

**Vaccine wastage at primary, secondary, and tertiary level of healthcare system—A study from Northern India**

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**Abstract**

**Background:** High vaccine wastage results in escalation of budget of immunization program. **Objective:** To analyze vaccine wastage at three levels of service delivery under public sector, such as at district level, community health Centre (CHC), and sub center (SC). **Study Design:** A retrospective cross-sectional record based study in a north Indian state. **Materials and Methods:** The record from January to June 2016 was taken from randomly selected 5 districts of the state at 3 levels; for number of doses of vaccine used and number of children vaccinated for BCG, OPV, Hepatitis B, Pentavalent, DPT, IPV, Measles, and TT (vaccines being given in state in the study year). A total of 67,550 vaccine doses in routine immunization were studied. **Statistical analysis used:** Data were presented in mean ± standard deviation. One-way ANOVA test was used to compare the means among three levels. **Results:** Vaccine wastage for Pentavalent was remarkably low (4.86% at district level, 8.35% at CHC and 11.50% at SC) in contrast to other similar 10 dose vials of vaccines like DPT, TT, Hep B. For both the lyophilized vaccines, interestingly BCG wastage was not only significant but over the permissible levels at 60.39%, whereas it is not so for measles. Result indicated that mean difference of the vaccine wastage among three levels was significant for the BCG, OPV, Hepatitis B, Pentavalent, and TT (P < 0.05); while insignificant for the DPT, IPV, and Measles (P > 0.05). **Conclusions:** Not all vaccine wastage is preventable, but pruning the corners where feasible and allowing where it is desirable should depend on prioritizing stakeholders at the receiving end.

**Keywords:** Immunization, public sector, universal immunization program, vaccine wastage

**Introduction**

World Bank database projected immunization as major contributor for fall in mortality rate of under-five in India from 233 to 37 per thousand live births.[¹]

Promulgation of National Vaccine Policy in April 2011 ushered a new era, leading to evidence-based approach with R&D in production, procurement and quality assessment of vaccines under Universal Immunization Program (UIP).[²]

In world, India has the largest birth cohort with 27 million children born, but contrastingly only 44% receiving full schedule of vaccinations as reported in year 2013.[³] However, by 2015–16, the reported coverage has escalated to 63.9% and with introduction of Mission Indradhanush and Intensified Mission Indradhanush the target have been kept to reach above 90% and such efforts are showing results on the ground.[⁴]

Primary care physicians by advocating vaccination can help people in preventing many infectious diseases in children and thus

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can avoid their hospitalization, preventing long-term disability leading to overall increased productivity.

Poor vaccine administration practices embrace wastage of opened and unopened vials and forms major encumbrance to proficient and cost effective immunization.\(^5\)

UNICEF highlighted that point of service delivery as locus of maximum wastage while supply chain level wastage was comparatively minimal.\(^6\)

If vaccine wastage monitoring is incorporated as a monitoring tool, Program improvement and raising the efficacy becomes a possibility.

### Materials and Methods

To assess cost-effectiveness and find remedies, a retrospective cross-sectional study was conducted and vaccine related data was collected from the selected health centers in the designed format. BCG, OPV, Hepatitis B, Pentavalent, DPT, IPV, Measles, and TT were being given as per National immunization Schedule in study year of 2016. The ministry of health and family welfare, Government of India allows vaccine wastage of 50% for BCG, 25% for Measles, and 10% for rest of vaccines as permissible.\(^7\)

Measles is a 5 dose vial, OPV being 20 dose vial and rest all are 10 dose vials. BCG and Measles are supplied in lyophilized dry powder form, so have to be reconstituted. Once vial is opened and reconstituted, the lyophilized freeze-dried vaccines need be discarded within 4 h as per multi-dose vaccine policy. All liquid vaccine vials are discarded on four week duration if maintained in cold chain after opening of vial and if returned unopened for three times.\(^8\)

The state of Punjab has 22 districts, out of which 5 districts namely: Patiala, Mansa, Rupnagar, Ludhiana, and Jalandhar were selected randomly for this study. Out of these 5 selected districts, 13 CHCs and 34 SCs were selected using purpose sampling and further data was taken from 3 levels, that is, District, Community health center (CHC), and sub center (SC) level. Record from January to June 2016 was taken for number of doses of vaccine used and number of children vaccinated for each vaccine. A total of 67,550 vaccine doses in routine immunization were studied.

The Number of doses wasted = (Number of doses issued - Number of children vaccinated)

Vaccine wastage rate = (Number of doses wasted/Number of doses issued) X 100\(^9\)

Due approval was taken from Institutional Ethics Committee, Government Medical College, Patiala, Punjab, India. Approval from the ethics committee was obtained in 2016 and revised permission again with IEC No. 2474 dated 23rd Jan 2020.

### Statistical analysis

Normality of the continuous data was tested. Normally distributed data was presented in mean ± standard deviation.

One-way ANOVA was used to compare the means among the three levels (District, CHC, and SC). In case P value was found significant, multiple comparisons were used. Mean ± ISD of the levels was presented using error bar graph. The P value < 0.05 was considered as statistically significant. A licensed Statistical package for social sciences, version-23 (Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.) was used for data analysis.

### Results

Wastage of 8 types of vaccines namely; BCG, OPV, Hepatitis B, Pentavalent, DPT, IPV, Measles, and TT was studied. In Table 1, result indicated that in the district level, number of children vaccinated per vial was higher as compared to the CHC and SC for all the type of the vaccines except measles.

In Table 2, mean vaccine wastage at District, CHC, and SC level was compared using one-way ANOVA. Results indicated that mean difference of the wastage among three levels was significant for the BCG, OPV, Hepatitis B, Pentavalent, and TT (P < 0.05), while insignificant for the DPT, IPV, and Measles (P > 0.05). For BCG, as one-way ANOVA P value was significant, multiple comparison was used, and the results revealed that mean vaccine wastage percentage was significantly different between district level and CHC and district level and SC while mean difference was insignificant between CHC and SC (P > 0.05). Comparisons of the mean vaccine wastage (percentage) among three levels (District/CHC/SC) are presented using error bar graphs for BCG and OPV [Figure 1], Pentavalent, DPT, and IPV [Figure 2] and Measles and TT [Figure 3].

### Discussion

A glance at NFHS 4 (2015-16) for Punjab concerning child immunization depicts conspicuous fall from NFHS 3 period to the present data, in the children aged 12–23 months in private healthcare facility from 14.5% to 11%, indicating strong
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Vaccine wastage is an important determinant in forecasting vaccine needs. In the absence of local or national data on wastage rates, if incorrect figures are used, the country concerned may face serious vaccine shortages or be unable to consume received quantities. Hence, by both ways it will lead to increased wastage through expiry.\textsuperscript{[10]}

The present study when compared to analogous data available from various studies, shows that vaccine wastage either at par or much lower than most of the studies done here in India [Table 3]. Parmar DR et al., Tiwari R et al., and Daya AP et al. had lower or near equal wastage rates for all vaccines with exception of measles in study by Daya AP et al.\textsuperscript{[11‑13]} For IPV, only one comparable data was available as it is recently introduced under UIP.\textsuperscript{[12]}

Vaccine wastage at different levels of service delivery was compared with that reported by Mukherjee et al. where for district level (urban centers) with present study for BCG - 37.3/21.92; OPV -24.8/14.59; DPT - 19.2/11.74; Measles - 18.8/21.49, and for TT - 22.7/7.29. Vaccine wastage was compared with that by Mukherjee et al. for SCs with present study for BCG - 49.0/59.14; OPV - 63.3/21.62; DPT - 52.3/19.72; Measles - 29.0/24.08, and for TT - 52.3/25.84.\textsuperscript{[15]}

The vaccine wastage rate for BCG was much lower than the results found by other workers except those marked with *. As these (*) were from institutions; so more no. of deliveries there and more children available for vaccination and hence lower wastage.\textsuperscript{[12]}

The wastage rates were higher in lyophilized vaccines (43.42 for BCG, 21.67 for measles) compared to that of liquid vaccines (8.38 to 17.55%). This is similar to the findings from other studies.\textsuperscript{[16,19]} This may be because of the fact that the lyophilized vaccines need to be discarded within 4 h after reconstitution.\textsuperscript{[7]} But, however BCG and Measles both behaved differently, for BCG overall wastage was within permissible limits at District Level but not so at CHC and SC, whereas Measles had wastage within permissible limits at all service delivery points despite the fact that both being reconstituted vaccines and have to be discarded after 4 h. A similar finding that substantially higher wastage of lyophilized vaccines compared to liquid ones was observed in UNICEF study. It was further observed that five dose vials registered an overall low wastage, which is akin to current work.\textsuperscript{[8]}

Another finding is that Pentavalent has the least wastage at all levels of service delivery and similar were observations by Gupta V and C. Duttagupta et al.\textsuperscript{[14,17]} Though Pentavalent is among the 10 dose vial vaccines like DPT, TT, Hepatitis B, with same open vial policy applicable to these liquid vaccines, wastage was found to be lowest, though reasons unfathomable. Is it being the costlier vaccine and the program managers insisting on less wastage or/ and the more recently introduced vaccine and instructions yet being fresh in the minds at the time of study.

Measles and Pentavalent had the distinction to be within permissible limits of wastage at all 3 levels studied contrary to some other studies where measles had higher wastage rates.\textsuperscript{[9,10,13‑18]}

So, it is very important to study the wastage factor at this stage as this sector is catering to health needs of majority of population. Mere 5.7% continued to utilize private health facility from rural setup.

Development of faith in public sector.\textsuperscript{[3,9]}
Hepatitis B was not given at SC as deliveries were not reported there in the state.

A study conducted between two locations of Kangra, Himachal Pradesh and Pune, Maharashtra showed that overall wastage rates for almost all vaccines were higher in Kangra district (BCG 37.1%, DPT 32.1%, Measles 32.2%, OPV 50.8%, TT 34.1% and pentavalent 18.4%) than that of Pune district (BCG 35.1%, DPT 25.4%, Measles 21.7%, OPV 14.3%, TT 23.1% and pentavalent 13.2%).

In a tertiary care center in West Bengal, Wastage rate was found to be highest for bacillus Calmette–Guérin vaccine (68.9%) and lowest for oral polio vaccine (27.7%).

| Vaccine | At Level | Mean | Std. deviation | Minimum | Maximum | P       | Multiple comparisons | P |
|----------|----------|------|----------------|---------|---------|---------|----------------------|---|
| BCG wastage (%) | District level | 21.92 | 11.58 | 2.67 | 50.42 | <0.001 | District level | CHC | <0.001 |
|           | CHC      | 60.39 | 17.07 | 23.33 | 79.44 |
|           | SC       | 39.14 | 23.73 | 10.00 | 90.00 |
|           | Total    | 43.42 | 25.90 | 2.67 | 90.00 |
| OPV wastage (%) | District level | 14.59 | 7.47 | 0.80 | 31.03 | 0.004 | District level | CHC | 0.780 |
|           | CHC      | 13.72 | 9.26 | 3.75 | 31.50 |
|           | SC       | 21.62 | 10.73 | 5.00 | 45.00 |
|           | Total    | 17.55 | 9.91 | 0.80 | 45.00 |
| HEPB wastage (%) | District level | 6.27 | 5.52 | 0.67 | 22.31 | 0.002 | - | - |
|           | CHC      | 12.30 | 5.12 | 5.00 | 20.00 |
|           | SC       | -     | -     | -    | -     |
|           | Total    | 8.09 | 6.03 | 0.67 | 22.31 |
| PENTA wastage (%) | District level | 4.86 | 5.06 | -4.00 | 18.00 | 0.008 | District level | CHC | 0.204 |
|           | CHC      | 8.35 | 7.11 | 1.11 | 26.00 |
|           | SC       | 11.50 | 10.46 | 0.00 | 50.00 |
|           | Total    | 8.38 | 8.63 | -4.00 | 50.00 |
| DPT_ wastage (%) | District level | 11.74 | 10.40 | 0.00 | 46.43 | 0.105 | District level | CHC | 0.868 |
|           | CHC      | 13.18 | 7.58 | 0.00 | 27.50 |
|           | SC       | 19.72 | 20.27 | 0.00 | 80.00 |
|           | Total    | 15.45 | 15.52 | 0.00 | 80.00 |
| IPV_ wastage (%) | District level | 8.74 | 7.03 | 0.00 | 26.67 | 0.060 | District level | CHC | 0.073 |
|           | CHC      | 11.60 | 9.53 | 0.00 | 26.67 |
|           | SC       | 19.64 | 26.12 | -30.00 | 90.00 |
|           | Total    | 13.88 | 18.60 | -30.00 | 90.00 |
| MEASLES_ wastage (%) | District level | 21.49 | 17.99 | 1.29 | 54.29 | 0.297 | District level | CHC | 0.278 |
|           | CHC      | 15.81 | 5.81 | 7.14 | 28.00 |
|           | SC       | 24.08 | 17.00 | 0.00 | 73.33 |
|           | Total    | 21.67 | 16.21 | 0.00 | 73.33 |
| TT_ wastage (%) | District level | 7.29 | 5.32 | 0.00 | 21.05 | 0.001 | District level | CHC | 0.272 |
|           | CHC      | 12.83 | 11.89 | 0.00 | 45.00 |
|           | SC       | 25.84 | 26.98 | 0.00 | 80.00 |
|           | Total    | 16.41 | 20.59 | 0.00 | 80.00 |

Table 2: Comparison of vaccine wastage among Districts, PHC and SC levels

Table 3: Wastage of different vaccines, Present and published data comparison

| Studies | BCG | OPV | Hep B | Pentavalent | DPT | IPV | Measles | TT |
|---------|-----|-----|-------|-------------|-----|-----|--------|----|
| Present study | 43.42 | 17.55 | 8.09 | 8.38 | 15.45 | 13.88 | 21.67 | 16.41 |
| NRHM1/UNICEF[9] | 61 | 47 | 33 | - | 27 | - | 35 | 34 |
| Vikas Gupta et al. 2015[14] | 77.90 | 28.97 | 38.66 | 7.42 | 46.75 | - | 41.28 | 36.81 |
| Ajit Mukherjee et al. 2013[13] | 49.3 | 52.7 | - | - | 38.9 | - | 38.7 | 48.0 |
| Praveena Daya A et al. 2015[11] | 22.93 | 6.70 | 6.50 | 3.49 | - | - | 11.0 | 6.13 |
| *Debashish R. Parmar et al. 2016[31] | 70.9 | 48.1 | - | - | 38.6 | - | 39.9 | 62.8 |
| Palanivel Chinnakali et al. 2012[29] | 20.71 | 14.65 | 10.56 | 3.49 | 15.6 | 10.49 | 21.68 | 7.09 |
| *Tiwari R. et al. 2017[28] | 64.69 | 41.41 | - | 24.52 | - | - | 32.59 | - |
| C. Duttagupta et al. 2017[17] | 84.4 | - | - | - | 45.1 | - | 68.6 | 34.8 |
| Stephaine Guichard et al. 2010[9] | 45 | 25 | 21 | - | 16 | - | 28 | - |
| Shreyash Mehta et al. 2013[9] | 45 | 25 | 21 | - | 16 | - | 28 | - |

*Tertiary care centre with Medical colleges
In a study in African country Nigeria, with 10 dose MCV vial, DTP3 was administered in 84% of sessions compared to MCV in 63% and 30% reported being turned away for vaccination at least once.[12]

In African Gambia, Wastage rates for the lyophilized vaccines BCG and Measles ranged from 18.5 to 79.0 and 0 to 30.9%, mainly through unused doses at the end of an immunization session.[15]

WHO recommends that all infants should receive their first dose of vaccine as soon as possible after birth, preferably within 24 hours.

For any vaccine, wastage rates are lesser at District level and more at SC level. Barring two vaccines which had to be discarded at the end of session, all were under open vial policy. But the phenomenon was observed across all types of vaccines. The lower wastage rates at District level may be because of higher no. of beneficiaries and stricter administrative controls resulting in minimal wastage from the vials for left doses. The reverse is likely for SC level regarding beneficiaries and may be controls too, as perceived in National Vaccine Policy; session size and formulation were found to be responsible in containing vaccine wastage to a reasonable extent.[16]

The lower rates of wastage in the present study points to effective vaccine stock management, at storage and efficient utilization and planned management at service delivery points in the state.

Conclusion

The present study data is from a well-connected motor able region with good condition of roads and hence establishes a fact that management of UIP as far as vaccine wastage is concerned is commendable. The vaccine wastage for all these vaccines are not only below the permissible limits at all district level centers’ but also one of the lowest vaccine wastage among the studies reported. Out of all vaccines, Measles outperformed with wastage within permissible limits at all centers’ despite being a five dose vial. Among all the vaccines, Pentavalent stood out distinctively with least wastage at different levels of service delivery indicating a higher awareness among vaccination staff and parents.

Recommendations

Vaccine utilization and wastage vary regionally from place to place. What is important is the type of wastage. Wastage because of logistics and administrative lapses need to be identified as they are preventable or reducible and so avoided, whereas those wastage occurring because of prioritizing patient/or in public interest, may be acceptable.

Contrary to general perception, vaccination, a medical intervention doesn’t remain just so but turns into a management-dominant modality. So UIP needs managerial, administrative interventions and governance related inadequacies need be addressed on priority. Among the inadequacies lies inevitable vaccine wastage. Higher wastage rates are acceptable to increase vaccine coverage in a low vaccine coverage setting.[10]

Not all vaccine wastage is preventable, but pruning the corners where feasible and allowing where it is desirable should depend on prioritizing stakeholders at the receiving end like tightrope walk balancing the pros and cons.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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