

ASSESSMENT THE FACTORS AFFECTING VACCINE WASTAGE AT FAMILY MEDICINE UNITS AND HEALTH OFFICES IN ALEXANDRIA CITY

¹Safaa Hassan Zaki, ²Gehan Galal El-Bialy, ³Rehab Gamel Hussien

¹PHD in Nursing Administration, Faculty of Nursing, Alexandria University, Egypt

²Professor of Nursing Administration, Faculty of Nursing, Alexandria University, Egypt

³Lecturer of Nursing Administration, Faculty of Nursing, Alexandria University, Egypt

Abstract: Wastage is defined as loss by use, decay, erosion, leakage and wastefulness. WHO (2005) reported over 50% vaccine wastage around the world. Despite the availability of many tools for reducing such wastage, high wastage rates are still occurring in many countries' Objective: assess the factors affecting the vaccine wastage at Family Medicine Units (FMUs) and Health Offices (Hos) in Alexandria City. Research question: What are the factors affecting the vaccine wastage at Family Medicine Units and Health Offices in Alexandria City? Research design: descriptive research design was used in this study. Setting: The study was carried out in family medicine units (FMUs) and health offices (HOs) in Alexandria city districts. Subjects: All staff nurses (N= 48) and all health inspectors (N= 36) who were working in immunization clinics in the previous randomly selected FMUs and Hos were included in this study and the period of data collection from 1st of March 2014 to 30th June 2014. Results: HOs showed acceptable level of vaccine wastage rate, while FMUs showed moderate level of vaccine waste, there was a statistically significant difference detected regarding vaccine wastage rate between HOs and FMUs. Conclusion: The findings of the present study showed acceptable level of vaccine wastage rate in HOs, while FMUs showed moderate level of vaccine waste.

Keywords: vaccine wastage, Family Medicine Units, vaccine waste.

1. INTRODUCTION

Vaccine is a suspension of weakened, killed, or fragmented microorganisms or toxins or of antibodies or lymphocytes that is administered primarily to prevent disease⁽¹⁾. Any vaccine that cannot be used is considered to be wasted this includes vaccines that are spoiled and those that have expired^(2,3). Wastage is defined as loss by use, decay, erosion or leakage and wastefulness

Assessing the frequency of vaccine wastage and the relative magnitude of its various causes may help to target efforts to reduce losses and to husband funds for increasingly expensive vaccines⁽⁴⁾. Vaccine wastage is one of the key factors to be considered with regards to vaccine forecasting and need estimation. 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, leading to increased wastage through expiry^(5, 6). Such monitoring can provide program managers with good guidance on the introduction of corrective actions to reduce wastage whenever necessary. With the introduction of new vaccine management policies such as the application of multidose vial policy (MDVP), the effective use of vaccine vial monitors (VVMs), and improved immunization strategies and practices, vaccine wastage is expected to decrease⁽⁷⁻⁹⁾.

In the present times; it is significant to note that the demand for vaccines is increasing whilst at the same time the supply is decreasing. The decrease in vaccine supply has been attributed mainly to rising cost of production, a situation that poses great threat to many national immunization programs. Although for many developing countries, access to vaccines is limited due to weak financial positions there is evidence of high vaccine wastage rates due to inadequate knowledge and skills of the staff managing the scarce resources^(7, 9). therefore the study was carried out to assess the factors affecting vaccine wastage at family medicine units and health officers in Alexandria city.

2. MATERIALS AND METHOD

MATERIALS

RESEARCH DESIGN:

The descriptive research design was used in this study.

SETTING:

The study was carried out in FMUs and HOs in Alexandria city districts (East, West, Middle, Almontazah and Algomrok).

SUBJECTS:

Two groups were included in the study **all staff nurses (N= 48) and all health inspectors (N= 36)** who were working in immunization clinics in the previous randomly selected FMUs and HOs and who were available during the period of data collection from 1st of March 2014 to 30th June 2014.

TOOLS:

Tool one: Factors affecting vaccine wastage questionnaire:

It was developed by the researcher based on the review of current related literatures^(3,5, 6, 10,11- 13) to identify factors affecting vaccine wastage as perceived by nurses and health inspectors, it consisted of two parts:

First part: it included 11 items related to the factors affecting vaccine wastage; responses were measured on a five point likert scale ranging from (5) strongly agree to (1) strongly disagree. Also one open ended question about the factors affecting vaccine wastage from their point of view was added.

Second part: it included one open ended question about suggestions for reducing vaccine wastage from nurses' and health inspectors' points of view.

In addition, nurses' and health inspectors' demographic data were included such as: Age, sex, marital status, level of education, nature of work time, working shift, years of experience in nursing and years of experience in the current unit/ office .

METHOD

The study design was accomplished as follow

1. Written approval was obtained from the administrative authority of Ministry of Health to carry out the study in the selected districts in Alexandria.
2. **Factors affecting vaccine wastage questionnaire** (tool 1) was developed in Arabic by the researcher based on the review of the current related literature.
3. Content validity of the all study tools was done by seven experts in the field of quality, immunization services .The necessary modification was done accordingly.
4. The reliability of the study tools was tested statistically for factors affecting vaccine wastage questionnaire was 0.783, this means that they are all reliable.
5. A pilot study was carried out nine nurses and health inspectors in order to check and ensure the clarity, objectivity, feasibility of the study tools, the results were excluded from the study.

Actual data collection

- Factors affecting vaccine wastage questionnaire was distributed to all nurses and health inspectors in the selected FMUs and HOs to identify factors affecting vaccine wastage from their point of view and their suggestions for reducing vaccine wastage in the immunization delivery services. Time needed to fill the previously mentioned tool was 30 minutes
- Data collection took a period of four months from 1/3/2014 to 30/6/2014

6. Statistical analysis

Data were fed to the computer using IBM SPSS software package version 20.0. Qualitative data were described using number and percent. Comparison between different groups regarding categorical variables was tested using Chi-square test. Quantitative data were described using mean and standard deviation for normally distributed data while abnormally distributed data was expressed using median, minimum and maximum.

For normally distributed data, comparison between two independent population were done using independent t-test while more than two population were analyzed by F-test (ANOVA) used. Significance test results are quoted as two-tailed probabilities. Significance of the obtained results was judged at the 5% level

Ethical considerations

- 1- Written informed consents were obtained from the study subjects for collecting needed data and privacy was considered during collection of data.
- 2- The anonymity and confidentiality of data, voluntary participation and right to refuse to participate in the study were emphasized to the subject.

3. RESULTS

Table 1: shows that the range of the age of the nurses and health inspectors was 25-59 with Mean±S.D. 43.5±8.31, regarding the professional years of experience, nurses and health inspectors with Range 2-40 years with Mean±S.D. (22.95±7.2) Moreover they have a range 1-32 years of experience in the current unit with Mean±S.D (12.07±7.806)

As regards the educational level about two thirds of nurses (62.5 %) had secondary technical nursing school diploma and about one third (33.0%) of them had Technical Health Institute diploma, the minorities had Bachelor of Science in nursing (4.5%). In relation to the type of unit, it can be observed that the majority of them (81.8%) worked in HOs.

Table 2: illustrates that the highest vaccine wastage rates in both HOs and FMUs were in BCG vaccine (27.3 % and 46.7% respectively) followed by polio vaccine (18.2% and 31.7% respectively). While , the lowest vaccine wastage rate among all vaccines were in vitamin A capsules (zero) in both of HOs and FMUs followed by MMR (3.8% and 7.1% respectively) .

Table 3: shows that in HOs, the highest vaccine wastage rate (15.9%) was in West district and the lowest wastage rate was in Almontazah district (5.2%). While, in FMUs, the highest vaccine wastage rate (47.37%) was in Algomrok district and the lowest wastage rate was in Almontazah district (10.96 %). The difference being statistically significant between HOs and FMUs in all districts (F= 4.98, p=0.038 and F= 12.65, p=0.001 respectively)

Table 4: shows that regarding the vaccine wastage rate , HOs shows acceptable level of vaccine wastage rate (11.3%) , while FMUs shows moderate level of vaccine waste(28.9%) with a statistically significant difference detected (t=3.22 , p= 0.003)

Regarding to all types of vaccines, table 5 shows that as, the highest mean scores of causes of vaccine wastage was regarding to “ the large number of doses per vaccine vial ” , followed by “ irregular monitoring of the temperature of refrigerators vaccinations” (3.43±1.03) and (2.89±0.98) respectively. While, “the breaking of vaccine vial ” constituted the lowest mean score of causes (2.56±0.89) as perceived by nurses and health inspectors.

Regarding the polio vaccine, the highest mean score of causes of polio vaccine wastage as perceived by nurses and health inspectors, was “the movement of the child during a vaccination as a result of lack of cooperation from the parent”, followed by “loss of an amount of vaccine during opening of the vial” (3.02±1.16) and (2.67±0.89) respectively, while, “precipitation of vaccine in the vial” constituted the lowest mean scores of causes (2.44±0.785).

Table 1: Distribution of nurses and health inspectors according to their demographic and professional characteristics

Demographic and professional characteristics	Nurses and health inspectors (n=88)	
Age		
Range	25-59	
Mean±S.D.	43.5±8.31	
Years of experience in nursing		
Range	2-40	
Mean±S.D.	22.95±7.2	
Years of experience in the current unit/ office		
Range	1-32	
Mean±S.D	12.07±7.806	
Level of education	NO	%
Secondary Technical Nursing school Diploma	55	62.5
Technical Health Institute Diploma(health inspectors section)	29	33
Bachelor of Science in Nursing	4	4.5
District	NO	
West	29	33
Montaza	17	19.3
Elgomrok	14	15.9
East	14	15.9
Middle	14	15.9
Type of Unit		
Health office	72	81.8
Family medicine unit	16	18.2

Table 2: Vaccine wastage rate in relation to vaccine type in health offices and FMUs

Vaccine type	Health offices					FMUs				
	Doses opened for use	Children vaccinated	Doses wasted	Wastage rate (%)	Wastage factor	Doses opened for use	Children vaccinated	Doses wasted	Wastage rate (%)	Wastage factor
Polio	9040	7397	1643	18.2	1.22	2740	1872	868	31.7	1.46
BCG	1340	974	366	27.3	1.38	360	167	193	46.4	1.86
HBV	1130	1046	84	7.4	1.08	430	297	133	30.9	1.45
DPT	2360	2067	293	12.4	1.14	790	618	172	21.8	1.28
MMR	2180	2096	84	3.8	1.04	730	678	52	7.1	1.07
• VITACAPSULE	3522	2343	0	0	1	1002	599	0	0	1

- Differences in vitamin A capsules doses are due to that in immunization schedule 18 months child given two capsules of vitamin A

Table 3: Vaccine wastage rates in health offices and FMUs in relation to districts

Districts	Average vaccine wastage rate (%)	
	HOs	FMUs
West t-test (value, p)	15.9	29.08
	2.98, 0.013*	
Almontazah t-test (value, p)	5.2	10.96
	2.11, 0.032*	
Middle t-test (value, p)	6.36	24.31
	7.11, 0.002**	
Algomrok t-test (value, p)	15.0	47.37
	5.65, 0.002**	
East t-test (value, p)	13.75	32.6
	5.25, 0.001**	
ANOVA (over all to all districts) p	4.98 0.038*	12.65 0.001**

* Statistically significant difference at $p \leq 0.05$

** Statistically significant difference at $p \leq 0.01$

Table 4: Overall vaccine wastage rates in health offices and FMUs in Alexandria city

	Health offices	FMU S
2- Vaccine wastage rate		
25 % acceptable level of waste	11.3%	28.9 %
25, 1%- < 50% moderate level of waste		
50%- < 75% high level of waste	Acceptable level of waste	moderate level of waste
≥ 75% extreme level of waste		
t-test (value, p)	3.22, 0.003**	

* Statistically significant difference at $p \leq 0.05$

** Statistically significant difference at $p \leq 0.01$

Table 5: Mean scores of the causes of vaccine wastage as perceived by nurses and health inspectors.

Causes of vaccine wastage	Mean ±S.D.	Ranking
1-In all types of vaccines:		
The large number of doses per vaccine vial	3.43±1.03	1
Irregular monitoring of the temperature of vaccine refrigerators	2.89±0.98	2
Bad preparation of the vaccination session by not assembling to the children by their dates of birth for the next session and defaulters from the previous sessions.	2.74±0.889	3
Lack of continuous training for nurses and health inspectors about vaccination procedure	2.74±1.01	4
Disappearance of the name of vaccine on the vial due to label detached or missed on vial; vaccine identity uncertain	2.59±1.11	5
Breaking of vaccines vials	2.56±0.89	6
2- In Polio vaccine		
The movement of the child during vaccination as a result of lack of cooperation from the parent	3.02±1.16	1
Loss of an amount of the vaccine during opening the vial	2.67±0.89	2
Flow of the vaccine during vaccination	2.58±0.98	3
Precipitation of the vaccine in the vial	2.44±0.785	4

4. DISCUSSION

Many factors contribute to vaccine wastage, ranging from the vaccine to the vaccinator. They are not independent of each other. The presence of one factor may trigger the appearance of another. Factors affecting vaccine wastage can be categorized in different ways. No matter how they are categorized, wastage in unopened vials is avoidable and should be treated as unacceptable⁽¹⁴⁾. Vaccine wastage is believed to be higher at the service level than elsewhere. In many countries, however, vaccine wastage in unopened vials is quite high in vaccine stores. One reason is that vaccine stores keep large quantities of vaccines, and if something goes wrong the whole amount is at risk of being damaged and therefore discarded⁽¹⁵⁾. Therefore the study was done to assess the factors affecting the vaccine wastage at FMUs and HOs in Alexandria City.

In relation to vaccine wastage rates in HOs and FMUs in relation to districts the present study revealed that in HOs, the highest vaccine wastage rate was in West district and the lowest wastage rate was in Almontazah district. While, in FMUs, the highest vaccine wastage rate was in Algomrok district and the lowest wastage rate was in Almontazah district. This may be due to that Almontazah health office's health inspectors are responsible for preparation of the vaccination session by assembling the children by their dates of birth for the next session and call defaulters from the previous sessions, setting a target for each session to Almontazah health office and Almontazah FMU which is attached to the health office. The difference being statistically significant between HOs and FMUs in all districts ($F= 4.98, p=0.038$ and $F= 12.65, p=0.001$ respectively). Few papers were discussing this topic.

Open vial waste is a significant cause of vaccine wastage at the clinical level, as the present study highlights. The higher BCG vaccine wastage rate in FMUs than health offices may be due to the low number of pregnancies and births that registered in the files of family medicine units. So, BCG in West districts is given only at HOs to decrease its wastage rate. In this respect, Chinnakali et al. (2012)⁽¹⁶⁾ reported that among all vaccines, BCG has got the highest wastage rate. Field based assessment and observation in India (2013)⁽¹⁷⁾ at session sites found the wastage rate of BCG was 61% which more than the wastage rate obtained from the present study. Moreover, Guichard et al. (2010)⁽¹⁴⁾ documented high wastage rates in Bangladesh.

In the current study, opened vial wastage rates for OPV in both HOs and FMUs and for DPT were lower than BCG wastage rate. This may be due to that more number of doses of DPT/ OPV (4 and 7 doses respectively) versus single dose of BCG (at birth only) and the lower number of eligible children would be available per immunization session. This is in the line with Guichard et al. (2010)⁽¹⁴⁾, Chinnakali et al. (2012)⁽¹⁶⁾ and Mukherjee et al. (2013)⁽¹⁹⁾ who reported OPV/ DPT vaccine wastage rate lower than BCG wastage rate.

A field based assessment and observation in India (2013)⁽¹⁷⁾ at session sites found the wastage rate of OPV for DPT was more than the wastage rate obtained from the present study. Vaccine vial monitor (VVM) is a valuable logistic management tool for indicating vaccine potency. It is present on all OPV vials supplied by UNICEF since 1997. The VVM basically monitors the cumulative heat exposure of the vaccine vial and provides information only about that vials to which it is attached⁽⁹⁷⁾. The availability of VVMs on OPV has facilitated the implementation of the multi-dose vial policy by WHO, This has led to a dramatic reduction in the discard rate of the vaccine due to heat exposure and unused portion of opened vials in the current study setting.

Moreover, the current study findings revealed that opened vial wastage rates for HBV was in FMUs more than in HOs. The higher wastage rate in FMUs may be due to the small number of eligible children available for immunization who were registered in the files of FMUs and HBV vaccine administered in a three-dose schedule (two, four and six months only). A field based assessment and observation in India (2013)⁽¹⁷⁾ at session sites found the wastage rate of HBV was more than the wastage rate obtained from the present study.

In addition, no vaccine wastage rate among all vaccines were in vitamin A capsules (zero) in both of HOs and FMUs. This may be due to that the vitamin A capsules is one dose vaccine and the difference between doses opened for use and doses given to children was due to the fact that in the expanded program of immunization vitamin A capsules given two capsules in the 18 month vaccination. Bloem et al. (2002)⁽²⁰⁾ reported no vitamin A capsules wastage rate in Bangladesh.

Furthermore, the current study revealed that there is low opened vial wastage rates for MMR in both HOs and FMUs, the low percentage of wastage in this vaccine may be due to the shortage of MMR supply from the ministry of health during 2014 up till now to both HOs and FMUs. So, the MMR vaccine vial was not opened unless ten children are collected in the session. Praveena et al. (2015)⁽²¹⁾ reported MMR wastage rate of 1.4% in South India. In contrast, Danovaro et al. (2012)⁽²²⁾ reported that high MMR wastage rate in Brazil and Palanivel et al. (2012)⁽³⁾ reported MMR also high wastage rate in India.

In relation to the causes of vaccine wastage, nurses and health inspectors in the current study perceived that among the different causes of vaccine wastage, the large number of doses per vaccine vial followed by irregular monitoring of the temperature of refrigerators vaccinations constitutes the highest mean scores (3.43±1.03 and 2.89±0.98 respectively). In this respect, Kumar and Aggarwal. (2013)⁽²³⁾ stated that correct temperature was not maintained in 31.25% of the studied health centers.

In relation to third cause of vaccine wastage which is preparation for the vaccination session by assembling the children by their dates of birth for the next session and call defaulters from the previous sessions as mentioned by nurses and health inspectors this is may be due to the absence of health inspectors employed in the most of FMUs who are responsible for this task.

Regarding the polio vaccine, the highest mean score of different causes of polio vaccine wastage as perceived by nurses and health inspectors was the movement of the child during a vaccination as a result of lack of cooperation by the parent followed by loss of an amount of vaccine during opening of the vial (3.02±1.16 and 2.67±0.89 respectively). Mukherjee et al. (2013)⁽¹⁹⁾ and Linkines et al. (1995)⁽²⁴⁾ stated that residual vaccine left in the vial was the most frequently reported reason for OPV wastage.

5. CONCLUSION AND RECOMMENDATIONS

HOs showed acceptable level of vaccine wastage rate, while, FMUs showed moderate level of vaccine wastage rate with a statistically significant difference detected. **In the light of the findings of the current study, the following recommendations are suggested:**

The Ministry of Health should:

- ✓ Employ at least one health inspector in every FMU to help in good preparation in the vaccination session and to conduct periodic regular auditing at the end of each session, use the immunization register and/or reminder cards to make a list of children who were due for vaccines but did not attend the session.
- ✓ Introduce vials of variable sizes (5, 10 and 20 dose) vials for each type of vaccines so that these vials could be used judiciously depending upon the number of target children available on the day of immunization.
- ✓ Monitor vaccine wastage rates and immunization coverage rates at all service delivery points for ensuring timely corrective actions in terms of estimation and forecasting of vaccine needs.

Health inspectors should:

- ✓ Provide consistent and good announcement of immunization session times.
- ✓ Provide good preparation of the immunization session and expectation of the children eligible to vaccination.
- ✓ Send out invitations/alerts for vaccination events to parents/legal guardians.

Research related recommendations:

Further researches should be conducted to:

- ✓ Investigate the impact of accurate vaccine wastage assessment on the forecasting of vaccine needs.
- ✓ Assess factors that influence the use of different vial sizes.
- ✓ Assess caregiver's satisfaction of children below 2 Years of Age towards the quality of immunization services.
- ✓ Assess vaccine adverse event reporting system.

International Journal of Novel Research in Healthcare and Nursing

Vol. 7, Issue 1, pp: (1-13), Month: January - April 2020, Available at: www.noveltyjournals.com

REFERENCES

- [1] Encyclopedia Britannica. Emily K. Brunson. Vaccine <https://www.britannica.com/contributor/Emily-K-Brunson/9620764> last retrieved 15/12/2019
- [2] World Health Organization. Tool for the assessment of injection safety. Department of Vaccines and Biologicals . 2011. Available at: http://www.who.int/immunization_delivery/systems_policy/optimize/en last retrieved on 20/10/2019.
- [3] Palanivel C., Kulkarni V., Kalaiselvi S., Baridalyne N. Vaccine wastage assessment in a primary care setting in urban India. *Journal of Pediatric Sciences*. 2012; 4(1):119-25.
- [4] Cutts F., Glik D., Gordon A., Parker K., Diallo S., Haba F. Application of multiple methods to study the immunization program in an urban area of Guinea. *Bulletin of WHO* .2004; 68(6):769- 76.
- [5] Ladden M., Bednash G., Steves D., Moore G. Vaccine wastage assessment in a primary care setting in developing countries. *Journal of Pediatric Science*. 2011; 55(16): 245-51.
- [6] Berwick D. Evaluation of vaccine wastage in Africa .*National Journal of Community Medicine* .2013; 4(1):182–4.
- [7] World Health Organization. Expanded Program on Immunization: Guidelines for vaccine wastage monitoring sentinel project in Ghana. 2005. available at: www.ghanahealthservice.org last retrieved on 25/12/2019.
- [8] Rashmi K., Akash B., Vijay KB., Ashwini K., Sanjeev B., Animesh J. Quality assessment of immunization program for children under five in Davangere Taluk of South India. *Journal of Clinical and Diagnostic Research* .2012; 6(5): 828-31.
- [9] Barnighausen D., Bloom M. Economic evaluation of vaccination: Capturing the full benefits. *Clinical Microbiology and Infection Journal*. 2012; 18 (5): 70–6.
- [10] Donabedian A. The definition of quality and approaches to its assessment .1988.Available at: <http://psnet.ahrq.gov/resource.aspx?resourceLast> retrieved on 29/10/2019.
- [11] Ministry of Health. The quality assurance unit: The expanded program of immunization (EPI) services standards in Egypt. 2004.
- [12] Department of Health and Human Services. Office of inspector general. Vaccines for children program: Vulnerabilities in vaccine management. June 2012. .Available at: <http://oig.hhs.gov/oei/reports/oei-04-10-00430.asp>. Last retrieved on 14/8/2019.
- [13] Drain PK., Nelson CM., Lloyd JS. Single-dose versus multi-dose vaccine vials for immunization program in developing countries. *Bulletin World Health Organization*. 2003; 81(10):726–31.
- [14] Guichard S., Hymbaugh K., Burkholder B., Diorditsa S., Navarro C., Ahmed S., Rahman M. Vaccine wastage in Bangladesh. *Vaccine Journal*. 2010 8; 28(3):858-63.
- [15] Setia S., Mainzer ., Washington ML., Coil G., Snyder R., Weniger B. Frequency and causes of vaccine wastage. *Vaccine Journal*. 2002; 2 (20):1148–56.
- [16] Chinnakali P ., Kulkarni V., Kalaiselvi S. Nongkynrih B. Vaccine wastage assessment in a primary care setting in urban India. *Journal of Pediatric Science*. 2012; 4(1): 211-78.
- [17] United Nations Children's Emergency Fund. Vaccine wastage assessment. Field assessment and observations from national stores and five selected states of India. 2013. Available at: http://www.unicef.org/india/Vaccine_Wastage_Assessment last retrieved on 19/12/2019
- [18] Agarwa M ., Idris M.Z ., Ahmed N . Quality of child health services at primary care level (rural vs urban) in Lucknow District. *Indian. Journal of Community Medicine*. 2004; 29(4): 10-12.

International Journal of Novel Research in Healthcare and NursingVol. 7, Issue 1, pp: (1-13), Month: January - April 2020, Available at: www.noveltyjournals.com

- [19] Mukherjee A., Das V., Srivastava A., Gupta A., Anupma U., Pandey S. An assessment of wastage multiplier factor (WMF) and percent wastage of vaccines during routine immunization under the universal immunization programme (UIP), Government of India (GOI). *Journal of Vaccines* .2013; 4(3): 2-5.
- [20] Bloem MW., Hye A., Wijnroks M., Ralte A., Wpest KP. The role of universal distribution of vitamin A capsules in combatting vitamin A deficiency in Bangladesh. *Journal of Epidemiology*. 2002; 142(3):843–55.
- [21] Praveena D., Selvaraj K., Veerakuma AM., Nair D., Ramaswamy G. Vaccine wastage assessment in a primary care setting in south India. *International Journal of Contemporary Pediatrics*. 2015; 2(1):7-11.
- [22] Danovaro A., Castillo N., Ruiz C., Matus N. Brazil's experience with the development of a vaccine-wastage evaluation system. *Academic Journal*.2012; 34(1):1-5.
- [23] Kumar H., Aggarwal A. Cold chain maintenance and vaccine administration practices in hospitals and clinics of Mangalore City – A health system's research. *National Journal of Community Medicine* 2013; 4(2): 231-35.
- [24] Linkins RW., Mansour E., Wassif O., Hassan HH., Patriarca PA. Evaluation of house-to-house versus fixed-site oral poliovirus vaccine delivery strategies in a mass immunization campaign in Egypt. *Bulletin World Health Organization* .1995; 73 (5): 589- 95.