Assessing Covid-19 Vaccine Wastage – A Indian Case study

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***Abstract*—The aim of the study is to analyze the wastage of open vials in the vaccination centers of Simdega district in Jharkhand. The data collected consisted of details regarding the vaccination centers and their current vaccination statistics along with their active slot booking status (different vaccines including Covaxin and Covishield). Upon analysis several discrepancies were observed. To have a better understanding, further data was collected regarding the vaccination in the PHC's across the district and was analyzed to estimate different parameters like wastage, average wastage and center performance taking into account the 10% vaccine wastage benchmark. As a result, around 4.45% of the vaccine could have been saved from each 78 centers in the district in 16 days, if the centers would not have opened vials for less than 5 people in a day.**

Keywords—COVID - 19 , vaccination , vials, wastage

I. Introduction

COVID-19 disease is a communicable disease caused by a newly discovered coronavirus. Most people infected with the COVID-19 virus will experience light to moderate respiratory illness and recover without the need for special medications. Older people and people with underlying medical problems like disorder, cardiovascular disease, diabetes, chronic respiratory illness, and cancer are more probable to develop serious illnesses.

With rising new Covid-19 cases day by day , the active cases have surged to an all-time high in India with a peak of nearly 4 lakh cases. Covid-19 has not only put India but the world into a state of utter confusion and chaos and after being in the pandemic for nearly a year ,vaccination seems to be the only feasible and appropriate solution to combat this virus. In India the People currently have two alternative vaccines – the homegrown Covaxin vaccine, developed by Bharat Biotech and the Oxford-AstraZeneca vaccine Covishield, which is being manufactured under a license by the Serum Institute of India. The number of COVID-19 vaccine doses administered were 53 Crores as of 13th August,2021. Most of the earlier doses were given to the healthcare and frontline workers and high- risk groups like the elderly and people above the age of 60. On April 1, 2021 the government lowered the age of those eligible for vaccines to everyone over 45 .The authorities said their main aim was to keep the vaccine wastage down to less than 1% which could not be achieved due to the lack of facilities and cold chain infrastructure across the country.

Few of the main reasons which accounts in the significant wastage of vaccines are disposal of remaining doses in the vial after a particular day of vaccination meaning when nurses are not able to draw 10 doses from one vial, contamination of vials due to dust or water droplets, poor management of vaccines in the center, poor handling of vaccines during logistics, expiration of vaccine vials, not maintaining the right temperature, miscellaneous activities like theft and blackmarketing also leads to vaccine wastage. For a nation like India with a staggering population of nearly 135 crores, vaccinating its population is a monumental task requiring lakhs of doses to be administered daily and with these huge numbers comes the huge problem of wastage and the main motive of this project is to address some wastage issues suggest possible solutions to tackle this problem.

II. Literature Review

Vaccine wastage occurs at different stages of the vaccination process and the device dead space and the filling process technique are some of the main reasons behind it.[4] The two forms of wastage, namely the frequency and relative magnitude, reveals that there could be potential value in

developing a kind of vaccines which could have a longer shelf life and improved stability against heat[3].

Cold stores play an important role in the pharmaceutical industry like it does in storing vegetables and fruits. Just like it reduces the losses and increases the shelf life of consumable products, it increases the shelf life of injection doses and insulins.[8] Cold chain in the pharmaceutical industry plays an important role because it is where the supply of medicines or drugs with precise quantity and quality can be delivered to destined places and designated customers and at the scheduled time,because if they didn't deliver it on scheduled time it may lead to failure for the customer.[6] Wastage Vaccine can be a result of a number of underlying causes such as expiration before usage can occur; heat (or freezing) damage due to breaks in the “cold chain” in case the vaccine vial is not put in refrigeration; when the equipment for insulation or cooling fails, there can also be certain damage physically may be due to loss of label ,drop-ping, or crushing losses in inventory or transit and may also happened because of incompletely using the the nominal number of doses present in a multidose vials.[3] Lack of infrastructures like constant supply of electric power and well constructed roads in Indian Subcontinent, a high cost is required to make proper use of the cold chain industries in India, not only insetting up the stores but also in enabling a good infrastructure as required. Due to poor infrastructure India has faced unnecessary vaccine wastage causing lack of vaccines when it is most required.[7]

Storage of products like vaccines in the cold stores enhances the regular supply of the less demanded or high cost products. Cold chain also ensures a stabilized price and distribution of products without any major losses. The cold stores in India require a high amount of repair to serve both the agricultural and pharmaceutical companies.[8] Data capturing and monitoring when combined with optimization models on top of ensuring visibility can add extra benefits, like building an optimal storage plan and transportation plan for the vaccine delivery.[2] Data analytics should be focused upon to design an optimal solution, and nowadays for proper management of cold chain, the cold chain logistics have been implementing data analytics to design the optimal solutions. As a result these solutions are improved, flexible and well managed, in the cold chain industry, resulting in reduction of wastage and increment of surplus. [2]

Cold chain in India is a Sunrise sector which means it is in the emerging stage and our country needs a well organised and planned out cold chain facilities. The cold chain industry in India was developed during the start of the twentieth century, but the industry has experienced a very slow growth in the country.[10] The service of the cold chain transporters and service providers should be taken care of, to prevent any losses due to poor service or management of products in cold stores or in logistics. These are the few reasons, which clearly explains the slow growth of cold chain industry in India. [7]

As a prevention of this vaccine wastage, a proper format should be made to vaccinate people, and the healthcare should be held responsive for any vaccine wasted from their health center. The responsiveness of workers will lead to low vaccine wastage, as the government can check the datas of vaccine provided to the center and vaccines used.[1] Having well designed program chart, which would also include the ways which lead to the vaccine wastage.This chart is expected to look into the ideas which can be implemented to reduce the vaccine wastage, this is a phenomena where the future is possible but can't be exactly predicted.[16] The vaccine wastage was quite high because of smaller session sizes and a larger vial size being used it resulted in the dispose of the unused doses.[4] This paper was an evidence that if the vial size is reduced to 5 ml doses, 20% to 40% vaccines can be properly optimized resulting in the proper use of given supply. [4] Better micro-planning can be done for increasing the over session size and procurement of vaccine vial having a smaller vial size could have been used as a tactic for reducing vaccine wastage[11].

The aim of the study is to analyze the wastage of open vials in the vaccination centers of Simdega district in Jharkhand. This paper addresses the issue and tries to formulate possible solutions to tackle the problem of vaccine wastage. This paper is making an attempt to help curb wastage at a small district in India but the principles could be applied at a much larger scale. Application of this study on a large scale will help India to minimize its wastage and save many costs like vaccine manufacturing cost, logistics cost, staff cost, facilities and equipment, electricity etc.

III. Methodology

For getting a thorough understanding why vaccine wastage occurs the various causes vaccine wastage were categorized under broader categories with the use of a cause and effect diagram, the causes for vaccine wastage were explored under the eight categories of materials/methods, management, people, external environment, machines, logistics, communication, health systems and policy. After better understanding the causes of wastage, identification of possible solutions was conducted by brain writing and affinity diagram.

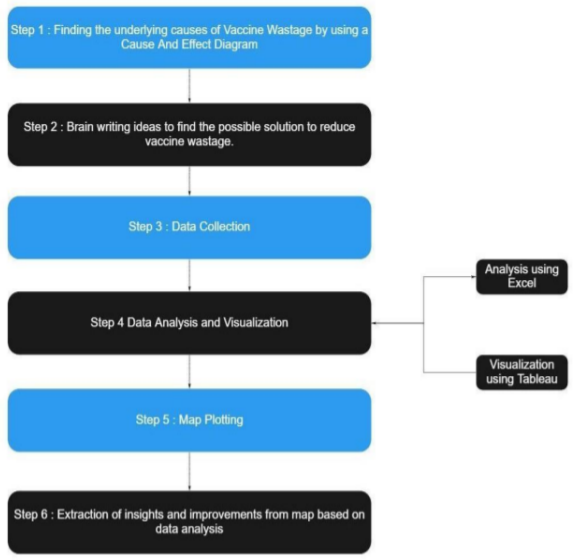


Fig. 1 Flow Chart explaining the methodology involved

. In order to gain a better insight into the possibilities for improvement of the vaccination, data were collected from the cowin dashboard. Out of all the states and Union Territories, Simdega district in Jharkhand was selected as it had the maximum vaccine wastage in the month prior to the study period. The daily data of vaccines administered were collected from all the primary healthcare centers present in Simdega. It included center names in the district, along with doses administered on that day, and total number of vaccines administered till that day. The collected data was then analysed for various trends and anomalies upon which identification of good and poor performing centers was done using excel and further visualised using Tableau. After that all the primary healthcare centers were plotted onto the map of Simdega district, centers which are located very nearby were analysed, and then categorised as good or bad performing centers which could be the criterion to keep a center open or closed based on their performance and later insights were collected from the collected data and possible improvements were provided for primary healthcare centers as plotted on map. A model for conducting feature analysis on categorical data of wastage was also designed to find the importance and correlation of each of the categories with overall wastage.

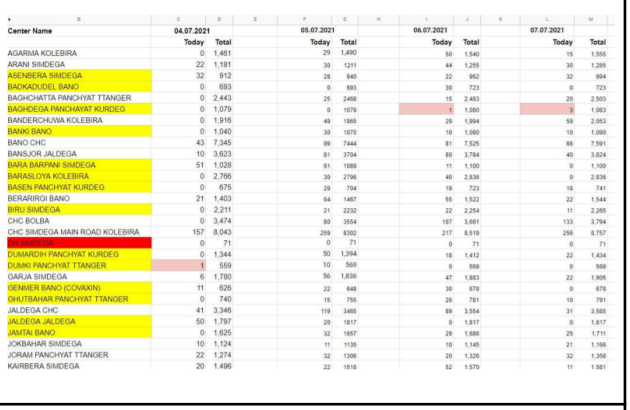
IV. EQUATIONS

$$Wastage = \frac{Number\ of\ doses\ wasted}{Number\ of\ doses\ given} * 100 \quad (1)$$

$$Average\ Wastage = \frac{Total\ Wastage\ from\ a\ center}{Number\ of\ days\ the\ center\ was\ active} \quad (2)$$

$$Performance = \frac{Number\ of\ days\ wastage\ was\ less\ than\ 10\%\ in\ the\ center}{Number\ of\ days\ center\ was\ active} \quad (3)$$

IV. DISCUSSIONS



Center Name	04.07.2021		05.07.2021		06.07.2021		07.07.2021	
	Today	Total	Today	Total	Today	Total	Today	Total
AGARMA KOLEBIRA	0	1,461	29	1,490	50	1,540	15	1,555
ARANI SIMDEGA	22	1,181	30	1211	44	1,255	30	1,285
ASENBERA SIMDEGA	32	912	28	940	22	962	32	994
BADKADUDEL BANO	0	693	0	693	30	723	0	723
BAGHCHATTA PANCHYAT TTANGER	0	2,443	25	2468	15	2,483	20	2,503
BAGHDEGA PANCHAYAT KURDEG	0	1,079	0	1079	1	1,080	3	1,083
BANDERCHUWA KOLEBIRA	0	1,916	49	1965	29	1,994	59	2,053
BANKI BANO	0	1,040	30	1070	10	1,080	10	1,090
BANO CHC	43	7,345	99	7444	81	7,525	66	7,591
BANSJOR JALDEGA	10	3,623	81	3704	80	3,784	40	3,824
BARA BARPANI SIMDEGA	51	1,028	61	1089	11	1,100	0	1,100
BARASLOYA KOLEBIRA	0	2,786	30	2796	40	2,836	0	2,836
BASEN PANCHYAT KURDEG	0	675	29	704	19	723	18	741
BERARIRGI BANO	21	1,403	64	1467	55	1,522	22	1,544
BIRU SIMDEGA	0	2,211	21	2232	22	2,254	11	2,265
CHC BOLBA	0	3,474	80	3554	107	3,661	133	3,794
CHC SIMDEGA MAIN ROAD KOLEBIRA	157	8,043	259	8302	217	8,519	256	8,757
DH SIMDEGA	0	71	0	71	0	71	0	71
DUMARDIH PANCHYAT KURDEG	0	1,344	50	1,394	18	1,412	22	1,434
DUMKI PANCHYAT TTANGER	1	559	10	569	0	569	0	569
GARJA SIMDEGA	6	1,780	56	1,836	47	1,883	22	1,905
GENMER BANO (COVAXIN)	11	626	22	648	30	678	0	678
GHUTBAHAR PANCHYAT TTANGER	0	740	15	755	26	781	10	791
JALDEGA CHC	41	3,346	119	3465	89	3,554	31	3,585
JALDEGA JALDEGA	50	1,797	20	1817	0	1,817	0	1,817
JAMTAI BANO	0	1,625	32	1657	29	1,686	25	1,711
JOKBAHAR SIMDEGA	10	1,124	11	1135	10	1,145	21	1,166
JORAM PANCHYAT TTANGER	22	1,274	32	1306	20	1,326	32	1,358
KAIRBERA SIMDEGA	20	1,496	22	1518	52	1,570	11	1,581

Fig. 2 Vaccination centre with their respective data

The conclusions drawn from the study are discussed below:

- Awareness campaign to be organised in the district, in the areas where the population is high but the vaccination centers in those areas administer very few doses as compared to the number of people in the area. As, people might be hesitant to take vaccine doses.
- Centers should keep a check on the daily no. of registrations and if it is less than 10, they should organise the vaccination for the ones registered once in 2-3 days. For instance, 2 people registered for a particular day and 7 for the day after, then vaccination should be done on one single day for all the 9 registrations.As a result, only 1 dose gets wasted instead of 11 (8 on the first day + 3 on the second day) doses for vaccinating the same number of people.

A. Data Inferences

- Two centers DH SIMDEGA and RENGARI PANCHAYAT T.TANGER should be shut down as they were idle in all 16 days in the data recording period, which simply added to the running cost in the vaccination programme. The costs majorly included the cost of nurses in the center and electricity cost.

- In the data collected , there are many centres which administer very few doses in a day (1 ,2 doses a day), which leads to disposing of the remaining doses, which as a result increases the wastage percentage. In the data it can be seen that, in a 16 day period span, 196 doses were wasted for vaccinating 21 people only. Therefore, centres should not open a vial unless there are 9-10 people to get vaccinated on a particular day.

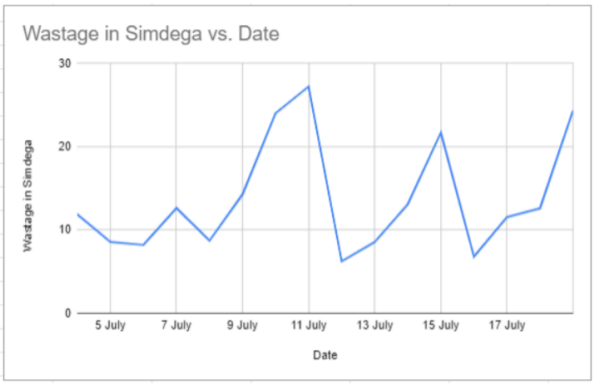


Fig. 3 Graph depicting the wastage of vaccine (in percentage) on a certain date.

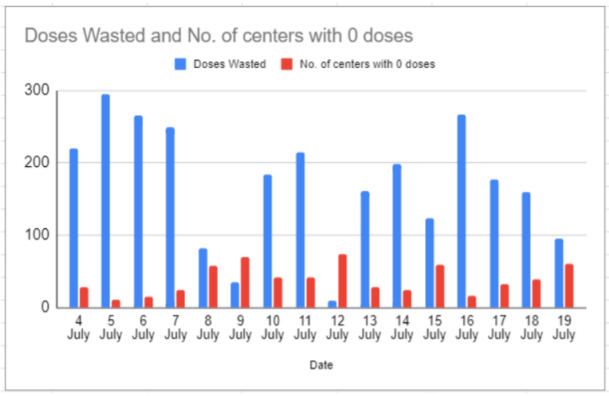


Fig. 4 Two column bar graph representing the vaccine wastage and the centre with 0 doses given on a particular date

- The centres exhibiting highest wastage percentage are Samsera Panchayat Bolba, Meromdega Panchyat Ttanger ,Koromiya Panchyat Ttanger ,Panchyat Konjoba Kurdeg, Kutungia Jaldega

- Inactive vaccination centres like Bintuka Panchayat Bano, Bongra Kolebira , CHC Bano , Sbmc Biru Simdega , SS High School Bansjor , Jaldega , Tati Jaldega can be closed down and people in these areas can be vaccinated by organizing camps as and when supply of vaccines are received, and proper advertisements to be done through newspapers and pamphlets to inform the people in the area about the date of vaccination, so that they can actively take part on those specific days and helps in fastening the process.

B. Map Inferences :

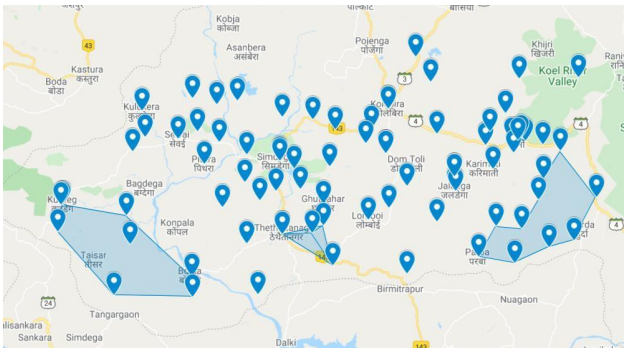


Fig. 5 Vaccination Centres of Simdega plotted on the map

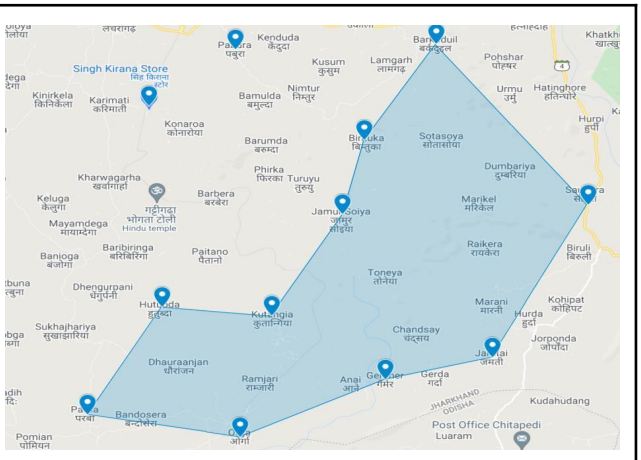


Fig. 6 Total of 10 centres marked with the objective of mobile vaccination drives

- Out of the 79 active centres in the district, the center with poor performance should be closed, and some other method of vaccinating people in the area should be implemented. As marked in the map, in the bottom right belt of the district (highlighted with blue zone). As shown in the fig. 6, 5 centers were operational (centres on the right part of the belt) , they should be shut down and a different method like organising mobile vaccination camps in 10 different locations in the nearby region could be adopted to vaccinate the people. This helps to vaccinate people in the area where no centres were set-up. With this method, people would feel more comfortable in getting vaccinated as they don't need to travel to the centres, which might be far from their residence.

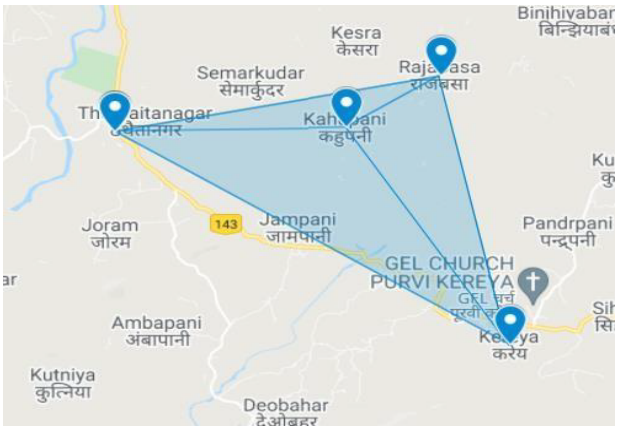


Fig. 7 Establishment of a new vaccination centre with the resources and manpower from the existing non performing centres (Assumed 1)

- As shown in Fig. 7, the centres namely Rajabhasa, Refral Hospital T. Thaitnagar, Kerya were underperforming and closing them for a new centre at Kahupani (named as Assumed 1) equidistant from all 3 centres would be an economically viable option. performance and easier to manage the wastage factors.

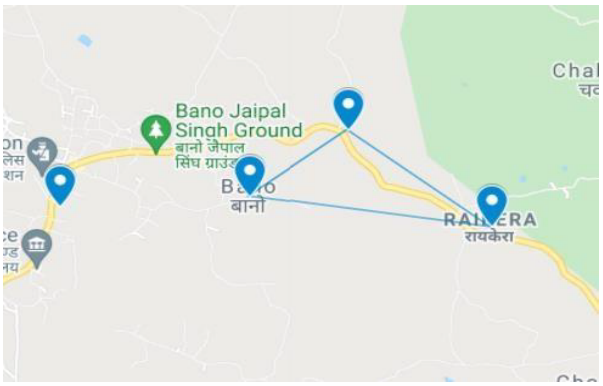


Fig. 8 Clubbing of 2 existing centres into a new one (Assumed 2)

- As shown in figure 8, 2 centers Raikera and Banki Bano were clubbed to one and the clubbed center in map was named as Assumed 2. This could be done because both the existing centers were underperforming, so their resources are wasted if they are kept operational. But if both of their resources and management are combined and a new center is made operational equidistant from the existing two, they could work more efficiently and wastage could be reduced drastically.

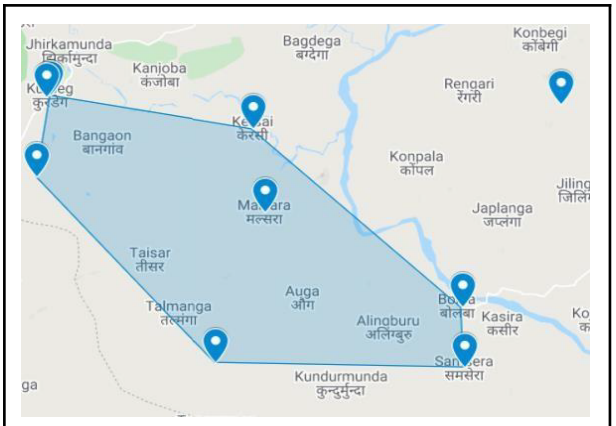


Fig. 9 Centres marked in this belt need to work together and adopt better practices.

- As shown in figure 9, Centers marked in the bottom left side should try to incorporate the practices of Bolba and Kersai, as their performance is good in the area. Nurses with rotating shifts and steps like door to door vaccination could be adopted in order to increase their productivity and reduce wastage.

Conclusion

Few inferences that can be drawn from the study are around 15 centers in the district should be shut down out of 78 centers in the entire district, and around 3 centers should be open, and vaccination camps should be organized in 5 different locations once in 3 days or even once in a week, depending on the population of the location selected for camp. This practice will save the cost of running 12 extra centers in the district and in turn help to better monitor the wastage in those centers. The decrease in wastage of doses in the district is 38%. In turn, around 4.45% of the vaccine could have been saved from each 78 centers in the district in 16 days, if the centers would not have opened vials for less than 5 people in a day. By shutting down the five centers, it is observed that daily wastage percentage drops nearly by 1-2%. Around 7.75% of the doses could have been saved in total if the five poor performing centers were shut down beforehand.

The state governments could identify the cause of wastage in their respective state, and can apply the similar type of solutions presented in this paper. Application of this study on a large scale will help India to minimize its wastage and save many costs like vaccine manufacturing cost, logistics cost, staff cost, facilities and equipment, electricity etc. Along with wastage, the states could easily locate the point where malpractices and theft might have taken place, and stricter actions can be taken against them. Also, if something similar happens in future, this project could work as a reference for the researchers.

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