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Short communication

Needle-free injectors for mass administration of fractional dose inactivated poliovirus vaccine in Karachi, Pakistan: A survey of caregiver and vaccinator acceptability

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ABSTRACT

The first large-scale vaccination campaign using needle-free jet injectors to administer fractional doses of inactivated poliovirus vaccine (fIPV) was conducted in Karachi, Pakistan, in February 2019. Data on acceptability of jet injectors were collected from 610 vaccinators and 4898 caregivers during the first four days of the campaign. Of those with prior needle and syringe experience, both vaccinators and caregivers expressed a strong preference for jet injectors (578/592 [97.6%] and 4792/4813 [99.6%], respectively), citing ease of use, appearance, and child's response to vaccination. Among caregivers, 4638 (94.7%) stated they would be more likely to bring their child for vaccination in a future campaign that used jet injectors. Mean vaccine coverage among towns administering fIPV was 98.7% – an increase by 18.4% over the preceding campaign involving full-dose IPV. Our findings demonstrate the strong acceptability of fIPV jet injectors and highlight the potential value of this method in future mass campaigns.

1. Introduction

Inactivated poliovirus vaccine (IPV) has become increasingly important to the polio eradication endgame strategy, which includes both eradication of wild poliovirus (WPV) from endemic countries and global withdrawal of all oral poliovirus vaccines (OPVs). In preparation for global withdrawal of the serotype-2 component of OPV in April 2016, all OPV-using countries were required to introduce at least one dose of IPV into their routine immunisation (RI) schedules. Moreover, IPV has successfully been used during supplementary immunisation activities (SIAs) in WPV1 endemic countries [1] and in outbreak response [2,3] to mitigate risk of wild and circulating vaccine-derived poliovirus (cVDPV) transmission by boosting mucosal immunity among children who have previously received OPV [4,5]. Despite the importance of IPV in the global polio eradication strategy, there are substantial supply constraints that have necessitated research into dose-sparing strategies. Intradermal administration of a fractional (1/5) dose of IPV (fIPV) has been shown to boost mucosal and humoral protection among OPV-immunised children [6,7], and two fIPV doses are more immunogenic than one full dose when administered within a RI schedule [7,8]. Moreover, while fIPV administration with a needle and syringe requires experienced vaccinators, alternative delivery formats such as needle-free jet injectors, which deliver fluid intradermally with an auto-disabling syringe, have demonstrated improved acceptability among vaccinators owing to their ease of administration [9], potentially facilitating large-scale implementation.

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Pakistan remains one of three WPV endemic countries (alongside Afghanistan and Nigeria), with Karachi being a core reservoir of poliovirus transmission. Karachi is the most populated city in Pakistan with >2.1 million children <5 years of age [10]. The highest risk town of Gadap has not interrupted poliovirus transmission in >2 years [11]. High population density, coupled with poor sanitation, extensive population movement (including to and from Afghanistan) and increasing community resistance to vaccination [12] continue to hamper the Pakistan polio programme's efforts to halt transmission in this area. In order to mitigate risk of ongoing transmission in Karachi, additional strategies have been explored.

In February 2019, an IPV SIA was conducted in 10 towns of Karachi targeting approximately 1.3 million children between 4 and 59 months of age. The primary aim of the SIA was to reduce the immunity gap in these high-risk areas (both in terms of protection against paralysis and boosting of mucosal immunity, particularly in the older age group). As part of this SIA, the Pakistan polio programme conducted the first large-scale campaign (targeting > 10,000 children) using jet injectors for fIPV administration in four towns of Karachi (target population approximately 0.5 million children 4–59 months of age). The model used – the Pharmajet® Tropis® needle-free injection system – administers vaccine through a single-use, single-dose, auto-disabling and disposable syringe (Supplementary Fig. 1). Operational research was conducted in parallel with this campaign to: (i) determine the feasibility of the jet injectors in a large-scale campaign; (ii) solicit vaccinator and caregiver feedback on the experience of the jet injectors compared to needle injections; and (iii) gather qualitative information on training content and administration.

2. Materials and methods

2.1. Study design and location

The IPV/fIPV campaign was implemented at fixed (e.g. hospitals) and outreach (temporary vaccination location) sites in 10 towns of Karachi (Baldia, Bin Qasim, Gadap, Gulshan-e-Iqbal, Orangi, Site, Korangi, Landhi, Liaqatabad, and North Nazimabad), which were selected based on epidemiological risk of WPV1 detection; the first six implementing full-dose IPV and the latter four fIPV. fIPV towns were selected based on a variety of factors including increased operational feasibility, vaccine acceptance, and poliovirus risk. The study was conducted in all 43 Union Councils (UCs; the smallest administrative unit in Pakistan) of the fIPV towns. Additionally, the time taken to administer the vaccine was evaluated in 14 UCs of IPV towns.

2.2. Jet injector acceptability (vaccinator and caregiver)

The survey of vaccinator and caregiver attitudes towards the jet injectors was conducted during the first four days (18–21 February 2019) of the campaign. Polio programme staff from the Karachi towns not part of the campaign were recruited to act as surveyors. They attended a one-day training session, conducted in Urdu (the local language), on the vaccinator survey, caregiver survey and jet injectors. Data were collected on mobile phones using Open Data Kit (ODK).

Each of the 43 UCs within towns receiving fIPV was assigned one surveyor (with the exception of three Korangi UCs with a large number of vaccination teams, which were assigned two surveyors). Each surveyor was requested to interview at least four vaccinators and 20 caregivers (five per vaccination site) per day (16 vaccinators and 80 caregivers in total per UC across the 4 days of the survey). Campaign site locations were provided by UC Medical Officers, and surveyors determined interview locations based on feasibility.

The vaccinator survey included questions on vaccinators' prior experience, jet injector ease of use, observed response of children to jet injections (compared to needle injections), training feedback, and vaccinator preference for jet injector or needle (see Appendix 1 for complete survey). After completion of the campaign, vaccinators were contacted via telephone to verify their prior vaccination experience.

The caregiver survey included questions encompassing whether they preferred jet injector or needle injections for their child, the reasons for this preference, as well as whether the use of jet injectors would influence their decision to vaccinate their children in future campaigns. Caregivers were also asked to rank the vaccination experience on a scale of 1–10, with 10 being the best.

Surveyors were instructed to explain the rationale and utility of the study, and to obtain verbal consent from vaccinators and caregivers prior to commencing interviews. Meetings were held with vaccinators and social mobilisers in April 2019 to gather additional qualitative data on their experience with, and caregiver feedback on, the jet injectors.

2.3. Vaccine administration time (fIPV versus IPV)

In the fIPV towns, the time taken to administer the vaccine was recorded three times per vaccinator, spanning the act of preparing the jet injector through disposal of the needle-free syringe. Timing results were excluded if they did not vary among the three replicates or if the average administration time was less than 15 s (field observations of proficient vaccinators indicated administration times at or below this to be unrealistic and such observations were therefore assumed to be erroneous). If a UC had <16 vaccinators the surveyor was instructed to assess vaccinators a second time during the data collection period; the resulting data were used to compare vaccine administration timing between the first and second interview.

An additional eight surveyors were assigned to time administration of full-dose IPV with needle and syringe (three times per vaccinator). The towns of Gadap 4 (five surveyors across five UCs) and Site (three surveyors across nine UCs) were selected for these surveys.

2.4. Vaccinator training

A cascaded training approach was used, whereby master trainers trained supervisors at the district level, who in turn trained supervisors and vaccinators in UCs. In areas where fIPV was planned, master trainers directly trained supervisors and vaccinators on correct use of the jet injectors. A total of 48 master trainers attended a two-day training session in Karachi prior to the campaign, involving a demonstration of the jet injectors and an opportunity to practice with the devices. Master training was conducted by staff from WHO, UNICEF, Sindh provincial government, and Pharmajet, as well as Aga Khan University researchers with prior jet injector experience [13]. An instructional video recorded in Urdu was provided to master trainers for distribution to field staff during subsequent training of supervisors and vaccinators from 12 to 17 February 2019. The video could then be referred to by vaccination teams prior to and during the campaign. During the survey, vaccinators were interviewed on whether sufficient time was allotted for training components (demonstration/training video, and test injection practice session), number of test injections administered, whether they reviewed the training video before or during the campaign, trainer preparedness, and whether they felt the training sufficiently prepared them to use the jet injectors in a campaign setting (and if not, the reason(s)).

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2.5. Vaccination coverage

In all UCs included in this survey, community-based vaccinators maintain microcensus records tracking every child <5 years of age. SIA target populations are developed based on these data and vaccination coverage is routinely estimated by comparing the number of doses administered with these targets. For each town included in the study, we compared government data on SIA coverage for the February 2019 IPV/fIPV campaign with the preceding IPV campaign in August 2018. Notably, since vaccination is not restricted to children within the target population during an SIA, coverage estimates may exceed 100% if unregistered children (e.g. visiting from another location) are vaccinated.

3. Results

3.1. Jet injector acceptability

A total of 610 fIPV vaccinators were surveyed during the campaign. Of 592 (97.0%) with prior campaign experience involving a needle, 578 (97.6%) indicated a preference for the jet injectors, 10 (1.7%) preferred needle-based vaccination, and four did not state a preference. The most commonly selected survey options for favoring the jet injectors were ease of use (533 [92.2%]), positive caregiver response (387 [67.0%]), less discomfort/crying from the child (298 [51.6%]), and speed of use (295 [51.0%]) (Fig. 1A). When asked if they observed a difference in child response to the jet injectors compared with needle and syringe, 538 vaccinators (90.9%) reported a noticeable change, of which the most common was less crying in the child (526 [97.8%]) (Fig. 1B).

Data were collected from 4898 caregivers after their child was vaccinated using the jet injector. A total of 4813 (98.3%) reported prior experience bringing a child for a vaccine administered via needle and syringe. Of these, 4792 (99.6%) stated a preference for the jet injector. The most common reasons for this preference were the better appearance of the jet injectors (3769 [78.7%]) and the child's response to the vaccination (2431 [50.7%]) (Fig. 1C). Of the 21 caregivers who expressed a preference for needle and syringe, predominant reasons were the appearance and/or lack of noise associated with this method, and greater comfort or familiarity. Overall, 4638 respondents (94.7%) stated they would be more likely to bring a child for a future vaccination campaign involving jet injectors, 169 (3.5%) stated it would have no impact on their decision, and 91 (1.9%) would be less likely to attend. Finally, when asked to rate the vaccination experience on a scale of 1–10, with 10 being the best, the mean response was 9.3, and 3046/4898 (62%) gave a response of 10.

3.2. Vaccine administration time

Median administration times were 51.0 (interquartile range 41.8–64.8) seconds for fIPV (591 vaccinators) and 39.0 (31.0–46.0) seconds for intramuscular IPV with needle and syringe (197 vaccinators) (Fig. 2). Of the 110 fIPV vaccinators timed twice during the four-day data collection period, the median jet injection time decreased from 57.2 (44.0–67.0) seconds at the first visit to 43.2 (36.2–52.0) seconds at the second visit.

3.3. Vaccinator feedback on training

Most vaccinators (571 [93.6%]) reported being satisfied with the training they received. Notably, of those that received the instructional video (n = 480), 355 (74.0%) reviewed it either before or during the campaign, highlighting its utility as a training resource. Several social mobilisers also reported using the video to demonstrate the needle-free injection technique to parents. Of 39 vaccinators (6.4%) who felt the training was insufficient, primary reasons included the need for more practice injections (n = 15) and more experienced trainers (n = 10). In several instances, surveyors observed some vaccinators positioning the jet injector at a 45° angle to the skin (as with an intradermal needle injection) rather than at 90° per correct procedure, highlighting the need to tailor training to individuals with prior intradermal needle experience.

3.4. Vaccine coverage

Average coverage in February 2019 for the four fIPV towns was 98.7% (range 93.4% to 104.4%), while in the August 2018 full-dose IPV campaign, the average coverage for these towns was 80.3% (range 77.4% to 84.7%) (Fig. 3). In the six towns receiving full-dose IPV in both campaigns, mean coverage was 83.5% (range 74.4% to 90.3%) in February 2019 and 81.1% (range 73.2% to 93.7%) in August 2018. Overall, there was an increase in mean coverage of 8.8% between the August 2018 (80.8%) and February 2019 (89.6%) SIAs. For towns that administered fIPV in February 2019, the increase in reported coverage compared to the August 2018 IPV campaign ranged from 16.1% in Korangi to 24.3% in Liaqatabad. In the towns implementing IPV both rounds, the difference in February 2019 coverage compared to August 2018 ranged from −5.9% in Orangi to 11.5% in Bin Qasim.

4. Discussion

The use of IPV in mass vaccination campaigns has played an increasingly prominent role in the global polio eradication strategy; particularly in response to ongoing transmission of WPV1 in Pakistan and Afghanistan and outbreaks of serotype-2 cVDPV in Africa and Asia. Dose-sparing strategies of IPV would help alleviate current supply constraints; however, administration of fIPV via BCG needle and syringe is technically difficult and requires skilled personnel, limiting its use in campaign settings. Needle-free jet injectors for administering fIPV have the potential to improve the ease and acceptability of these campaigns. Single-use, auto-disabling syringes also eliminate the risk of blood-borne disease transmission posed by the reuse of BCG needles, which has been reported in Pakistan. Assessing the feasibility and acceptance of large-scale use of jet-injectors for fIPV administration is paramount before it can be adopted more widely into the global polio eradication strategy.

In February 2019, the Pakistan polio programme implemented the first large-scale SIA using jet injectors to administer fIPV (in Karachi, Sindh). High coverage (>90%) was achieved in all towns of Karachi that used jet injectors, highlighting the feasibility of this approach in a mass campaign setting. Moreover, vaccination coverage was higher (mean absolute difference >18%) when using jet-injectors to administer fIPV compared to the previous campaign administering full-dose IPV via needle and syringe; supporting the acceptance of this mode of vaccine delivery in the community. Furthermore, nearly all surveyed vaccinators and caregivers preferred the jet-injectors to needle-based methods (97.6% and 99.6%, respectively), specifically citing ease of use, positive parent response, improved child response, and the jet injectors' more favourable appearance (lack of needle). The high coverage and strong acceptability of the jet-injectors in this setting provide support for exploring the use of this mode of delivery to administer fIPV in areas with community resistance to vaccination – a key challenge to interrupting WPV1 transmission in Pakistan and in particular, the city of Karachi. Finally, despite the strong preference by vaccinators and caregivers for fIPV via jet injectors, vaccine

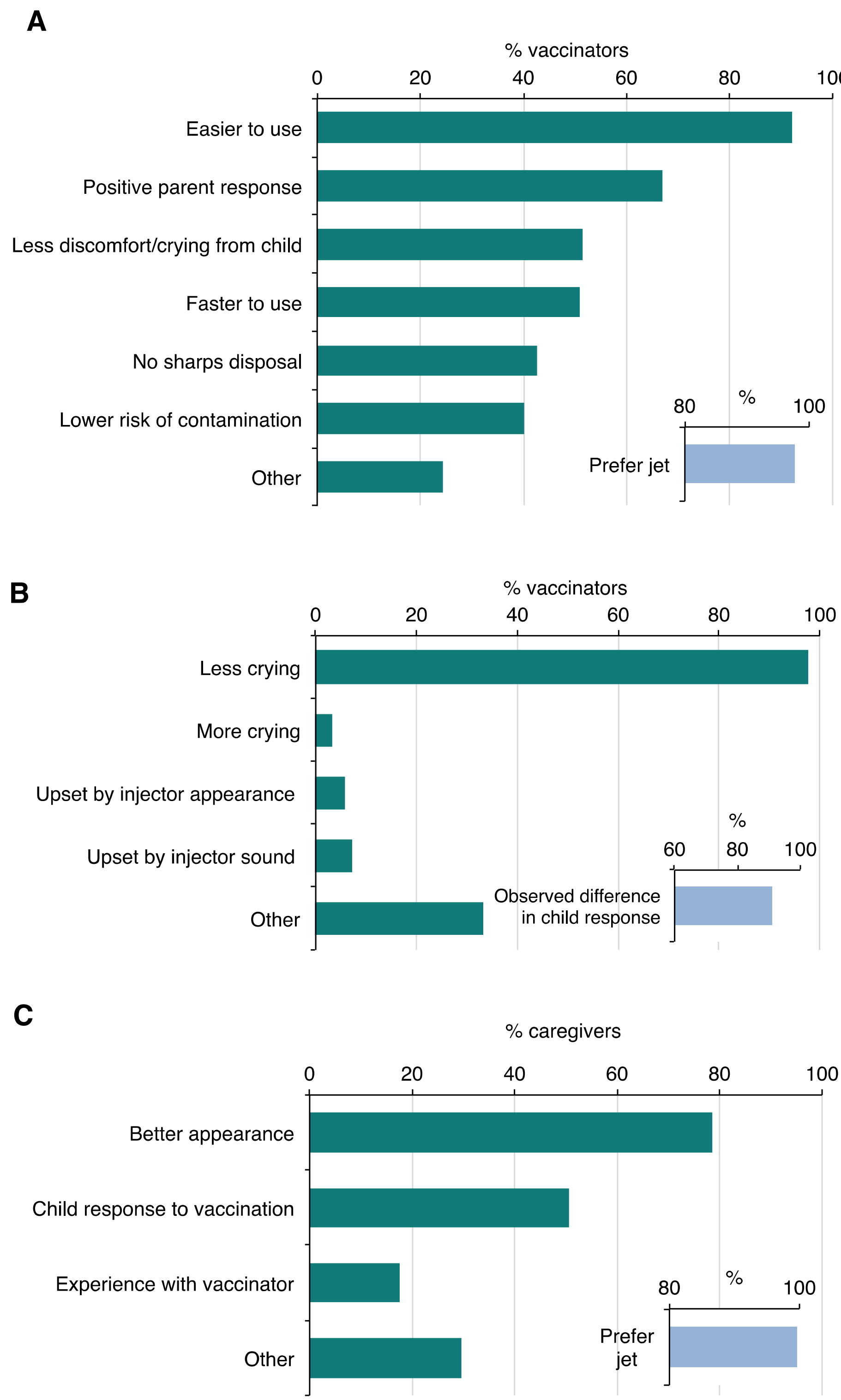

Fig. 1. Acceptability of jet injectors among caregivers and vaccinators. Multiple selections were permitted. (A) Response of vaccinators to jet injectors. (B) Vaccinator observations of child response to jet injectors compared to needle injection. (C) Response of caregivers to jet injectors.

administration time was longer than for IPV; however, this duration for administering fIPV decreased over the course of the campaign, consistent with previous studies [13]. This highlights the importance of proper training of vaccinators on using jet injectors prior to the start of the campaign.

Our study has several limitations. First, caregivers were surveyed at fixed and outreach vaccination stations. Therefore, there may be a selection bias in our survey towards individuals with more positive attitudes towards vaccination; however, this would not impact their preference for mode of vaccine administration (i.e. jet injectors or needle and syringe). Second, there was minor variation between the August and February SIAs in terms of duration of post-campaign catch-up vaccination days (i.e. reduced by 1–2 days in August) and estimation of vaccination coverage (i.e. new method

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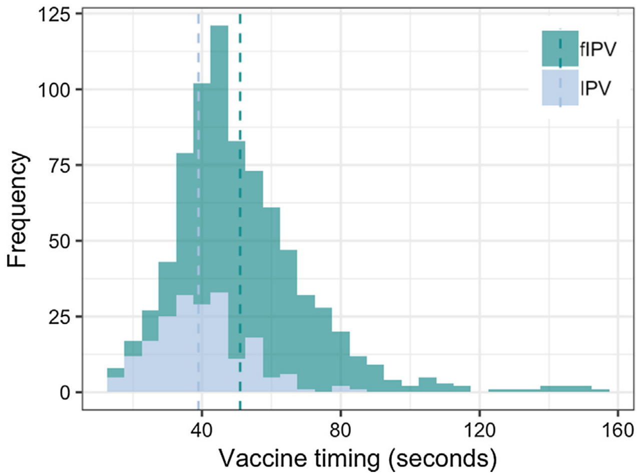

Fig. 2. Time taken to administer vaccine. Mean vaccination time was measured across three measurements per vaccinator. Valid readings were obtained for 591 vaccinators administering fIPV and 197 administering IPV. Median values in each group are indicated by dotted lines.

of estimation employed across all towns in February to reduce potential for double counting vaccinated children), potentially compromising the comparability of the administrative coverage data. However, removing vaccination through catch-up activities for both campaigns yielded similar results and the new method of estimation would have influenced all towns with equal probability. Third, the majority of fIPV vaccinators were skilled workers with prior campaign experience using needle-based methods; the feasibility of deploying jet injectors in a campaign utilising workers without this level of experience was not tested. Finally, given the uncertainty over their acceptability, fIPV jet injectors were administered in select areas. The extent to which our findings can be extrapolated to higher-risk areas is therefore equivocal, although fIPV acceptability and coverage was high across all UCs surveyed.

Overall, our findings demonstrate the strong feasibility and acceptability of fIPV jet injectors among both vaccinators and caregivers, highlighting the potential value of this method in future mass campaigns. Therefore, the use of jet-injectors to administer fIPV in mass campaigns can be a viable option for the global polio eradication strategy to help achieve eradication of all wild and vaccine-derived polioviruses.

5. Financial disclaimer

The survey was funded by the World Health Organization, Pakistan. The jet injectors were purchased by the Bill and Melinda Gates Foundations for the Pakistan polio programme. A representative from Pharmajet accompanied polio programme staff during the first three days of field visits but was not involved in data collection or interpretation of results.

6. Contributors

Natalia Molodecky and Abdiraham Mahamud conceived the idea for the study. Rana Safdar and Umar Farooq Bullo endorsed the study at the national and provincial level. Catherine Daly, Natalia Molodecky and Meghana Sreevatsana developed the survey tool. Mumtaz Laghari, Asalif Belayneh, Meghana Sreevatsana and Catherine Daly coordinated field implementation. Catherine Daly performed data analysis and wrote the first draft of the manu-

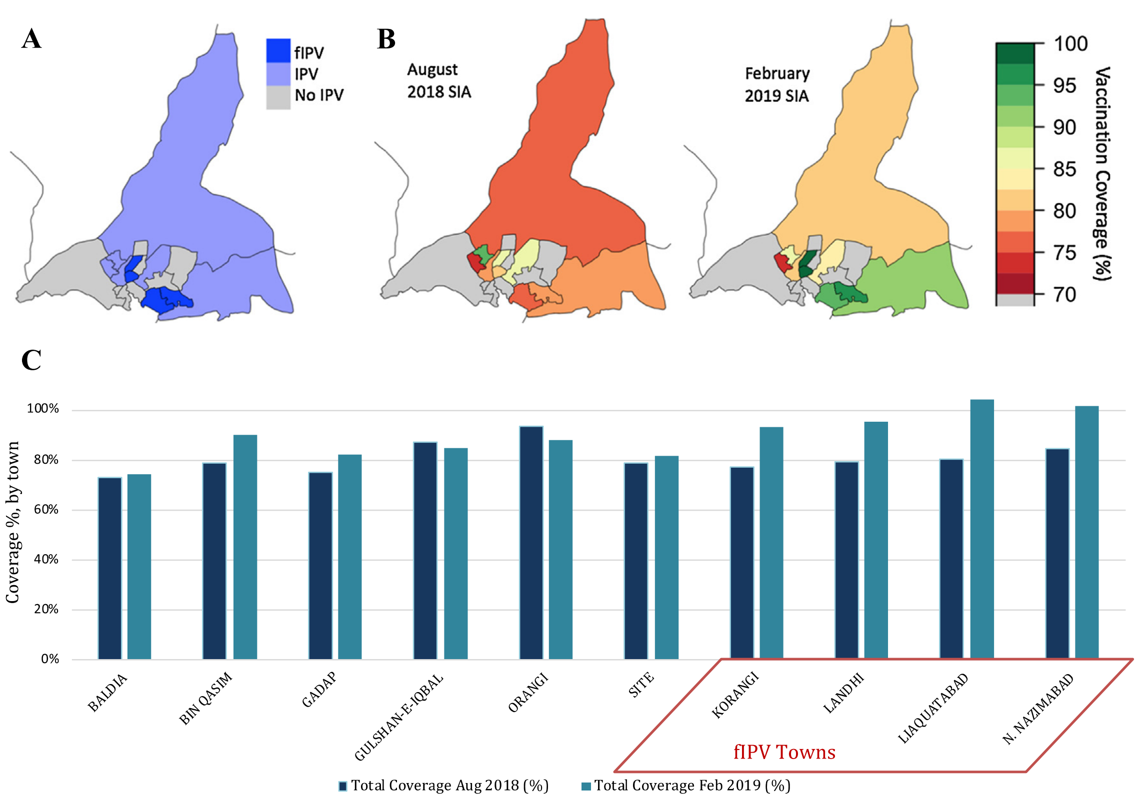

Fig. 3. Vaccination coverage of IPV SIAs in Karachi, Sindh. (A) Vaccine use in Karachi towns in February SIA. Dark blue indicates towns using fractional IPV with jet injectors and light blue indicates towns using full-dose IPV. (B) IPV vaccination coverage in August 2018 (all towns using full dose) and IPV/fIPV coverage in February 2019. (C) Comparison of vaccination coverage between August 2018 and February 2019. Abbreviations: fIPV, fractional inactivated poliovirus vaccine; IPV, inactivated poliovirus vaccine. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

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script. John Agbor, Safi Malik, Jeff Partridge, Ahmed Shaikh and Shoukat Chandio provided feedback on data analysis and results. Natalia Molodecky contributed manuscript revisions, statistical analysis, and tables and figures. All authors reviewed and revised subsequent drafts.

CRediT authorship contribution statement

Catherine Daly: Supervision, Methodology, Formal analysis, Writing - original draft, Writing - review & editing. **Natalia A. Molodecky:** Conceptualization, Methodology, Formal analysis, Visualization, Writing - review & editing. **Meghana Sreevatsava:** Project administration, Methodology, Writing - review & editing. **Asalif D. Belayneh:** Project administration, Writing - review & editing. **Shoukat A. Chandio:** Writing - review & editing. **Jeff Partridge:** Writing - review & editing. **Ahmed Shaikh:** Writing - review & editing. **Mumtaz Laghari:** Project administration, Writing - review & editing. **John Agbor:** Writing - review & editing. **Rana M. Safdar:** Resources, Writing - review & editing. **Umar Farooq Bullo:** Resources, Writing - review & editing. **Safi M. Malik:** Writing - review & editing. **Abdirahman Mahamud:** Conceptualization, Supervision, Writing - review & editing, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2019.12.059.

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