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Review Article

Vaccine Storage and Distribution in Rural Bangladesh

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ABSTRACT

Aim: This paper investigates vaccine storage and distribution in Kushtia, Bangladesh. Planning and executing the distribution of vaccines and maintaining their quality plays a vital role in preventing the spread of infectious diseases. This study aims to identify the vaccine distribution processes, vaccine handling, and systems management processes to achieve the goal of ensuring the successful operation of the vaccine supply chain system and to help determine if promoting the outsourcing of vaccine cold chain in Kushtia is a viable strategy. **Materials and Methods:** Survey data was collected from both public and private institutions. The research involved a total of 403 respondents (371 males and 22 females). The study integrates spatial analysis using static maps and web maps and contains data on the most commonly used vaccine, the most needed vaccine, the age group who receives the highest number of vaccinations, vaccine distribution information, vaccine logistics information, inventory information, and finally the problem of vaccine distribution. **Results and Conclusion:** The study identified that there is a need for proper system storage and distribution in the rural area of Bangladesh and offers recommendations to improve the existing status.
Keyword: Vaccination, Immunization, Cold Chain, Kushtia, Bangladesh.

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INTRODUCTION

Every year, millions of lives are saved through immunization programmes throughout the world. The impact of vaccination on individuals is immediate in terms of reduced morbidity and mortality. However, it is important to recognize that vaccinations provide significant and broad secondary impact by: (i) empowering primary care givers (most often women); (ii) improving local community economics; and (iii) improving efficiency by reducing costs associated with healthcare delivery. There is a need to develop best practices for cold chain operations including but not limited to, vaccine handling, transport and storage, standard operating procedures (SOPs), staff training and temperature monitoring equipment in order to avoid wastage and ensure effective distribution of vaccines.[1]

Bangladesh entered into an intense immunization era in May 1974 through the 'Expanded Programme on Immunization' (EPI) launched by WHO, through which 10,000 children were immunized every day for the purpose of protecting all children from tuberculosis, polio, diphtheria, whooping cough, tetanus and measles by the year 2000.[2,3] WHO has declared Bangladesh as a Polio free country in 2014.[3]

Essential vaccines for children are provided free of cost by the Government of Bangladesh under the EPI program and these vaccines are mandatory for all children (Table 1 and 2 showing EPI Vaccines name).

Vaccine Distribution Challenges in Rural Bangladesh

Despite continuous progress, the goal of vaccinating every child in Bangladesh remains a serious challenge. In the face of the COVID-19 pandemic, the challenge is even greater and a national rollout of any potential vaccine will require new logistics including ultracold refrigeration infrastuctures.

The Rationale of the Study

It has been reported that 42.8% of urban children received vaccination which is the highest amongst all age groups. In comparison, only 36.7% of the children in rural areas received vaccinations. In addition, there is variation in the level of vaccine distribution in rural areas as well: rural areas of Khulna (38.8%) and Rajshahi (49.1%) received the most vaccines.[5]

The study by Afzal and Zainab[5] show that the vaccination rate varies in the urban and rural areas of Bangladesh. Poor storage, high price of the vaccine, lack of trained personnel, and supply chain contribute to this variation.

The data and analysis from the current study in Kushtia gives an estimation on the resources available for vaccination, including vaccine storage facility, cold chain and handling breakage of the cold chain, vaccine distribution plan, and knowledge level of personnel at a granular level.

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Vaccine	Disease	No. of Dose	Interval between doses	Starting time of doses	Route of Administration
BCG	Tuberculosis	1	-	After birth/ If not possible with Penta 1	Intra dermal
Pentavalent	Diphtheria, Pertussis, Tetanus, Hepatitis B, Haemophilus Influenza B	3	4 Weeks	6 weeks of age	IM
PCV	Pneumococcal Pneumonia	3	4 Weeks	6 weeks of age	IM
OPV	Poliomyelitis	4 (additional 0 dose at birth)	4 Weeks	6 weeks of age	Oral
MR	Measles Rubella	1	-	After completion of 9 months	Subcutaneous
Measles	Measles	1	-	After completion of 15 months	Subcutaneous

Table 1: Expanded Programme on Immunization (EPI) immunization schedule of Bangladesh for children 0 - 1 year of age.[4]

Vaccine	Disease	No. of Dose	Starting time of doses	Route of Administration
MR	Measles and Rubella	1	At 15 years with the 1st dose of TT	Subcutaneous
TT (Tetanus toxoid)	Tetanus	5	TT-1: At 15 years	IM
			TT-2: 28 days after TT-1	IM
			TT-3: 6 months after TT-2	IM
			TT-4: 1 year after TT-3	IM
			TT-5: 1 year after TT-4	IM

Table 2: Expanded Programme on Immunization (EPI) immunization schedule of Bangladesh for women of child bearing age 15-49 years.[4]

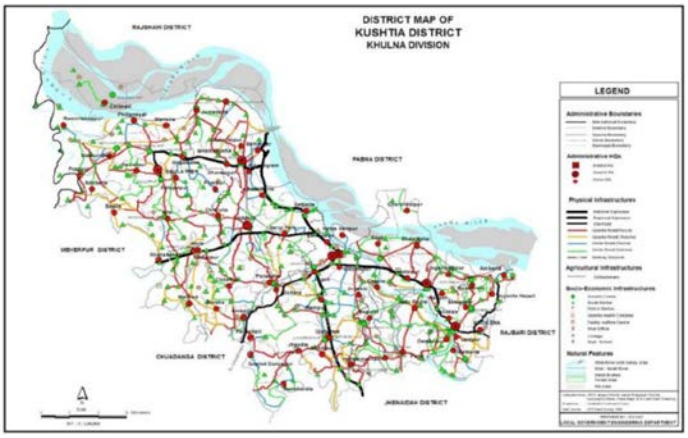
Vaccine	Disease	No. of Dose	Starting time of doses	Route of Administration
MR	Measles & Rubella	1	At 15 years with the 1st dose of TT	Subcutaneous
TT (Tetanus toxoid)	Tetanus	5	TT-1: At 15 years	IM
			TT-2: 28 days after TT-1	IM
			TT-3: 6 months after TT-2	IM
			TT-4: 1 year after TT-3	IM
			TT-5: 1 year after TT-4	IM

Aim of the Study

This study seeks to define vaccine delivery processes, adherence to temperature requirements, vaccine handling, and management processes to fulfill the goal of delivering effective vaccines to the children of Kushtia.

Table 3: Sample Distribution.

Upazila (Sub-district) Name	N	%
Kushtia Sadar	75	18.61
Bheramara	62	15.38
Mirpur	76	18.86
Doulotpur	76	18.86
Khoksha	51	12.66
Kumarkhali	63	15.63



Study Area Kushtia. Source: Local Government Engineering Department, 2020.

It will also inform strategies on outsourcing of vaccine cold chains in Kushtia to ensure that the supply chain system operates effectively.

METHODS

Methods of Data Collection and Types of Respondents

Data was collected both from primary and secondary sources. Primary data was collected through a quantitative approach: data was collected from respondents in Kushtia, Bangladesh (medicine businessman and health professional) through face-to-face interviews involving semi-structured questionnaires. Furthermore, Web Map and ArcGIS was used for spatial analysis from the survey data. Secondary data provided backup to the primary information and regulated validity and reliability of the research objectives. In this research, the secondary

sources of information include online publications, books, journal articles, blogs etc.

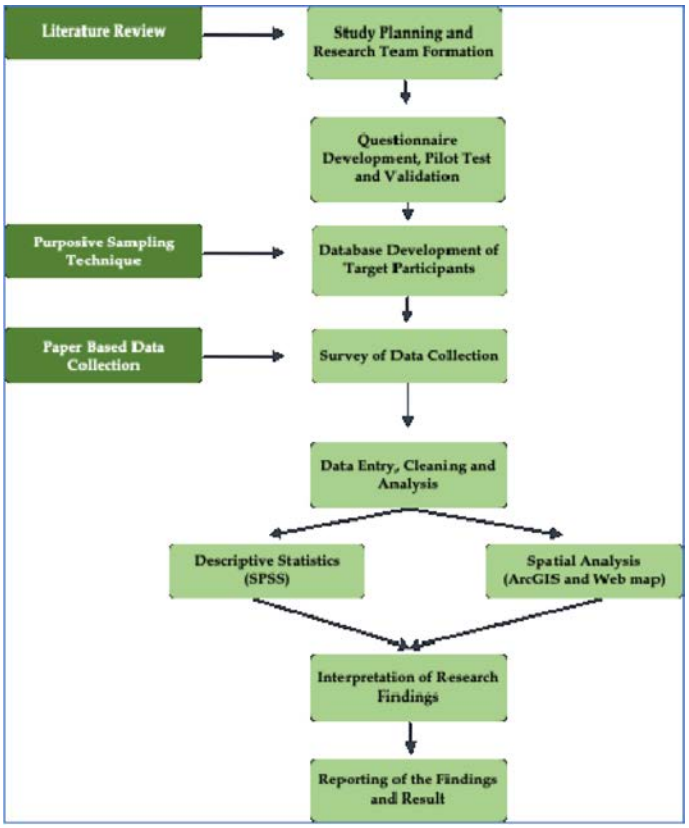
Study Area and Sample Size

The respondents involved in the survey were selected by the survey teams whom the team felt were capable to provide the necessary information. Table 3 shows the samples from the sub-district area of Kushtia.

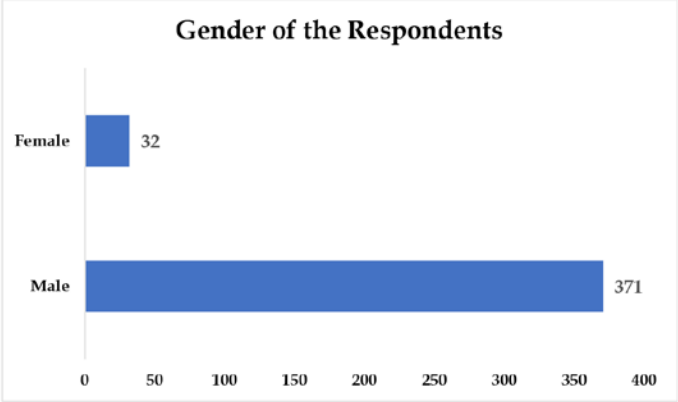
Supervision and Quality Control Mechanism of Data Collection Activities

Data was collected by trained field teams. One team collected data from pharmacies while another team collected data from Government, Private, and Non-Government health professionals. The following criteria were considered for recruiting the survey team: educational qualification, relevant work experience, and the capacity to work in a team. One day of intensive online zoom training was arranged for the field teams to familiarize them with data collection instruments including collecting GPS coordinate recording. After completing the training, interviewers participated in Mock Interview Sessions. Successful candidates were hired as members of the survey team. All team members, including the team leader, monitored the entire process to assess and ensure the quality of selection, training, and the interviewer's level of understanding about data collection and data quality.

Data Entry and Data Processing



The data entry template was developed and cross-checked by the team leader in consultation with the team statistician. After data entry, data analysis was conducted using the latest version of the Statistical Package for the Social Sciences (SPSS 25), web mapping using html, JavaScript, leaflet and ArcGIS. Experienced personnel were selected for data entry and trained on this issue. During the data entry procedure, the team



Research Methodology Flow Chart

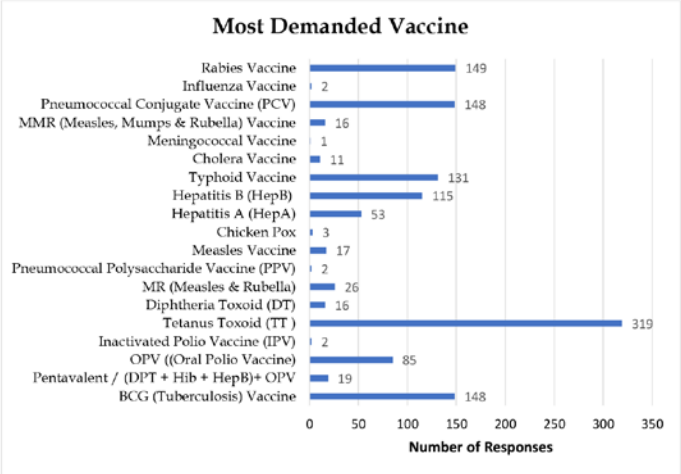


Figure 1: Name of the Vaccine They Receive.

leader and deputy team leader randomly checked the data to ensure accuracy, validity, and reliability of the dataset. The tasks of editing, coding, and data entry were also done under the close supervision of the team leader and deputy team leader.

Analytical Approach

The cleaned data was analyzed using a combination of quantitative technique using SPSS 25 and ArcGIS. Descriptive statistics, web mapping, and ArcGIS were used for quantitative analysis. The appropriate graphical presentation is given wherever needed.

Ethical Issues, Privacy and Confidentiality

The study took the risks and benefits of the respondents into account and ensured that highest ethical standards were maintained. Before conducting data collection, each respondent was informed about the purposes, type of information coverage, confidentiality, and interview time. The right to refuse the interview was explained to all participants. The names and other identifying details of the respondents were kept strictly confidential. All participants gave their verbal consent to take part in the survey.

RESULTS

Table 4: Demographic Information.

SL No.	Demographic Information	Number of Responses	%
1	**Age of the Respondents**		
	16-30 Years	135	33.50
	31-45 Years	228	56.58
	46-60 Years	38	9.43
	60+ Years	2	0.50
2	**Occupation of the Respondents**		
	Government Health Professionals	49	12.16
	Private Health Professionals	70	17.37
	Medicine Vendors	283	70.22
	Salesman (Medicine)	1	0.25
3	**Name of the Institution**		
	Government Hospital	49	12.16
	Private Hospital	72	17.87
	Private Medicine Shop	279	69.23
	Non-Government Organization	1	0.25
	Mother and Child Health Center	2	0.50
4	**Type of Institution**		
	Government	55	13.65
	Private	348	86.35

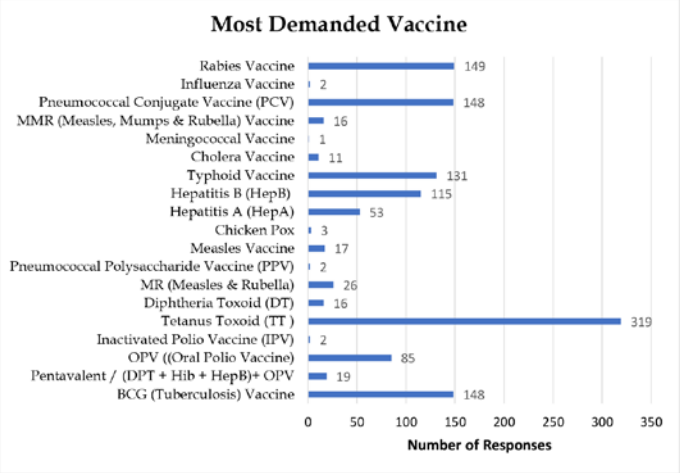


Figure 2: Most Commonly Used Vaccine.

General Characteristics of the Respondents

Figure 1 represents the gender of the respondents from the study area. A total of 403 respondents participated in the process of data collection. Out of the 403 respondents, 371 were male and 22 were female. This represents the male-female ratio in the medical sector in Kushtia.

Table 4 represents the demographic profile of the respondents. The first session of the questionnaire contained questions about their sex, age, occupation, name of institution, and type of institution. The majority of respondents were aged 31-45 Years (56.58%), whereas the age group for

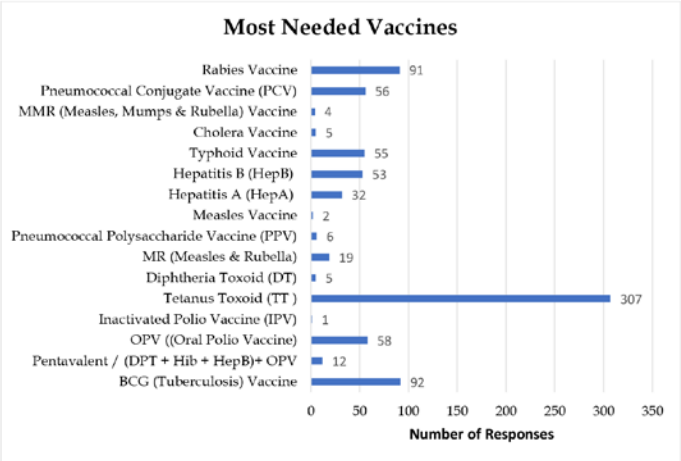


Figure 3: Most Needed Vaccines.

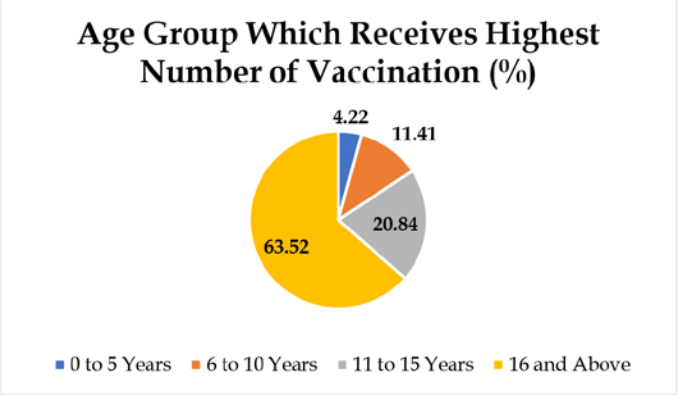


Figure 4: Age group Receives Highest Number of Vaccination (%).

over 60 years was represented by only 0.50%. Among the respondents, the majority (70.22%) respondents were medicine vendors, followed by Private Health Professionals (17.37%), and Government Health Professionals (12.16%).

Figure 2 represents the units of vaccines available in pharmacies and hospitals. It shows that most of the respondents have Tetanus Toxoid (326) followed by Pneumococcal Conjugate Vaccine (151), Rabies Vaccine (150), BCG Vaccine (144), Typhoid (135) in their possession. The availability of Rota Virus Vaccine, Yellow Fever Vaccine and Meningococcal Vaccine and Pneumococcal Polysaccharide Vaccine (PPV) were among the lowest in stock. Furthermore, no respondent had HPV Vaccine (Human Papillomavirus).

Figure 3 portrays the most demanded vaccine in Kushtia. It shows that 319 respondents stated Tetanus Toxoid is the most frequently used vaccine whereas Diphtheria Toxoid (DT), Pneumococcal Polysaccharide Vaccine (PPV), Chicken Pox Vaccines, Influenza vaccines were not widely used.

Figure 4 denotes the most needed vaccines for Kushtia. It shows that Tetanus Toxoid was the most needed vaccine followed by BCG (92), Rabies (91), OPV (58), PCV (56).

Figure 5 illustrates the age group which received the highest number of vaccinations in the investigated area.

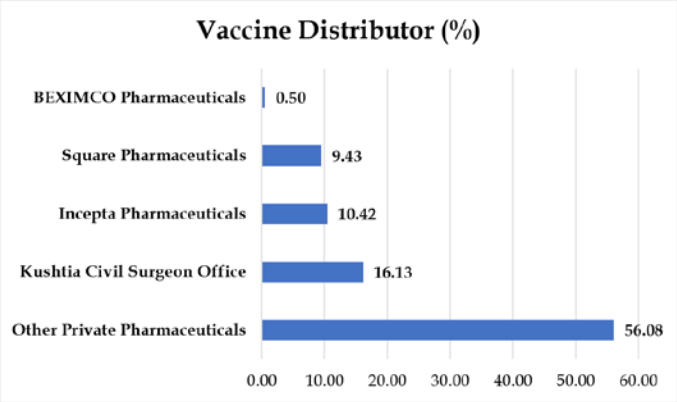


Figure 5: Vaccination Distributor.

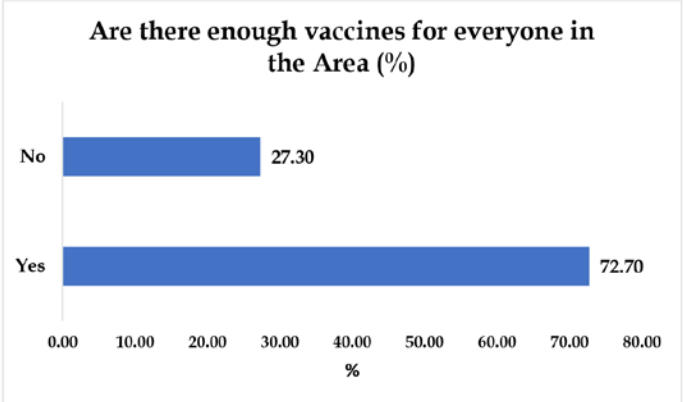


Figure 6: Are there enough vaccines for everyone in the Area (%).

Table 5: Vaccine Distribution/ Site Information.

SL No	Questions	Number of Responses	%
1	**Where have the vaccines been distributed along with the supply chain?**		
	Dhaka	397	98.51
	Savar	6	1.49
2	**Where have the vaccines been distributed along with the supply chain?**		
	Upazila Health Complex	61	15.14
	Private Pharmaceuticals	323	80.15
3	**Distribution Works performed**		
	Salesman	62	15.38
	Own Staff (Medicine Shop)	85	21.09
	Third Party	256	63.52
4	**Has shockproof packaging been used to redistribute vaccines?**		
	Yes	296	73.45
	No	107	26.55
5	**What is the profit of selling vaccination?**		
	100tk to 500tk	213	52.85
	500tk to 1000tk	53	13.15
	1000tk to 1500tk	8	1.99
	1500tk and Above	46	11.41
	Don't Know	83	20.60
6	**What is the cost of owning/ renting/ managing these storage sites-employees, electricity, security? (BDT)**		
	100tk to 250tk	137	34.00
	250tk to 500tk	7	1.74
	500tk and Above	10	2.48
	Don't Know	249	61.79

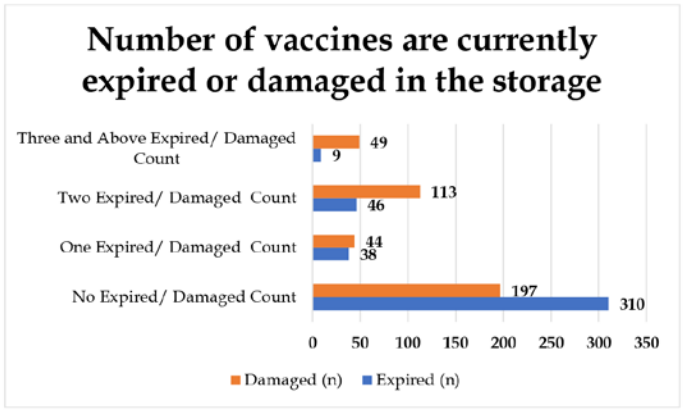


Figure 7: Number of vaccines are currently expired or damaged in the storage.

Figure 6 represents vaccination distributors in the study area. The Figure displays more than the one half (56.08%) of the vaccination distribution is done by private pharmaceuticals followed by Kushtia Civil Surgeon Office (16.13%) in collaboration with the Bangladesh Government, Incepta pharmaceuticals (10.42%), and Square pharmaceuticals (9.43%).

Table 5 displays the questions regarding Vaccine Distribution/Site Information. From the field survey, we found that 98.51% of all vaccines were sent from the capital city Dhaka. The majority of the distribution was carried out by the private sector pharmaceuticals (80.15%). The study also shows that shockproof system was used for one third of redistributed vaccines in order to minimize the risk of damage to vaccines. We also found significant variations in the profit made and the costs (owing and renting storage spaces, employee and security costs, and electricity) incurred in selling vaccinations.

Our field study shows that almost one third (72.70%) of the respondents stated vaccination is enough for the study area whereas the others denied. (Figure 7)

Table 6 displays questions regarding vaccination logistical information. From the quantitative study we found that almost half of (43,67%) vaccines were transported via truck followed by 39.45% van by and 10.67% by other vehicles such as mini pickup and cycle.

Figure 8 portrays the number of vaccines currently expired or damaged in the storage facilities . From the field survey, majority of the

Table 6: Vaccine Logistics Information.

SL No	Questions	Number of Responses	%
7	Where do vaccines come from and how are they transported to village storage?		
	Car	25	6.20
	Van	159	39.45
	Truck	176	43.67
	Other	43	10.67
8	What is the wage of fuel and working workers in the transport sector?		
	100tk to 250tk	28	6.95
	250tk to 500tk	90	22.33
	500tk and Above	224	55.58
	Don't Know	249	61.79

respondents (310) stated that they do not maintain any record for the number of vaccines which have expired or are damaged. 197 respondents said no expiration records were maintained and only a few respondents confirmed that they maintain a count of the number of expired and damaged vaccines.

Table 7 represents questions regarding inventory information. In the first question, respondents stated that they maintained hard copy records for more than one-third (77.67%) of the vaccines and used digital means for keeping counts on the remaining 22.33%. From the study, we found 99.50%vaccines were preserved by means of a refrigerator calibrated to ensure that the appropriate temperature for the vaccines are maintained. Moreover, around one-third (72.46%) mentioned they have a backup generator for the refrigerator to avoid trouble during load-shedding.

Figure 9 portrays the challenges faced for vaccination distribution. The biggest challenge was transportation (which was highlighted by 172 respondents) s followed by electricity failures (126), inadequate infrastructure (137), and poor road structure (4).

DISCUSSION

This study aims to identify areas that need improvement in order to optimize management of the vaccine supply chain. Knowledge of the details of the supply chain will be needed to prepare for increasing vaccine volumes that may burden the cold chain network in the future. This study focuses on determining the most commonly used vaccines, the most needed vaccines, the age group that receives the highest number of vaccinations, vaccine distribution information, vaccine logistics information, inventory information, and finally the problem of vaccines distribution in Kushtia district, a rural area of Bangladesh.

We determined that availability of Virus Vaccine, Yellow Fever Vaccine and Meningococcal Vaccine and Pneumococcal Polysaccharide Vaccine (PPV) is quite low, whereas Tetanus Toxoid (326) followed by Pneumococcal Conjugate Vaccine (151), Rabies Vaccine (150), BCG Vaccine (144), Typhoid vaccine (135) appear to be in adequate supply. Additionally, the majority of the respondents (319) claim Tetanus Toxoid is the most frequently used vaccine in Kushtia. Whereas a study showed BCG vaccine coverage was the highest in Bangladesh (97.1%), followed by the third dose of OPV (91.8%), third dose of pentavalent vaccine (91.0%) and first dose of MCV (84.8%). In comparison to vaccine

Table 7: Inventory Information.

SL No	Questions	Number of Responses	%
9	**How is the vaccine administered?**		
	Digital	90	22.33
	Register Copy	313	77.67
10	**How many people in charge of the disposal of damaged/ expired vaccines?**		
	One People In-charge	247	61.29
	Two People In-charge	110	27.30
	Three and More People In-charge	46	11.41
11	**What kind of equipment is used to preserve the vaccine-?**		
	Refrigerator	401	99.50
	Other	2	0.50
12	**Does the fridge have enough capacity for expected vaccine volume that is delivered?**		
	Yes	374	92.80
	No	29	7.20
13	**Is the Fridge used mainly for vaccine storage or are other Items stored in the fridge as well?**		
	Yes	395	98.01
	Other	8	1.99
14	**Is the Fridge backed up by a generator during load shedding?**		
	Yes	292	72.46
	No	111	27.54
15	**Is there any alarm for temperature excursion?**		
	Yes	261	64.76
	No	142	35.24
16	**Do you evaluate these reports regularly?**		
	Yes	394	97.77
	No	9	2.23
17	**How often are the report assessed?**		
	Daily	198	49.13
	Weekly	190	47.15
	Bi-weekly (Two-weeks)	10	2.48
	Monthly	5	1.24
18	**Do you think there is unregulated flow of vaccines?**		
	Yes	401	99.50
	No	2	0.50
19	**What proportion of the vaccination do you think is unregulated?**		
	>10%	248	61.54
	>30%	136	33.75
	>50%	6	1.49
	>80%	13	3.23

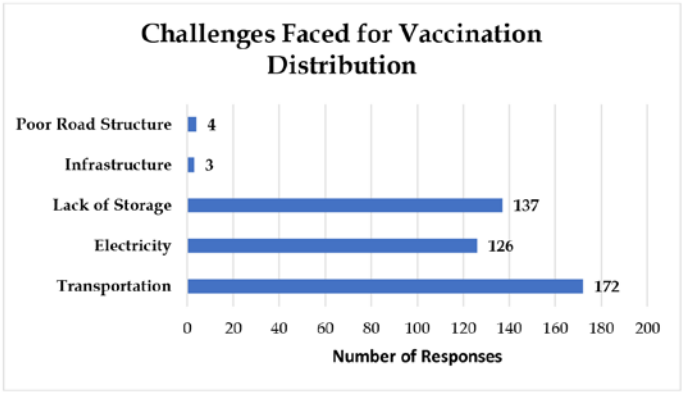


Figure 8: Challenges Faced for Vaccination Distribution.

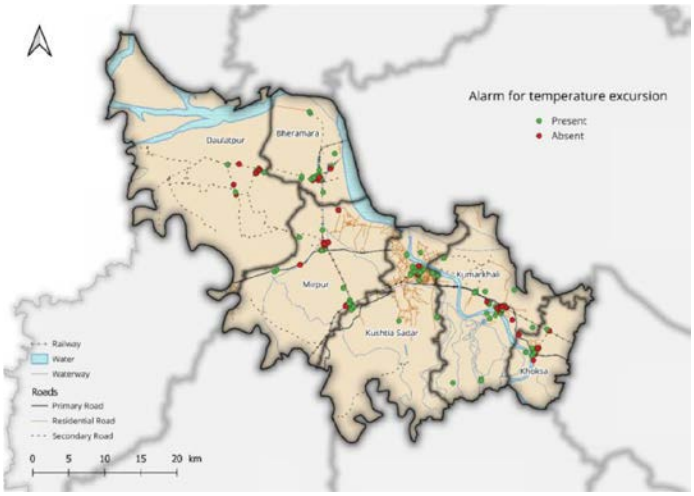


Figure 9: Alarm for Temperature Excursion.

coverage level all across the country, Kushtia has fallen behind due to less coverage of the BCG vaccine.

It is worth noting that only 17% of the vaccine carriers contained thermometers for monitoring the temperature under which the vaccines were being stored whereas from our study 64.76% respondents stated they have alarm for temperature excursion and 97.77% respondents evaluate these reports regularly.[6] Storing vaccines at the right temperature is of absolute necessity and thus all vaccine carriers must contain thermometers displaying the temperature.

A study on vaccine wastage in Bangladesh found that 22.5% Upazila health complex has ≥50% DTP wastage, 10% has ≥50% TT wastage, 95.0% of Upazilas have more than 50% measles wastage and 96.3% Upazila has maximum wastage ≥75% (wastage factor = 4.3–11.2) of BCG. The study also found wastage rate of liquid (TT, DTP) vaccine lower compared to freeze-dried vaccines (measles, BCG).[7] This study shows that 99.50%vaccines are preserved in refrigerator where majorities (72.46%) have a backup generator for the refrigerator to avoid trouble during load-shedding. On the other hand, findings of Mallick M. Billah's showed 13% district, City Corporation and health facilities face power failure lasting 24 hours and that they do not have a generator or alternative power source. On a positive note, 88% depots of all districts and City Corporations have vaccine storage space whereas 87% of private sectors have dedicated health facility storage for vaccines preservation.[6]

group between 6-10 actually has significantly higher access to vaccines compared to the 0-5 age group. According to the data that we have collected in Kushtia, it is strongly recommended to go or public-private outsourcing for vaccines as private institutions and organizations have a higher reach and presence in rural settings compared to governmental institutions in the medical sector. A united approach from both private and public institutions will tend to close the gap in access to various types of vaccinations in last mile communities in Bangladesh.

Study Limitations

Vaccine storage and distribution in rural Bangladesh is a relatively new study and we recognize that there were several limitations to our study. The focus of this study on one district in Bangladesh may not represent the national statistics.

CONCLUSION

Infectious diseases pose a threat to public health worldwide, and vaccines offer a safe and effective solution to this issue. Currently, vaccine supply chain optimization and management are a much-focused research field. Optimizing the vaccine supply route will minimize the expense of carrying the vaccines which will result in lower total costs. Thus, a better and more optimized system is needed. This study identifies the most commonly used vaccine, the most needed vaccine, the age group who receives the highest number of vaccinations, vaccine distribution information, vaccine logistics information, inventory information, and finally the problem of vaccine distribution in Kushtia, Bangladesh. The study clearly shows the limitations of the vaccine distribution chain Kushtia. This study also opens the scope for further studies on a similar but different and larger population.

ACKNOWLEDGEMENT

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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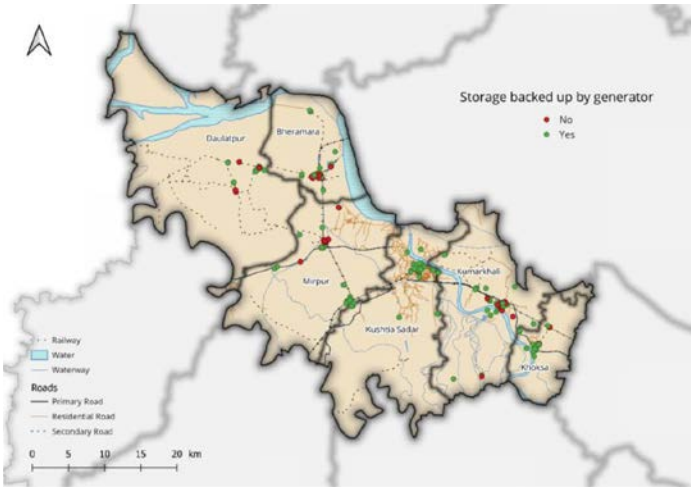
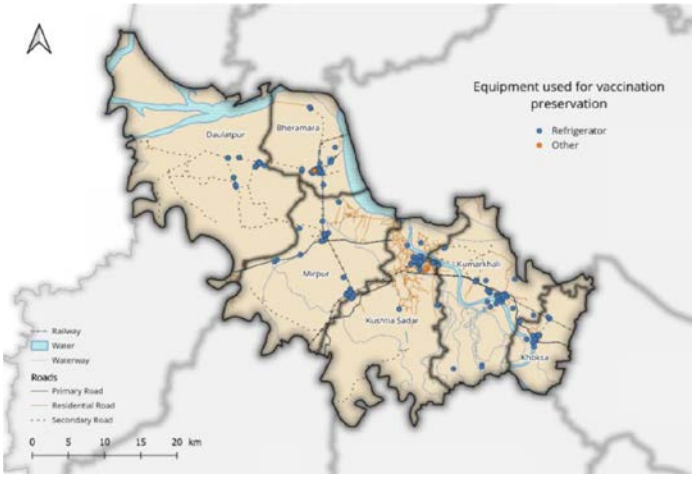
Annexure

Observation from Spatial Analysis

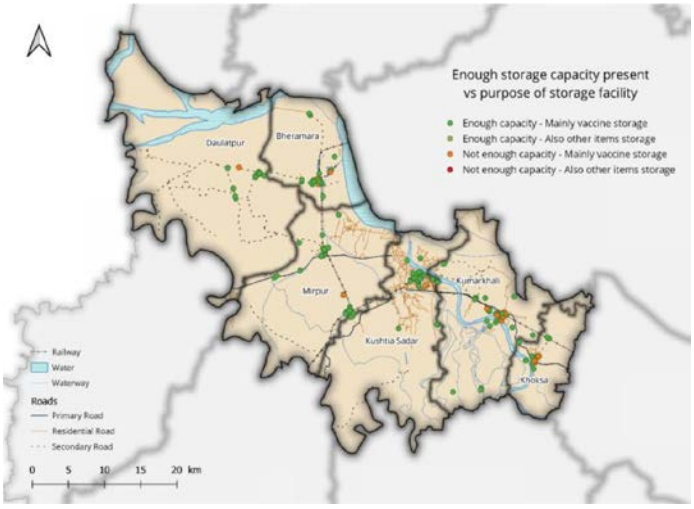
- Vaccine distribution maps shows that the vaccine reaches the semi-urban areas in satisfactory quantities but in rural areas the vaccine reaches less quantities.
- Vaccine distribution and storage carried out which positioning and secondary roads are present.
- From the spatial analysis, that road plays a significant role vaccine distribution.
- From the study area, we found less amount of alarm temperature excision in rural and remote areas.
- We found major three challenges: electricity, lack of storage and transportation which is very pronounced in both remote and semi-urban areas.
- In the study map shows that the challenge of electricity and lack of storage problem in a very acute both semi urban and rural areas.



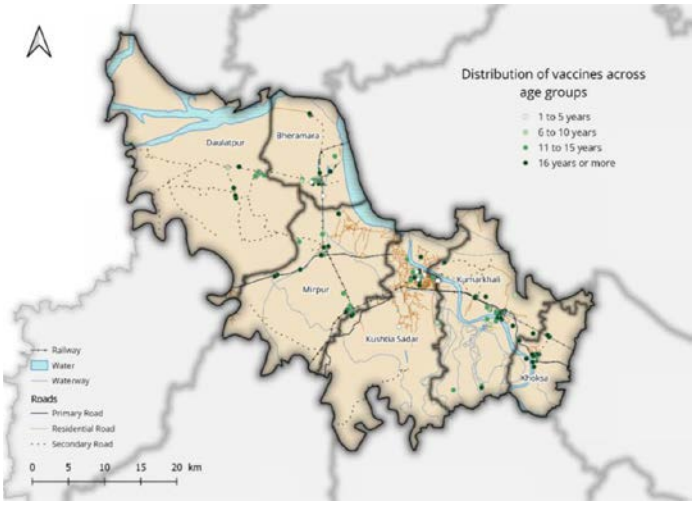
Storage Backed up by Generator.



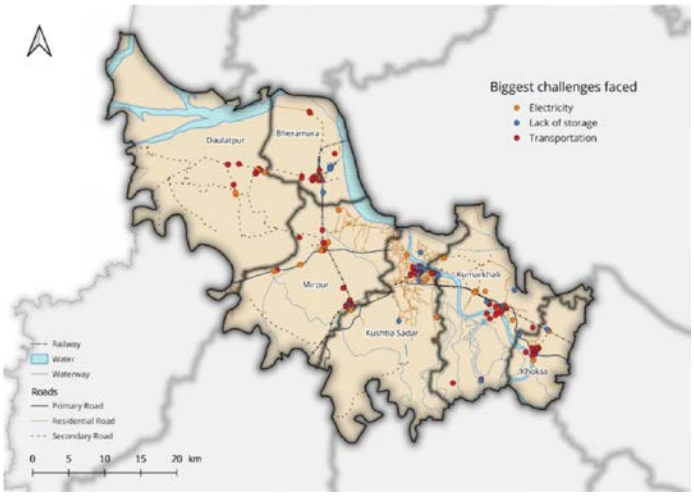
Equipment Used for Vaccination Preservation.



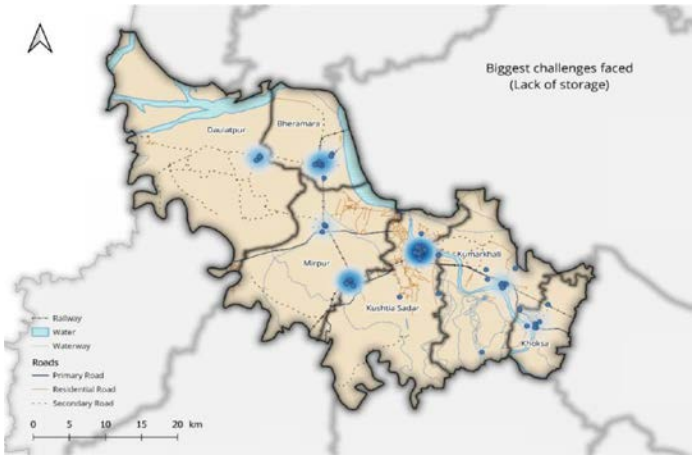
Enough Storage Capacity Present vs Purpose of Storage Facility.



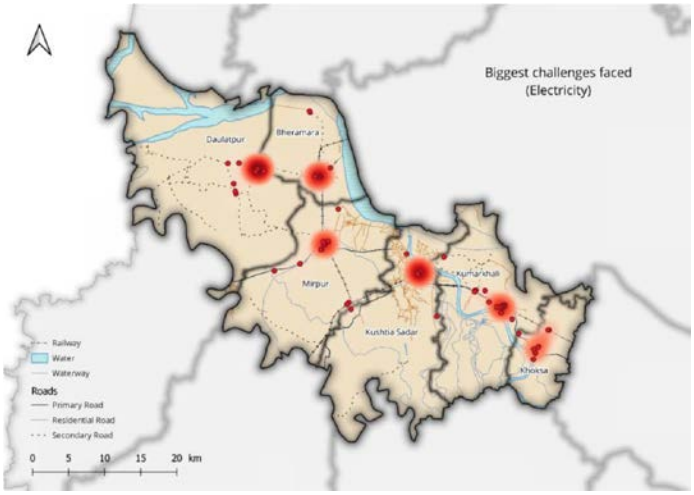
Distribution of Vaccines Across Age Groups.



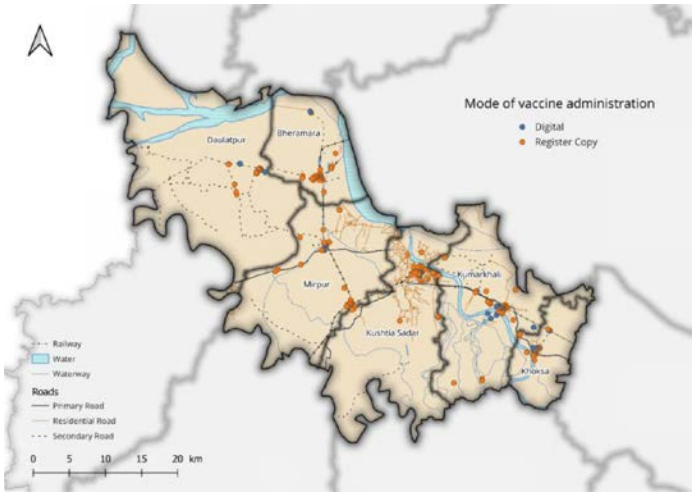
Biggest Challenges Faced.



Biggest Challenges Faced (Lack of Storage)



Biggest Challenges Faced (Electricity).



Mode of Vaccine Administration.