV vials could have been kept or hidden e.g. in almirahs and under the furniture; and (iv) scrutinizing tOPV related disposal records.

4.5. Data collection

Data was collected during 16–19 May2016 immediately following one-day orientation workshops for the assessors. The assessor-team spent two to three days in a district and worked according to a pre-defined work plan; a team was expected to inspect about 15 health facilities in each district that worked out to a cumulative500 cold chain points across the country. The exercise was conducted in close co-operation with the NPSP and state/local governments.

Two one day workshops were organized (on 14th May in Delhi and 15th May 2016 in Guwahati) for the field teams to orient them with the instruments, the type and quality of data to be collected and processes to be adopted when they were in the districts. The assessors were instructed to keep their findings confidential and they should not interact with press or media personnel in view of the sensitive nature of the work. Confidentiality agreement was signed by all participants and data was submitted to the

Table 3
NCCPE tOPV-bOPV switch validation: Cold chain points (CCP) and equipment (CCE).

Cold chain points (CCP)				Cold chain equipment (CCE)		
Type	Numbers	Number of CCPs in which t OPV vials found		Type	Numbers	No. of vials found
Public sector		Inside the CCE	Outside the CCE			Inside the CCE
Primary Health Centers	113	2	9 (84vials)	Walk in Coolers	54	
Community Health Centers	54	0	4 (5vials)	Ice Lined Refrigerators	614	5
Sub-district Hospitals	11	0	0	Deep Freezers	545	
District Hospitals	55	0	4 (18 vials)	Domestic Refrigerators	997	14
Medical Colleges	30	0	49 (12 vials)	Ice Boxes	96	
District Store	49	0	0	Vaccine Carriers [Immunization sessions and storage]	13,302	5 & 9 empty
Private sector		Number of CCPs in which tOPV vials found		Cold Chain Equipment	No. of tOPV vials Found	
		Inside the CCP	Outside the CCP	Type	Inside the CCE	Outside the CCE
Private practitioners	121	2	1	Domestic Refrigerators	6	Found but no. not available
Private Hospitals	88	3	0	Domestic Refrigerators	4	0
Private Stores	50	0	2	Domestic Refrigerators	0	17

Source: NCCPE, India.

NCCPE without retaining any copies. Two experts visited every district; the name of the designated district was shared with the team and the district NPSP staff just 24 h prior to their visit to maintain an element of surprise. The team of assessors was allocated the districts in a manner that they did not visit their home state.

Real-time analysis and report writing was done by the district team and the report was submitted to the NCCPE secretariat at the INCLEN Trust International Office in Delhi. The secretariat finalized the report on the evening of 19th May 2018 and had a teleconference with all the NCCPE members to ratify the report before forwarding the report to Regional Commission for Certification of Polio Eradication (RCCPE), South East Asia Regional Office (SEARO-WHO and the Ministry of Health and Family Welfare on 20 May 2016.

5. Results

5.1. Screening

A total of 15,610 cold chain equipment (CCE) were monitored across 571 cold chain points (CCP) spread over 48 districts and 2 union territories in the country. The screened CCE included 54 walk-in-coolers (WIC), 614 refrigerators (ice-lined refrigerators, deep freezers, and domestic refrigerators), 13,302 vaccine carriers (both in stores and sessions), 96 ice boxes (in stores) and 2 ice packs (in an immunization session). In terms of institutions, the 571 CCPs were spread across 54 community health centers (CHC), 11 sub-district hospitals, 113 primary health centers (PHC), 88 private hospitals, 121 private practitioners, 49 district stores, 30 medical colleges, 55 district hospitals and 50 private stores.

5.2. tOPV vials detected

tOPV vials inside the cold chain: In 8 districts out of 50 assessment units (districts), 29 live tOPV vials were detected; 19 vials in 3 PHCs of 3 districts and 10 vials kept in 5 domestic refrigerators in private clinics of 5 districts. In one of these PHCs, 13 vials were empty, but within the CCE (domestic refrigerator). Of the six filled (partial or total) vials, one was found in a domestic refrigerator of a PHC and the remaining five in the ILR of the third PHC. None of the vaccine distributors in the private sector had stocks of tOPV.

181 tOPV vials were detected *outside* the cold chain equipment: of these, 145 (only five were labeled 'for disposal') were found in 21 public health facilities (9 Primary Health Centers, 4 Community Health Centers, 4 medical colleges and 4 district hospitals) across 12 districts. Nineteen vials were found in the museum of the Community Medicine departments of four medical colleges, preserved for teaching purposes and 17 vials were detected (none were labeled 'for disposal') in a private store. Further, two teams also reported detecting unlabeled vials from a private store and a private practitioner across two districts; the specific number of such vials was not reported.

5.3. Availability of bOPV and IPV

The bOPV vials were available in 97.9% and 68% public and private health facilities respectively. In contrast, 85% public and only 30% private health facilities had IPV. Out of 571 cold chain points screened, 118 (21%) did not have any stock of bOPV and 261 (46%) did not have any stock of IPV.

Bivalent OPV (bOPV), which protects against both types 1 and 3 serotypes concurrently, was introduced in India in January 2010. The timeline for procurement of bOPV was worked out considering the procurement lead time. The tOPV procurement and supply was adjusted to ensure no stock-outs prior to switch to bOPV and minimal tOPV surplus stocks post-switch. The MoHFW maintains a rolling buffer stock of tOPV and bOPV vaccines for undertaking emergency mop ups. India is committed to procuring prequalified mOPV2 from the global stockpile in case of an event of outbreak of type 2 polio, post- switch (tOPV to bOPV). India introduced IPV in a phased manner across the country to cover the eligible population. While it was initially administered as a single intramuscular dose, the country shifted to two doses of fractional IPV (fIPV) at 6 weeks and 14 weeks since March 2017 on account of a lack of adequate supply of IPV in the global market. Vaccine security was ensured by adopting several key measures: (i) two yearly cycle of vaccine projections; (ii) lead time of one year was taken into account while planning vaccine supplies; (iii) procurement orders were placed accordingly; and (iv) adequate buffer was maintained at the national level.

The throttling strategy was carefully planned and implemented, and demonstrated to be effective. This entailed reducing the supply of tOPV to the stores at the district, state and regional levels in a calibrated manner. The Immunization Division of the Ministry of

Health and Family Welfare worked with the Drug Controller General of India to withdraw manufacturing licenses of the tOPV vaccine manufacturers and advised the distributors/stockists of vaccines to work closely with Drug Inspectors and Clearing and Forwarding Agents (of vaccines) to remove the stocks at district and sub-district levels. In effect, relatively small quantities of tOPV were available on or around the switch date; simultaneously, the supply of bOPV was enhanced. bOPV and IPV stocks were available in the public sector health facilities in all the districts that were visited. By contrast, these were available in only about two-thirds and one third of the private sector facilities respectively.

The disposal strategy worked well; in 11 out of 50 districts tOPV vials had been removed from the CCE but neither labeled for disposal nor sent back for final disposal during the time of the validation exercise. Relevant documentation including disposal certificates was reviewed. The disposal mechanism had worked well with cold chain points in public facilities. Although the Indian Academy of Pediatrics (IAP) and the Indian Medical Association (IMA) had sensitized their members regarding disposal strategies through sensitization sessions and messaging services; several practitioners and managers of the private health facilities had scant information on final disposal. Private distributors (of vaccines) reported close coordination with Drug Inspectors and Clearing and Forwarding Agents for removal and disposal of the stocks; this was triangulated by review of disposal certificates.

6. Discussion

The NCCPE-India led exercise in 50 districts across 25states and 2 union territories to validate the national tOPV-bOPV switch as per the global guidelines. Overall the switch appeared to be successful and had the desired objectives. Support for the visiting NCCPE expert groups was received from all stakeholders; there were occasional incidents of resistance by private providers to show the cold chain equipment.

It was important to underscore the key features of this mega but successful switch strategy:

- The program managers had started the planning and preparedness almost a year in advance and engaged all stakeholders, several times over. Professional associations played an important role to bring large number of the private sector providers on board.
- The 'dry runs' conducted nearly an year ahead of the switch led to identification of critical bottlenecks in immunization systems and allowed program managers to find context appropriate practical solutions and develop contingency plans.
- Meticulous planning had begun well in advance and Immunization Division, Ministry of Health and Family Welfare (GoI-MoHFW) formulated a plan that effectively addressed the complexity and diversity of the program in the country to minimize stockout and losses due to wastage.
- A 'throttling strategy' was developed about six months in advance to this end. Stock management was carefully monitored by the central, state and district authorities in tandem. For this, regulators were also involved to regulate the tOPV supply in the market and cancel the manufacturing licenses for tOPV in sync with the switch date. Last tOPV orders were carefully scrutinized and played a key role in the withdrawal of tOPV. In sync with the withdrawal, bOPV pre-positioning was also done, taking care to minimize the risk of stockout at cold chain points.
- An accountability framework was put in place at the planning stage; the key personnel up to district level were identified and the framework was rigorously implemented.

Earlier, in November-December 2013, the NCCPE successfully designed, invited faculty members from the INCLEN Network and undertook spot appraisal of the interruption of WPV circulation (across 50 districts and state capitals of 35 States and Union Territories) to validate the polio-free status in India; the RCCPE certification was incumbent on this validation [3]. The INCLEN Network had been engaged on large multi-centric studies with medical colleges across India since 1993 and contributed to national policy planning. NCCPE-India leveraged upon the experience of 2013 for designing and implementing the switch validation exercise in 2016. The risk based purposive sampling entailed validating across the most inaccessible institutions *within* the highest risk districts and thus gave credibility to the exercise and confidence to NCCPE. This exercise also necessitated seamless movement of 100-plus experts over six to seven days from their home institution to the training sites (Guwahati for eight eastern and north-eastern states and New Delhi for 15states) thereafter to the sampled districts and back to their home stations. Data was analyzed real time and the entire operation including submission of the report to the NCCPE was completed in exactly a week while maintaining a high degree of secrecy and confidentiality (regarding chosen districts and health facilities). This was possible owing to two sets of factors: (i) support of departments of health across states and districts and NPSP units who agreed to facilitate the district level activities on the spot when asked for, and (ii) the NCCPE secretariat at the INCLEN Trust Executive Office. INCLEN has nurtured a unique network of clinical and public health professionals across India over nearly two decades [8]. The investment in network and experience of conducting large-scale multi-site studies was critical for the swift and successful accomplishment of the validation exercise.

6.1. Resilience of health systems

The Ebola crisis brought the concept of resilience of health systems to focus even in areas with limited resources and capacities; health systems are considered to be resilient if they protect human life and produce good health outcomes for all during a crisis and in its aftermath [7]. Resilient health systems have also been recognized to be of critical importance in delivering routine services, leading to positive health outcomes; referred to as 'the resilience dividend' [9].

While there is no denying that the health system in India suffers from systemic weaknesses, the performance of the polio eradication program through the last two decades bears testimony to the inherent resilience. The swift and successful implementation of the switch plan across an estimated 27,000 cold chain points is the most recent evidence. The major challenges in implementing the switch strategy were four-fold: (i) a pan-India inventory/recall of tOPV and assured supply of bOPV required strong accountability mechanisms the oversight and monitoring being provided by the Vaccine Introduction Working Group (VIWG); (ii) generating awareness among the health workforce about tOPV withdrawal and switch strategy, that was crafted through well planned cascading trainings, mostly using the opportunity of National Immunization Day (NID) vaccinator's training sessions; (iii) containment of WPV2 and tOPV was critical, for which the (then) recently concluded task of phase 1 containment was leveraged; (iv) the large private sector using tOPV was to be reached, this was addressed through targeted communications engaging technical bodies like the Indian Academy of Pediatrics (IAP) and the Indian Medical Association (IMA) and commercial vaccine distributor networks.

It has been amply demonstrated through the eradication campaign in delivering the vaccine to geographically challenging and conflict areas, negotiating with social resistance and more recently in operationalizing the emergency preparedness and response

plans (EPRP) to vaccine derived polio virus (VDPV) cases [10]. VPDV surveillance is being done in both AFP cases and through environmental surveillance. Polio laboratories were enrolled by the WHO as a part of the India polio laboratory network to support testing of stool samples and environmental samples for polioviruses. WHO supported these laboratories with human resources, equipment and supplies, training to build technical capacity and data management in addition to the setting up and implementation of a quality assurance mechanism for these laboratories. New technologies were introduced in these laboratories over time to ensure reliable results are available to the program in the shortest time possible. Environmental surveillance is now available at 45 sites across 18 cities in 8 states; further expansion is proposed in 3 more cities; the environmental surveillance system has been robust enough to detect VDPV2 viruses and the EPRP was operationalized in a very short time preventing any major circulation [3].

It is important to recognize that the polio eradication campaign achieved gradual integration (central to resilience) to the general health services. The Mission Indradhanush and Intensified Mission Indradhanush campaigns were recent examples where learning of polio program was applied to strengthen immunization systems (to cover partially immunized and unimmunized children in low performing areas in selected districts and urban areas) [11]. Resilient systems have been termed as the 'next big evolution in global health' [12]. All these were possible owing to the proven demonstration of some of the key elements of health systems resilience: accountability, commitment of workforce and adaptive mechanisms with inbuilt systems to encourage innovation [13].

Competing interests

None.

Acknowledgements

The authors thank the valuable contribution of the members of the Expert Group. Rashna Dass, Manoja K Das, Gaurav Banyal and Chandan Singh deserve special mention for their outstanding support in organization of the workshops and fieldwork.

Funding

Ministry of Health & Family Welfare, Government of India, Grant ID : DY. No. C-1321 dated 22-08-2016.2.

References

[1] SEARO, WHO. Governing body matters: Key issues arising out of the Sixty-eighth World Health Assembly and the 136th and 137th sessions of the WHO Executive Board. Available at <http://www.searo.who.int/mediacentre/events/governance/rc/68/rc68-19-11.1.pdf>, [accessed on August 8, 2016].
[2] Global Polio Eradication Initiative. Switch from tOPV to bOPV Guidelines for Developing National Operational Plans.
[3] Report of the National Validation of tOPV to bOPV Switch 20 May, 2016. NCCPE Secretariat. NCCPE India: tOPV to bOPV National Switch Validation; 2016. Unpublished.
[4] Haldar P, Agrawal P. India's preparedness for introduction of IPV and switch from tOPV to bOPV. Indian Pediatr 2016;53:S44–9.
[5] Report of the independent commission on health; 2008, available at <http://www.vhai.org/ceo/icdhi-publications/Health%20Status%20of%20The%20Districts%20of%20India.pdf>.
[6] The quality of governance: How have the Indian states performed?, available at <http://www.nipfp.org.in/media/medialibrary/2013/04/wp_2012_104.pdf>.
[7] Health facilities – inaccessibility, available at <http://www.nhsrcindia.org/index.php?option=com_content&view=article&id=288&Itemid=724>.
[8] <http://inclentrust.org/inclen/?page_id=5420>.
[9] Masten AS. Ordinary magic: resilience processes in development. Am Psychol 2001;56:227.
[10] Rodin J. The resilience dividend: being strong in a world where things go wrong. New York: Public Affairs; 2014.
[11] Mission Indradhanush, operational guidelines; 2016. Available at <https://mohfw.gov.in/sites/default/files/216846291201489665182.pdf,> [accessed on June 12, 2018].
[12] Myers M. Resilient systems: the next big evolution in global health; May 08, 2015. Available at <https://www.rockefellerfoundation.org/blog/resilient-systems-the-next-big-evolution-in-global-health/>, [accessed on August 7, 2016].
[13] Arora NK, Chaturvedi S, Dasgupta R. Global lessons from India's poliomyelitis elimination campaign. Bull WHO 2010;88:232–4.