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Accuracy of mother's reporting on child immunization in Yemen between 2012 and 2013

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Abstract: There is a complex interaction between infectious diseases and child nutritional status as infections usually entail some nutritional setback and vice versa. Therefore, vaccination against childhood infectious diseases is an important preventive measure against malnutrition itself, playing a key role in reducing child mortality. However, whereas referring to vaccination coverage it is crucial to have it clear how this coverage is measured, once it may vary considerably depending on the source of information. While child vaccination status is obtained from medical records in developed countries, in developing countries, they are mostly taken from vaccination cards and/or mothers' reports. Nevertheless, some researchers have come to diverse conclusions in terms of the accuracy of parents' reports. Based on a rich longitudinal household survey available for Yemen collected in 2012 – 2013, we find that although mothers' reports should not be discarded when estimating vaccination coverage (otherwise, coverage would be extremely overestimated), this information should be used with caution.

Keywords: Reporting accuracy; Vaccination coverage; Child immunization; Children; Maternal recall; Yemen; Yemen National Social Protection Monitoring Survey

1. Introduction

There is a complex interaction between infectious diseases and child nutritional status in the sense that infections usually entail some nutritional setback and vice versa. Therefore, vaccination against the main childhood infectious diseases may be an important preventive measure against malnutrition itself (CSO, PAPCHILD, and MI, 1994). Reducing child mortality is defined by the United Nations (UN) as the fourth millennium development goal, and vaccination plays a key determinant to achieve this goal. Since 1974, the Expanded Program on Immunization (EPI) and the substantially increased vaccination coverage in many countries have saved the lives of millions of children. However, while referring to vaccination coverage, it is crucial to have it clear how this coverage is measured, as it may vary considerably depending on the way vaccination status is determined (Langsten and Hill, 1998).

Since 1998, the World Health Organization (WHO), United Nations Children's Fund (UNICEF), and selected ministries of health have developed the Joint Reporting Form (JRF) by consensus. The JRF is a standard questionnaire that was sent to all member states to disseminate consistent data on immunization system performance. The information

collected in the JRF serves as a critical resource for tracking implementation of the Global Vaccine Action Plan (GVAP). These initiatives work as key frameworks to guide immunization strategies at global and regional levels and progress reports on GVAP (WHO, 2017).

While monitoring vaccination surveillance, there are two sources of vaccination coverage information, administrative records and specific surveys, which can be used to fill the gaps in administrative data. In this paper, we deal with data from specific vaccination surveys, which usually collect vaccination information through parents' recall and/or vaccination cards. Using the Yemen National Social Protection Monitoring Survey (NSPMS) data, the aim of the paper was to examine the level of accuracy of mothers' recalls on their children's vaccination histories. We did this by comparing mothers' reporting information in one round with the vaccination card shown in a subsequent round.

The usage of parents' recall and card information when analyzing vaccination coverage is widespread in the literature. Nevertheless, some researchers have questioned the validity of parents' recall of their children's vaccination. Although the literature indicates either over- or underestimation in parental recall, some researchers still conclude that including it in vaccination coverage yields more accurate estimates (Ndirangu, Bland, Barnighausen, *et al*., 2011; Brown, Monasch, Bicego, *et al*., 2002; Suarez, Simpson, and Smith, 1997; Langsten and Hill, 1998). However, there are also papers questioning parents' recall validity (Murray, Shengelia, Gupta, *et al*., 2003), and others even strongly do not recommend the use of parents' reports once they introduce recall bias (Valadez and Weld, 1992; Bolton, Holt, Ross, *et al*., 1998).

Vaccination coverage in Yemen has significantly improved between the nineties and mid-2000s, but there is still a long way to go for the country to reach vaccination coverage levels recommended by the WHO. For instance, 47% of children aged 12 – 23 months had received Diphtheria-Pertussis-Tetanus (DPT) vaccines in 1991 – 1992 (CSO, PAPCHILD, and MI, 1994), while 60% of them had received pentavalent in 2006 (MPHP and UNICEF, 2008). Since then, coverage has remained at the same level for some vaccines between 2006 and 2013, whereas for others, coverage has increased in the period. Aiming at boosting coverage levels, vaccination campaigns have been a constant effort in the country. In 2012 and 2013, there were nine polio vaccination campaigns. This may be the reason why polio vaccination coverage has significantly increased in Yemen, rising from 60% in 2006 (MPHP and UNICEF, 2008) to 74% in 2013 (International Policy Centre for Inclusive Growth [IPC-IG] and UNICEF, 2014).

It is worth highlighting the importance of mothers' reports in this context, as during most campaigns, vaccination may not be recorded on health cards so that survey enumerators can only obtain such information by parental recall (Langsten and Hill, 1998). Thus, it is very important to analyze the accuracy of mothers' reports. This is because on the one hand, if mothers' recall leads to coverage overestimation, children may be put at risk, as health workers may fail to vaccinate children who still need additional doses. On the other hand, if a mother's report leads to coverage underestimation, this may cause a waste of resources by vaccinating children already vaccinated (Valadez and Weld, 1992).

1.1. The history of Yemen's vaccination initiatives

Vaccination coverage in Yemen was very low until the 1980s. In the most favorable estimates, at most 10% of children were vaccinated (the Demographic and Health Surveys - DHS -1992 report). According to the WHO (1988), by the end of the 1980s, Yemen reported at least ten cases of poliomyelitis per year, and polio vaccination coverage was still lower than 30% (WHO, 1988). In 1990, with the vaccination for all campaign announced by the WHO, Yemen adopted national strategies for increasing vaccination coverage, reaching 80% of children vaccinated for most vaccines. However, before the mid-nineties, there was another relapse in vaccination coverage.

Yemen's vaccination coverage also suffered a noticeable drop after the mid-1990s because of a substantial fall in donor support starting in 1990 and a civil unrest taking place in 1994 (WHO and UNICEF, 2008). In 2005, it was not yet maintaining a consistent upward trend: having improved coverage levels in the early 2000s, it dropped again in mid-2003 (because of another poliovirus outbreak as a result of the spread of the virus from northern Nigeria) and recovered in 2004 (UNICEF, 2005; WHO, 2006). In 2005, Yemen still had active transmission of the imported virus, with 478 cases of children infected with poliomyelitis in the country. In that year, there were 6 national immunization days (WHO, 2006). The National Millennium Development Goals Report in 2010 pointed out that the national campaigns against polio carried out in Yemen in 2009 eliminated the disease in the country. Despite this, new cases were reported between 2011 and 2012. Similar results were found for measles, where campaigns showed very positive results in controlling the spread of the disease in the period between 2006 and 2009.

As can be noted, efforts to increase national vaccination coverage against the diseases covered by the EPI are part of a long-standing strategy to accelerate the reduction of child mortality in Yemen. According to UNICEF Yemen, several national and subnational vaccination campaigns took place in 2012 and 2013. The most recent vaccination campaigns are

especially important when analyzing the youngest children – aged <2 years old who should have taken all vaccines by the time they were 1 year old (UNICEF and IPC-IG, 2014).

2. Data and Methods

2.1. The dataset

The NSPMS is the only nationally representative longitudinal household survey available for Yemen where members of 6397 households were interviewed on a quarterly basis during a 12-month period between October 2012 and September 2013. During the four rounds of the NSPMS, caretakers were asked to show the vaccination card for every child under age five. The interviewers copied the vaccination information from the card onto the NSPMS questionnaire. If there was no vaccination card, the mother was asked to recall whether the child had received each of the vaccines, and in the case of multiple doses, interviewers also asked how many times the vaccine was given. Given the longitudinal nature of the NSPMS, households were visited 4 times over a 12-month period. These sequential visits allowed the survey to improve the information on children's vaccination histories, as they increased the likelihood of having access to vaccination cards and to find better informed interviewees on the children's vaccination histories.

This paper focuses on Bacillus Calmette-Guérin (BCG) and the third dose of polio vaccines (polio 3rd). Typically, indicators of children's vaccination coverage consider children aged 12 – 23 months as their target population. This is important because one would expect the memory error of mothers to be greatly reduced when considering the immunization schedule of very young children.

There were 1369 children aged 12 – 23 months in round 3 of the NSPMS data. It is important to emphasize that our sample comprises children aged 12 – 23 months in round 3 whose card was seen in this round and whose information on vaccines in round 1 was taken through the mother's report. In addition, concerning the dates of vaccination obtained in round 3, we only kept children with dates of vaccination that was consistent within this round. It is important to emphasize that for a particular child, their information on vaccines comes from different sources. For instance, it is possible for a child to have a consistent date at which BCG vaccine was taken but having no record on the card about third dose of polio and their mother reported them as not vaccinated against polio. This means that for the same child, it is possible to have information from either the vaccination card (through a readable or not readable date of vaccination) or the mother's report depending on the vaccine to be considered. In other words, card availability information varies obviously from child to child, but more than that, it varies from vaccine to vaccine even when considering the same child. Because of this type of vaccination history, the number of sampled children varies depending on the vaccine that is being used to analyze the accuracy of the mother's report.

2.2. Methods

The methodology for verifying the accuracy of mother's reports on child vaccination is adapted from Langsten and Hill (1998), and it is merely descriptive. First, we excluded from the analysis children with inconsistencies in the dates of vaccination copied from their vaccination card in round 3. That is, we excluded children whose (1) dates of vaccination were before their own birth and (2) vaccination dates in one round were after the date of the interview of that round. In addition, some children also lack information concerning their vaccination status, which means either "mother doesn't know," "mother doesn't remember" or "children not vaccinated." For the majority of children with missing information, the interviewer had seen their vaccination card, and we assumed that these children were not vaccinated according to the card.

Then, we analyzed the possible sources of disagreement between the mother's report in round 1 (R1) and the card information in round 3 (R3). Since data collection improved over time, it is important to mention that our definition of consistency criteria on mother's recall considers the round 3 information as our benchmark. After checking the consistency of the mother's report, the following metrics were calculated: accuracy, sensitivity, specificity, and predictive values. These measures are commonly used in research to validate and compare instruments (Selimuzzaman, Ullah, and Haque, 2008; Miles, Ryman, Dietz, *et al*., 2013).

The accuracy of mothers' reporting corresponds to the percentage of children whose mothers reporting information matched the information registered in their vaccination card: (TP + TN)/(TP+FP+FN+TN). Sensitivity is the percentage of vaccinated children who were reported by their mother as vaccinated: TP/(TP+FN). Specificity is defined as the percentage of nonvaccinated children who were reported by their mothers as not vaccinated: TN/(FP+TN). The positive predictive value (PPV) is the percentage of children reported as vaccinated who were actually vaccinated: TP/(TP+FP). Finally, the negative predictive value (NPV) is the percentage of children reported as not vaccinated who were actually

not vaccinated: TN/(FN+TN). In each of these equations, the acronyms mean the following: TP=true positives, TN=true negatives, FP=false positives, and FN=false negatives. The definition of true or false (positives or negatives) refers to the consistency between information on vaccination cards and mother's recall, taking into account that the former is our gold standard.

Based on these measures of agreement, we evaluated the level and pattern of accuracy of mothers' recall on their children's vaccination histories by comparing mother's reporting information in round 1 with the vaccination card shown in round 3. It is important to emphasize that validity refers to the degree to which the test or an estimate based on a test is able to determine the true value of what is being measured (in this case, vaccine coverage). In this sense, sensitivity and specificity (and therefore the accuracy itself) are properties inherent to the criterion of the evaluated test and do not vary except by technical error. Predictive values, however, depend on the prevalence of the phenomenon in the study population. The PPV increases with prevalence, while the NPV decreases. Thus, when the phenomenon is rare, the PPV is low, since most of the positive information results from mothers of unvaccinated children, representing false positive results. On the other hand, NPV is high at low prevalence (Fletcher, Fletcher, and Fletcher, 2014).

3. Results

3.1. Vaccination coverage by source of information: mother's report versus vaccination card

Figure 1 shows the percentage of vaccinated children – against BCG and polio (third dose), fully vaccinated (had received BCG, measles and third dose of polio and pentavalent), undervaccinated (had not received at least one of them) and even not vaccinated at all – among those whose information on all vaccines was available through their mothers' reports and the percentage of vaccinated children among those whose information on all vaccines was available on their vaccination cards. It is important to emphasize two features of this figure. First, it only includes children with available information on all vaccines (either from mother's report or vaccination card). Although having all children with complete information on their vaccination status would be the ideal situation, only 62% of children aged 12 – 23 months who have vaccination cards show information on all vaccines taken, and the percentage of children aged 12 – 23 months who have a vaccination card is as low as 42%. Second, it is important to highlight that the sample of children used in this table does not exactly correspond to the sample of children used in our empirical exercise. The idea of Figure 1 is giving a more general idea of how the estimates in vaccination coverage may vary depending on the source of vaccination information (whether it is mother's report or vaccination card).

The most striking aspect of these numbers is the significantly higher percentage of vaccinated children among those with vaccination cards in comparison to those whose mothers reported their vaccination status. For instance, approximately 83% of 557 children aged 12 – 23 months with vaccination cards available have received BCG. Among the 578 children whose mothers are their source of information, only 39% have received it. Whether we analyze children who have never taken any vaccine, only 5% of the children with vaccination cards fall in this category against 56% of children whose information comes from the mother's report. This is an indication of two possibilities that may be complementary to each

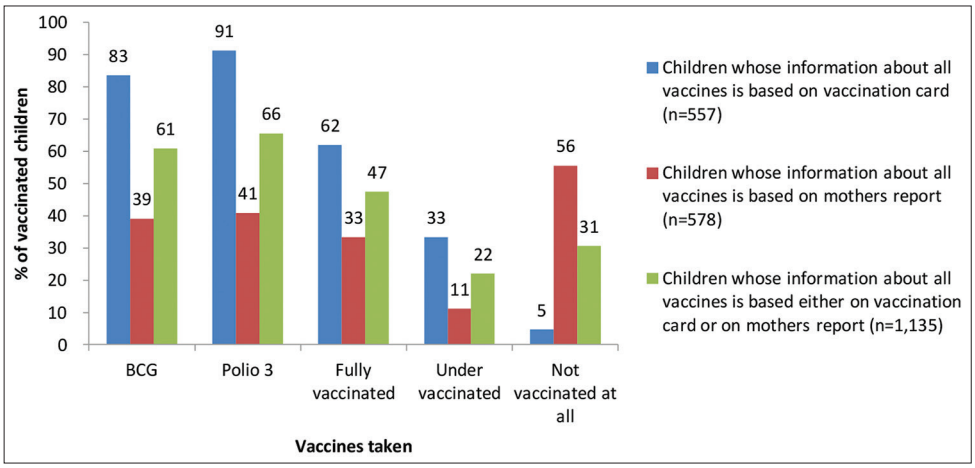

Figure 1. Percentage of vaccinated children among those aged 12 – 23 months in round 3 with information available on all vaccines taken according to the source of information – Yemen, 2013. **Source:** IPC-IG and UNICEF (2014), round 3.

other: (1) mother's recall of child vaccination is very incomplete in the sense that it probably underestimates children's vaccination status, and (2) vaccination cards are a key source of children's vaccination history.

3.2. The accuracy of mother's reporting on child vaccination status

We tested mother's precision while reporting their children's vaccination status regarding two main issues: (1) The overall quality of mother's reports based on both mother's reporting information and subsequent vaccination card information and (2) the direction of mothers misreporting, which indicates whether mother's report mostly leads to underestimation or overestimation of children's vaccination coverage.

3.2.1. Overall quality of mothers' reports

As proposed by Miles *et al*. (2013), we specified ≤80% as being a poor validity of the instrument/source of information (in this case, mother's report on vaccination status of children aged 12 – 23 months). For both vaccines, we found low agreement between the mother's reports in R1 and vaccination cards in R3, with accuracies of 67 and 71% for BCG and polio 3rd, respectively.

3.2.2. The direction of mothers' misreporting

Table 1 shows the sensitivity, specificity, PPV, and NPV while comparing the mother's report at R1 with the vaccination card at R3 (the latter being our gold standard). Before analyzing the results, we highlight that due to our sample restrictions, the sampled children are in better socioeconomic conditions compared to the others although, on average, both groups of children (those included or those not in the sample) do not have adequate living conditions as access to health facilities, water, sanitation, education, and food security are still scarce in a country where poverty rates were estimated at 45% in 2012 (IPC-IG and UNICEF, 2014). Although these conditions can affect both groups homogeneously, this possibility cannot be tested, which introduces a limitation to the study.

The sensitivity values were higher than the specificity, and the PPVs were higher than the NPVs for both vaccines. When comparing the type of vaccine, we easily see that there was relatively little change in sensitivity between them. Taking into account the cutoff of ≤80% as a low value, sensitivity was low for both vaccines, with BCG showing the lowest value (70%). Considering the specificity, the values were even worse for both types of vaccines, and BCG again presented the lowest value (56%). PPVs were high for polio 3rd and BCG (88 and 84%, respectively). In contrast, NPVs were low for both (38 and 36%).

These results indicate an acceptable effectiveness of the instrument (mother's report) while estimating vaccination coverage. However, some features should be highlighted. According to the results presented in Table 1, mother's information is more reliable when predicting children who were actually vaccinated, but it is more problematic when predicting those who were not vaccinated. This means that mothers usually underestimate the number of vaccines taken by their children in Yemen, which in turn may underestimate children's vaccination coverage, as for most children, the main source of information on their vaccination schedule is their mother (59% of children aged 12 – 23 months in Yemen does not have a vaccination card available). In fact, as we assumed that the gold standard for the assessment of coverage was the vaccination card, it is estimated that the vaccination coverage is 76.92% and 79.51%, respectively, for BCG and polio 3rd in our sample of children. The estimated coverage for the same sample based on mother's recall is more than 10 percentage points lower than that based on the vaccination card (64.10% and 66.34%, respectively).

4. Discussion

The previous sources of vaccination data in Yemen are the 1991 – 1992 and 1997 DHSs and the 2006 MICS, both offering access to cross-sectional data. Nevertheless, while adequately analyzing the accuracy of parents' recall, it is crucial to have access to longitudinal information. This is because in a household survey interview, caretakers are usually first asked to show the vaccination card of each child, and only in case they do not have it are they asked to recall whether the child had received each of the doses/vaccines. In this way, in cross-sectional data, the researcher will only have access to one source of information, either the vaccination card or parents' report. Based on the NSPMS longitudinal survey, it was possible to test the accuracy of mother's reports in Yemen by comparing mother's information at R1 with the information collected at R3 (6 months later).

It is important to highlight that although we also tested mothers' accuracy in a sample including all children aged 12 – 59 months, we found that memory errors increased significantly with age. In this sense, to minimize miscalculating

Table 1. Measures of agreement between vaccination card ("gold standard") and mother's report and vaccination coverage according to both sources of information – Yemen, 2013.

Agreement of instruments/sources of information	Children aged 12 – 23 months		
	Vaccinated children based on Card info at R3?		
	Yes	No	Total
BCG			
Vaccinated children based on mother's report at R1?			
Yes	105	20	125
No	45	25	70
Total	150	45	195
Indicators of Agreement			
Accuracy		66.67%	
Sensitivity		70.00%	
Specificity		55.56%	
PPV		84.00%	
NPV		35.71%	
Prevalence (vaccination coverage)			
Gold standard		76.92%	
Mother´s report		64.10%	
Polio 3rd			
Vaccinated children based on mother's report at R1			
Yes	120	16	136
No	43	26	69
Total	163	42	205
Indicators of Agreement			
Accuracy		71.22%	
Sensitivity		73.62%	
Specificity		61.90%	
PPV		88.24%	
NPV		37.68%	
Prevalence (vaccination coverage)			
Gold standard		79.51%	
Mother's report		66.34%	

Source: IPC-IG and UNICEF (2014), rounds 1 and 3.

vaccination coverage indicators in developing countries (where vaccination coverage estimates often depend on parents' information), we recommend it to be mainly estimated for children aged 12 – 23 months. The results for these children showed that the sensitivity and specificity had moderate values, except for BCG. This may be because this vaccine is given at birth, henceforth more subjected to parent memory errors when they are questioned, despite its typical scar. In this sense, an analysis that includes the temporal distance between the vaccination and the interview, although being an interesting complementary analysis, is beyond the scope of this study. Regarding the predictive values, while the PPVs were high, the NPVs were very low for both vaccines.

There is no consensus about the most appropriate thresholds to determine whether an instrument is valid to estimate vaccination coverage. We used a more restrictive criterion proposed by Miles *et al*. (2013), in which each measure of validity must be >80%. For service planning within the health sector, it is essential that the instruments used to evaluate the coverage of services present high levels of sensitivity and specificity. These features enhance the ability of policymakers to capture the actual distribution of a certain condition in the population, namely, children's vaccination coverage, in the case of this study.

From the clinical point of view, specificity is a more important characteristic, since it refers to a correct diagnosis for which we do not wish to make a mistake (i.e., to assign a positive diagnosis when it is not true). However, from the point of view of public health, actions are expected to be as sensitive as possible since it is more important to ensure high coverage for disease screening or preventive action coverage. Thus, in the case of vaccination, the higher the sensitivity, the better it is for the analysis of vaccine coverage because even though there is an overestimation of the coverage, it is assumed that the target population is covered by the action.

The moderate sensitivity associated with a high PPV indicated that the mother's report is highly accurate when identifying the proportion of children who were vaccinated in the Yemen population. However, the low NPVs indicated that many children may be misclassified as not vaccinated when they have actually been vaccinated. However, it is important to stress that although mothers' reports should not be discarded while estimating vaccination coverage in Yemen (otherwise, coverage would be extremely overestimated if only estimated based on vaccination cards), this information should be used with caution. From our results, we find that considering mother's information in estimating vaccination coverage in Yemen tends to underestimate this indicator (for instance, BCG vaccination coverage according to vaccination card is 77%, if based on mother's report, coverage decreases to 64%). If, on the one hand, this finding may cause certain relief as the real situation of child vaccination in Yemen may actually be better than the one based on the estimated coverage; on the other hand, there seems to be a waste of the already scarce resources of the country. With this analysis alone, we are not able to estimate a correction factor for an official vaccination coverage estimate (based on mother's report and/or vaccination card), as this factor would be strongly dependent on the prevalence of vaccination in Yemen, and we have a sample of those with (consistent) information. In addition, it would be important to analyze the characteristics of the families of children with vaccination card information compared to those with only mother reports. Further analysis is required to move forward at this point.

There are successful national immunization programs (NIPs) implemented in developing countries that could help other countries that still present low child vaccination coverage and limited resources – such as Yemen – rethink their immunization systems. Brazil has been considered an international case of success: eradicated smallpox in 1971, instituted the NIP in 1973, and held its first national campaign against polio in 1980. Despite all the advances, until the mid-1990s, the records of vaccination were not satisfactory. By the end of the 1980s, with the establishment of the Brazilian Unified Health System, a movement of decentralization was initiated that placed the municipality as the direct executor of health actions; among them, vaccination was included. It is worth mentioning that this decentralization in the actions is based on the integration between three levels — municipal, state and federal. With a national vaccination registration system, these three levels together discuss norms, definitions, goals, and results, providing the continued modernization of its infrastructure and operation. In this scenario, the NIP has ensured the provision of safe and effective vaccines with extremely high vaccination coverage for children (Silva Jr, 2013).

However, for the Brazilian NIP to be such a success, in addition to the program being part of the WHO's program, the Brazilian government also had the support of children's rights organizations such as UNICEF and the Pan-American Health Organization (Ministério da Saúde, 2014). In addition, the Brazilian Ministry of Health defined the NIP as one of its priorities, allocating resources to it in the annual budget in a separate item and not subjected to budget cutting as per the Budget Guidelines Law of 2011 (Domingues, Teixeira, and Carvalho, 2012). To reinforce the importance of maintaining high vaccination coverage among children in Brazil, the Ministry of Health in 2004 issued an ordinance making it mandatory to present children's vaccination cards in case of child enrollment in school, parent job hiring and receipt of social benefits. In case parents do not have the card in hand, the institution gives 2 months for them to present children's updated vaccination card. This shows the importance of a vaccination card, which should be reinforced in Yemen not only among families but also among health professionals. Vaccination cards can enhance health workers' ability to make decisions and empower caregivers on their child healthcare in addition to supporting public health monitoring (Brown, 2012).

According to Yemen's Planning Strategy for Immunization Service Delivery in a Catchment Area (MPHP, 2005), every year, each health facility is responsible for conducting a house-to-house census of the population eligible for immunization in their catchment area. Among the purposes of the annual house-to-house census are (1) verifying the immunization status of children aged <1 year and women of childbearing age; (2) providing immunizations to eligible children and women and providing them with immunization cards; (3) updating the records of immunizations given; and (4) educating men and women on the safety and importance of immunizations based on local needs. Despite all these efforts in guaranteeing population access to immunization cards at the facility level, families seem to not understand the importance of keeping vaccination cards at hand. This becomes clearer when using data on vaccination from Yemen's household surveys, as much of the information relies on parents' reports instead of vaccination cards.

5. Conclusion

Based on the sample of children used in our analysis, we found that considering mothers' reporting information in estimating vaccination coverage in Yemen tends to underestimate this indicator. Although this finding may cause relief, as the real situation of child vaccination in Yemen may actually be somewhat better than that based on the estimated coverage, this also means a waste of the already scarce resources of the country. An important fact to be mentioned is the considerable percentage of children who are born at home without the presence of skilled health personnel during childbirth in Yemen. Approximately 73% of women did not deliver births at a health facility in 2013. Moreover, only 14% of women delivering at home were attended by skilled health personnel during childbirth (IPC-IG and UNICEF, 2014). This fact is especially important when taking into account BCG vaccine (and first dose of polio), which is given at birth.

It is important to enhance families' and health workers' awareness of the importance of keeping children's vaccination schedules up-to-date. Maybe the fact that mothers make more mistakes answering that their child was not vaccinated when they were actually vaccinated indicates that mothers find vaccination somehow important – as if they do not remember whether their child was vaccinated or not, they may think it is better saying the child was not immunized so that they can be (re)vaccinated anyway. However, as highlighted earlier, this means that the resources used for child immunization in Yemen could be used more efficiently. Finally, while it is essential to improve the population's understanding in terms of the importance of the vaccination card, the centralization of the registration system and the continuous recording of children's vaccination can be seen as a recommendation for improving the management of childhood vaccination at the national level.

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Conflict of Interest

No conflicts of interest were reported by the authors.

Authors' Contributions

Conceived and designed: Laetícia Rodrigues De Souza. Review of literature: Laetícia Rodrigues De Souza and Luciana Correia Alves. Contributed to tools/materials/data collection: Laetícia Rodrigues De Souza, Luciana Correia Alves and Raphael Mendonça Guimarães. Analyzed the data: Laetícia Rodrigues De Souza, Luciana Correia Alves and Raphael Mendonça Guimarães. Drafted and wrote the manuscript: Laetícia Rodrigues De Souza and Luciana Correia Alves.

Ethical Approval

The human data used in our research are a publicly available household survey dataset that can be downloaded from the webpage http://nspms-yemen.ipc-undp.org/.

Availability of Supporting Data

The NSPMS dataset is in open access on the webpage dedicated to the UNICEF and IPC-IG joint project (http://nspms-yemen.ipc-undp.org/).

References

Bolton P, Holt E, Ross A, *et al*. (1998). Estimating vaccination coverage using parental recall, vaccination cards, and medical records. *Public Health Reports*, 113:521-526.

Brown DW. (2012). Child immunization cards: Essential yet underutilized in national immunization programmes. *The Open Vaccine Journal*, 5:1-7. https://doi.org/10.2174/1875035401205010001

Brown J, Monasch R, Bicego G, *et al.* (2002). *An Assessment of the Quality of National Child Immunization Coverage Estimates in*

Population-based Surveys. North Carolina: MEASURE Evaluation Project.

CSO, PAPCHILD, and MI. (1994). *Yemen Demographic and Maternal and Child Health Survey 1991/1992*. Calverton, Maryland: Central Statistical Organization, Pan Arab Project for Child Development and Macro International Inc.

Domingues CM, Teixeira AM, and Carvalho SM. (2012). National immunization program: Vaccination, compliance and pharmacovigilance. *Revista do Instituto de Medicina Tropical de São Paulo*, 54(Suppl 18):S22-S27. https://doi.org/10.1590/s0036-46652012000700009

Fletcher RH, Fletcher SW, and Fletcher GS. (2014). *Clinical Epidemiology*: *The Essentials*. 5th ed. Philadelphia, PA: Wolters Kluwer Health/Lippincott Williams and Wilkins.

IPC-IG and UNICEF. (2014). *Yemen National Social Protection Monitoring Survey (NSPMS): 2012-2013 Final Report*. Brasília: International Policy Centre for Inclusive Growth.

Langsten R and Hill K. (1998). The accuracy of mothers' reports of child vaccination: evidence from rural Egypt. *Social Science and Medicine*, 46(9):1205-1212. https://doi.org/10.1016/s0277-9536(97)10049-1

Miles M, Ryman TK, Dietz V, *et al*. (2013). Validity of vaccination cards and parental recall to estimate vaccination coverage: A systematic review of the literature. *Vaccine*, 31(12):1560-1568. https://doi.org/10.1016/j.vaccine.2012.10.089

Ministério da Saúde. (2014). *Programa Nacional de Imunizações-Vacinação*. Available from: https://www.gov.br/saude/pt-br/acesso-a-informacao/acoes-e-programas/programa-nacional-de-imunizacoes-vacinacao [Last accessed on 2021 Nov 30]. https://doi.org/10.22491/manual-imunizacoes

MPHP and UNICEF. (2008). *Yemen Multiple Indicator Cluster Survey 2006*: Final Report. Sana'a: Ministry of Public Health and Population.

MPHP. (2005). *Guidelines for Safe Immunization Practices and Monitoring Immunization Programs at the Facility and District Levels in Yemen*. Bethesda, MD: The Partners for Health Reformplus Project, Abt Associates Inc., Sana'a: Ministry of Public Health and Population.

Murray CJ, Shengelia B, Gupta N, *et al*. (2003). Validity of reported vaccination coverage in 45 countries. *The Lancet,* 362(9389): 1022-1027. https://doi.org/10.1016/s0140-6736(03)14411-x

Ndirangu J, Bland R, Barnighausen T, *et al.* (2011). Validating child vaccination status in a demographic surveillance system using data from a clinical cohort study: evidence from rural South Africa. *BMC Public Health*, 11:372. https://doi.org/10.1186/1471-2458-11-372

Selimuzzaman ABM, Ullah MA, and Haque MJ. (2008). Accuracy of mothers' reports regarding vaccination status of their children in urban Bangladesh. *The Journal of Teachers Association*, 21:40-43. https://doi.org/10.3329/taj.v21i1.3217

Silva JB Jr. (2013). 40 Anos do programa nacional de imunizações: Uma conquista da saúde pública Brasileira. *Epidemiologia e Serviços de Saúde*, 22:7-8. Available from: http://scielo.iec.gov.br/scielo.php?script=sci_arttext&pid=S1679-49742013000100001 [Last accessed on 2022 May 28].

Suarez L, Simpson DM, and Smith DR. (1997). Errors and correlates in parental recall of child immunizations: Effects on vaccination coverage estimates. *Pediatrics*, 99(5):1-5. https://doi.org/10.1542/peds.99.5.e3

UNICEF and IPC-IG. (2014). *Yemen National Social Protection Monitoring Survey: Version 1* [*Machine-readable Database*]. Brasília: International Policy Centre for Inclusive Growth.

UNICEF. (2005). *Progress for Children: A Report Card on Immunization*. New York: United Nations International Children's Emergency Fund.

Valadez JJ and Weld LH. (1992). Maternal recall error of child vaccination status in a developing nation. *American Journal of Public Health*, 82:120-122. https://doi.org/10.2105/ajph.82.1.120

WHO and UNICEF. (2008). *Review of National Immunization Coverage, 1980-2007, Yemen*. New York: World Health Organization.

WHO. (1988). *Poliomyelitis Eradication in the Eastern Mediterranean Region*. New York: World Health Organization.

WHO. (2006). *Global Polio Eradication Initiative 2005 Annual Report*. New York: World Health Organization.

WHO. (2017). *Seventieth World Health Assembly*: Geneva, 22-31 May 2017: *Resolutions and Decisions, Annexes.* Geneva: World Health Organization. Available from: https://apps.who.int/iris/handle/10665/259673 [Last accessed on 2022 May 28].