Mobile Phone Technology Based Incentives to Enhance Routine Childhood Immunization

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SUMMARY

In this randomized controlled trial (RCT), 608 children (age ≤24 months, median 5 mo) from a rural community in India were randomly assigned to either a control group or one of the study groups: (*i*) mobile phone reminders; or (*ii*) compliance-linked incentives. A cloud-based, biometric-linked software platform was used for positive identification, record keeping, and delivery of automated mobile phone reminders. Free talk time (worth Rs. 30) was offered as compliance-linked incentive for the study groups. Median immunization coverage at enrollment was 33% in all groups and increased to 41.7% (IQR 23.1-69.2%), 40.1% (IQR 30.8-69.2%), and 50.0% (IQR: 30.8-76.9%) by the end of the study in the control group, the group with mobile phone reminders, and the compliance-linked incentives group, respectively. Authors concluded that administration of compliance-linked incentives was independently associated with improvement in immunization coverage and a modest increase in timeliness of immunizations in resource-poor setting.

COMMENTARIES

Evidence-based Medicine Viewpoint

Relevance: Routine immunization is one of the bulwarks of the Indian healthcare delivery system. However, despite being freely available and accessible, vaccine acceptance is unduly low in our country. The National Family Health Survey (2015-16) reported that only 62% children aged between 1 and 2 years had received the six antigens administered in infancy [1,2]. Sadly, these dismal summary statistics also mask the inequities and disparities in vaccination coverage based on gender, family income, residence, maternal literacy, state, *etc*. [3]. An additional challenge with childhood immunization data in India is the reliance on manually filled immunization records (of individual children and/or healthcare facilities) or the crude recall method.

In recent years, considerable attention has been focused on strategies to improve routine immunization, especially in vulnerable populations. A detailed review highlighted feasible evidence-based measures such as interventions to build community participation, include non-professional healthcare workers, generate vaccine demand, and develop vaccination reminder systems [4]. Several groups of investigators have also explored the potential of using mobile telephony-based technology solutions to improve healthcare delivery to individuals as well as the community [5-9]. Against this backdrop, Seth, *et al*. [10] recently published this study designed with the dual objectives of developing a cloud server based immunization record maintenance system, and exploring mobile telephony based short messaging service (SMS) systems to remind and incentivize vaccination. However, the detailed methodology and outcomes of the first objective were not described in the publication [10] or the study protocol available online [11]. The second objective was addressed through a randomized controlled trial comparing immunization in three groups of children *viz* automated SMS-based reminder, automated SMS reminder plus compliance-based monetary incentive, and none of these intervention.

Critical appraisal: ***Table* I** summarizes the trial component of the study. ***Table* II** summarizes a critical appraisal of the RCT component of the study using the Cochrane Risk of Bias tool [12]. In addition to the methodological limitations described, this study had several other issues that limit its internal as well as external validity.

The term 'immunization coverage' conventionally refers to the proportion of eligible children in a community who have received age-appropriate vaccines. For example, a coverage of 33% would be interpreted as 33% vaccinated children and 67% unvaccinated children. In this study [10], 'immunization coverage' was defined as the ratio of vaccines received by individual children to

the vaccines required. Therefore 33% coverage means that a child having received only one-third of the total vaccines due to him/her. Thus this actually reflects 'vaccination completeness' and not 'vaccination coverage'. In this study, it is also unclear whether multiple vaccines received at a single visit are counted together or separately. For example, DPT and OPV are administered together at the same session. For 'vaccine coverage purposes', the two vaccines should be counted separately, whereas for 'vaccination completeness' the two can be considered together.

Table I in the study [10] refers to yet another term viz 'baseline immunization coverage per 100 person-immunizations'. The meaning and significance of this term are unclear, especially as the proportions shown are different from those reported as 'baseline immunization coverage' in Table II of the study. Fig. 2 in the study [10] introduces yet another undefined term *viz* 'immunization rate'.

The issue has deeper implications than mere semantics. A median vaccination completeness of 33% at enrollment implies that children had not received two-thirds of the vaccines for which they were eligible. In such a situation, it seems unusual that no efforts were made by the study personnel or the local healthcare system to complete the missing vaccinations. It appears that children in the study were merely administered some vaccines and allowed to revert back to the healthcare system as per the RCT arm they belonged to. It is even more alarming that despite following up the children for almost 10 months, the vaccination completeness at the end of the study remained unacceptably low in all three arms. Despite the statistically significant inter-group differences, the children had not received 50 to 60% of the vaccinations due to them.

In this study, more than one child could be enrolled per family. This creates a design effect, in the sense that all eligible children in the same family would behave similarly with respect to vaccination. This could have been avoided by simply restricting enrolment to one child per family. Further, multiple enrolments per family could also inflate the vaccination completeness of the incentivized group, because it translates to greater incentive per family with the same effort. This aspect has not been considered by the investigators.

Although the monetary value of the incentive used in this study [10] was not unduly high, it raises two issues. First, should childhood vaccination be incentivized at all? Intuitively it appears logical that vaccination should be demand-driven (*i.e.*, the community should be 'pulling'

TABLE I SUMMARY OF THE TRIAL

Parameter	*Details*
Study setting	Rural population in Mewat, Haryana (India)
Study duration	12 months
Inclusion criteria	Children <24 mo with mobile telephone(s) in the family, and caregiver(s) able to provide consent in writing.
Exclusion criteria	None specified.
Intervention and Comparison groups	The two Intervention groups received SMS reminders in Hindi (nature, content, timing, frequency, etc) have not been specified. One group also received monetary incentive (mobile phone talk time worth Rs. 30) for each completed vaccination. The Control group received verbal instructions about subsequent vaccination dates as per routine practice.
Outcomes	*Primary*: Immunization coverage defined as the ratio of vaccines actually received to the number expected as per age.
	Secondary: Timeliness of vaccination defined as proportion of vaccinations received either before or within 2 weeks of the scheduled date; Cost of interventions.
Sample size	No *a priori* sample size calculation was reported.
Data analysis	Intention-to-treat (ITT) analysis was not performed.
Summary of results	*Primary outcome*: At enrolment, the median ratio of vaccines received (compared to number required) was one-third in all three groups. This increased to 42% in the control group, 40% in the SMS group and 50% in the SMS plus incentive group.
	Secondary outcomes:
	• *Timeliness:* Control group 31.3%, SMS reminder group 24.7%, SMS + incentive group 40.8%.
	• *Cost:* Data not presented for all three groups.

Table II CRITICAL APPRAISAL OF THE RCT

Baseline characteristics of participants	The children in the three groups were comparable with respect to age, gender ratio, number of siblings, maternal education level, household income, and place of birth. Baseline immunization coverage (term not defined) was also comparable. For some reason, the duration of follow-up in the study was also presented as a baseline characteristic at enrolment.
Randomization procedure	Not described.
Allocation concealment	Not described.
Blinding	Neither the (families of) children receiving the interventions, nor the personnel assessing outcomes were blinded. The purpose and relevance of blinding other personnel is unclear.
Incomplete outcome data	608 children were randomized, but 59 were excluded thereafter for various reasons. Thus data were reported for 549 children (90.2%) who completed the study per protocol. Thus intention-to-treat analysis was not performed.
Selective outcome reporting	A key outcome in this type of study was not included viz the overall change in the immunization rate in the community compared to baseline (See text for further details).
Other sources of bias	No obvious bias
Overall assessment	High risk of bias

vaccines for their children, rather than the healthcare system 'pushing' vaccines onto the community). Theoretically, incentives can make the community more complacent in the long-run and drive the immunization coverage down. Incentivization has the other undesirable effect that the community's expectations of the monetary value of incentives provided can escalate in the future and similar incentives may be expected for other public health initiatives as well. Therefore, it is difficult to agree with the authors' contention that higher incentives would translate to better vaccination coverage.

The second aspect is that although the incentive itself was limited to Rs 30/- (hence relatively affordable for the healthcare system), the costs of developing the software, collection and maintenance of biometric data, and implementing the incentive-based system have not been considered at all. It appears unreasonable to invest in this intervention if the gain is restricted to just a marginal improvement in vaccination completeness as demonstrated in the study [10].

Conclusion: This RCT showed a marginal increase in vaccinations received by children in a rural community in India, with SMS-based reminders coupled with a small monetary incentive. However, methodological limitations and several additional issues diminish its internal and external validity, making the findings difficult to apply for public health benefits.

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Pediatrician's Viewpoint

The study by Seth, *et al*. [1] concludes that mobile phone incentives to caregivers of young children resulted in improvement of both immunization coverage and timeliness in a resource-poor setting. However, the increment in the rates was modest in the incentive-group, and even the control group has also registered some albeit non-significant improvement in the rates [1]. While highest increment in the immunization rates among incentive group was on the expected line, surprisingly, the second group with only automated mobile phone reminders registered the lowest increment amongst all the three groups [1].

One of the key reasons behind incomplete immunization or no immunization of young children in India has been the lack of awareness regarding vaccines and vaccination drives [2]. The findings of the above study underlie the importance of creating awareness amongst targeted community regarding vaccination along with offering some incentives (providing mobile phone talk time) to those who comply with the age-specific recommended immunization schedule [1].

How much impact do the incentive schemes make on the final rates of immunization, is a debatable issue. Whereas some studies have shown that incentives play a significant role in improving the immunization rates in both low and high baseline immunization coverage settings in low- and middle-income countries (LMICs) [3,4], a comprehensive systematic review by Cochrane Collaborators concludes that offering incentive to caregivers may not have much impact on fully immunized (FI) status of the target children [5]. There is moderate-certainty evidence that providing information to the parents and the community may have greater impact on the final tally of FI children [5]. Does the type and the quantum of incentive have any role? Banerjee, *et al*. [3] in an Indian study offered a modest 'non-monetary' incentive, a packet of raw lentils with a metal plate to the caregivers that resulted in a large positive impact on FI rates (more than 20% increment) than those who were not offered any incentive [3]. Similar study in Kenya found that the group offered higher cash incentive had significantly higher FI rates than those who got less amount of cash incentive [4]. Thus there may be some impact of the quantum of the incentive on the final immunization rates, but it varies from different regions and settings. There is a need to have more studies to formulate a sound, universal strategy for adoption in different LMICs. On the other hand, offering liberal, frequent incentives for a beneficial intervention may create doubt and suspicion in the community, and may in turn prove to be counterproductive, particularly among the underserved community with low overall literacy rates and history of resistance to vaccination drives.

There is another school of thought according to which the childhood immunization should be made compulsory, mandated by the state with a strict enforcement. Globally also, there is no uniformity. While some countries (*e.g.*, Australia) offer financial incentives to boost their FI rates, others (*e.g.*, Slovenia) impose heavy fine to non-compliant citizens [6]. Still, many countries concentrate on educating masses about the need and benefits of vaccination, and leave the choice on individuals. In a recent study from Italy, the concept of compulsory vaccination was generally welcomed, and it was concluded that the confidence in the health system had ultimately determined the trustworthiness of mandatory vaccination, not the social factors [7].

Currently, there is no magic bullet intervention that would be uniformly effective in closing the 'immunization gap' especially in LMICs. Offering incentives both in cash or in kind along with disseminating information to the parents by different means may be effective in improving immunization coverage and timeliness. Furthermore, there is a need to generate more data with cost-effectiveness analysis before these methods are employed on a larger population.

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Medical Information Technologist's Viewpoint

Seth, *et al.*, [1] have published an interesting study wherein they combine technology and incentives to improve vaccination compliance. The Indian government has launched various initiatives for digitization of services in the public sector with apps, such as DigiLocker and Umang, on common mobile software platforms, which use securely managed cloud-based data services [2]. These allow one to retrieve all documents related to individuals, including Aadhaar card and driving license. Seth, *et al.* [1] sent text message reminders but with falling costs, smartphones are likely to be available in the near future at the same penetration levels. This would allow app-based reminders and auto-generated vaccine cards to be utilized. This study relied on paper-based systems, but many states are moving towards digital records such as eMamta [3]. In the future, these records can be seamlessly integrated with apps on the phone allowing the state to have realtime information of children's health. National Health Protection Scheme is being launched soon throughout India and the technology used by Seth, *et al*. can be easily integrated into a patient-centric, federally controlled, application-programming interface enabled health information system [4]. Even with evolution of technology, including usage of Block chain combined with mHealthto ensure fidelity of records [5], the principles on which this study is based will remain and can be layered onto newer technology. The implementation of this study across large regions can improve the ease with which a clinician will be able to provide and track immunizations. Since there is rapid development of this sphere, I believe that it will be part of an integrated health tracking system rather than a standalone system for improving vaccination coverage.

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