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# Home-based records' quality and validity of caregivers' recall of children's vaccination in Lebanon

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ABSTRACT

*Introduction:* Home-based records (HBRs) (also known as vaccination cards) and caregivers' recall are the main means to ascertain vaccination status; however, data on the quality of HBRs and the validity of recall vaccination data compared to HBRs is scarce. This manuscript presents results from two analyses related to HBRs, one on HBR pictures taken during a vaccination coverage survey, including an assessment of the HBR quality and legibility, and an evaluation of the agreement between caregivers' recall and the vaccination information in the HBRs.

*Methods:* Using pictures from 500 randomly selected HBRs collected during the 2016 district-based immunization coverage evaluation survey in Lebanon, two independent researchers assessed the quality of the picture and then of the HBR itself against a pre-defined set of criteria. HBRs were classified into three types: private, public and all others. In addition, caregivers' recall was compared to data found in vaccination HBRs to assess measures of vaccination status agreement for 5713 children for whom both sources of data were available.

*Results:* Over 90% of the 500 HBR pictures reviewed were considered adequate to assess the HBR quality. In the sample, most cards were type 1 (41%), followed by type 2 (34%). Most HBRs met the set criteria for quality in terms of physical condition and legibility, while, among the 28 different types of cards, vaccination cards' content and design met a moderate level of quality. Concordance, sensitivity, specificity, positive and negative predictive values, and the Kappa statistic showed diverse levels of agreement for vaccination status per vaccine dose between caregivers' recall and vaccination HBRs.

*Conclusion:* This study illustrates that taking pictures of HBRs in a coverage survey is feasible and useful to conduct secondary analyses related to HBRs, such as assessing their quality and comparing recall with HBRs when both sources of data are available.



## 1. Introduction

Although essential for a population's health and national health program planning, measuring vaccination coverage is challenging due to record quality issues and persisting information biases [1,2]. Home-based records (HBRs) are commonly used, particularly in low- and middle-income countries to ascertain vaccination status which in turn is used for the estimation of vaccination coverage rates, particularly through surveys [3–5]. However, while HBRs are an important tool to document the vaccination status of children, evidence has shown that these records often appear to be underutilized and are rarely standardized in their application, content or design [6–8]. Another source, which is often relied on to assess vaccination in coverage surveys, is the caregivers' recall. Nevertheless, few studies have examined caregivers' recall agreement with HBR data on vaccination status, particularly in low and middle-income countries [3–5,9,10], whit those few studies

*Abbreviations:* DTP, diphtheria, tetanus, pertussis; HBR, home-based record; HepB, hepatitis B; Hib, *Haemophilus influenzae* type b; MCV, measles-containing vaccine; NPV, negative predictive value; PPV, positive predictive value; RCV, rubella-containing vaccine.

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showing that estimates based on caregivers' recall are prone to large variability, whereas other research concludes that the recall can be a reliable source to assess vaccination coverage [3–5]. In fact, in 2017, better understanding the reliability of vaccination recall was considered one of the top priorities in the global research agenda [11].

Regarding HBRs, few studies exist that have examined the diverse types of HBRs used and their completeness, readability and correctness [12]; this is lacking for the Lebanese context as well. In Lebanon, both public and private healthcare providers distribute HBRs in the form of vaccination cards. At public health facilities, every newborn is provided with a birth registry and a HBR, which comprises the national vaccine schedule established by the Ministry of Public Health (MoPH) [13]. At private health facilities, healthcare providers may distribute similar HBRs based on the national vaccine schedule, yet they may also rely on other vaccination schedules, such as the Recommended Immunization Schedule from the Lebanese Pediatric Society. Given the pluralistic healthcare system in Lebanon, diverse types of HBRs exist.

This manuscript presents the results of two distinct, but related, secondary analyses related to HBRs done from data collected during a multistage cluster survey conducted in 2016 in Lebanon using the World Health Organization (WHO) recommended methodology for vaccination coverage surveys adapted to the local context [14,15]. First, an evaluation of the quality of the pictures of HBRs taken during the 2016 vaccination coverage surveys, as taking pictures represents a new WHO recommendation [16], and then an assessment of the HBRs seen against criteria developed by an expert committee based on key WHO recommendations regarding HBR design and use [7]. Second, an evaluation of the agreement between caregivers' recall and HBRs.

## 2. Methods

### 2.1. Survey description and study material

During the 2016 district-based immunization coverage evaluation survey conducted in Lebanon, caregivers of children aged 12–59 months from 25 of 26 districts of Lebanon (excluding the Nabatieh district due to inaccessibility) were asked about the vaccination history of their child (recall) and to present their child's HBR for the assessment of routine immunization coverage. If a HBR was available, fieldworkers took pictures of the record following consent from the caregiver; no transcription of HBRs was done during the interview. Further details of the 2016 coverage evaluation survey can be found elsewhere [14,15].

Paper-based and electronic questionnaires were used in the 2016 survey [15]. If the fieldworker was able to use the electronic questionnaire, pictures of the HBR were simultaneously collected using the KoBoCollect application. If the questionnaire was paper-based, tablets were used to take and save pictures. Before taking a picture, the HBRs were marked by codes to provide a unique identifier linked to the household and child. Vaccination data extraction from pictures of HBRs was done by a trained team of public health agents extemporaneously and at a central location. Epidata software was used to enter any non-electronically collected information. Data from both the Epidata software and KoBoCollect application were merged into one final dataset, using Stata software, version 14.

### 2.2. HBR analysis

A random sample of 500 pictures of HBRs was selected from all cards for a picture and card quality assessment. The random selection was done using probability proportional to size to ensure a representative distribution of districts, irrespective of the card type [15]. This card quality assessment comprised: (a) a quality check of the HBR pictures, (b) an evaluation of card content and design using WHO recommended criteria [7] and (c) a card quality evaluation on physical condition and legibility. Criteria for the latter evaluation were adapted from a WHO working document used to assess cards in a coverage evaluation survey done in Bolivia in 2013 (full report available upon request) [17]. The WHO criteria were adapted to the Lebanese context and reduced to a total number of ten criteria (five core content criteria and five additional design criteria) by an expert committee supporting the survey [7]. Two researchers were trained to assess card quality using pre-set criteria along a categorical rating and independently assessed the pictures of the 500 HBRs selected. The Kappa statistic was then used to measure the inter-rater agreement between the two assessments. A Kappa score $\leq$0.20 indicated slight to poor agreement, 0.21–0.40 fair agreement, 0.41–0.60 moderate agreement, 0.61–0.80 substantial agreement, and 0.81–1.00 indicated almost perfect agreement.

### 2.3. Agreement between caregivers' recall and HBR analysis

The total sample of 5713 children aged 12–59 months with available recall and HBR data from the 2016 vaccination coverage survey was used to assess the agreement between the two vaccination data sources (recall and HBR) for hepatitis B birth dose (HepB 0) and dose series of polio, diphtheria-tetanus-pertussis (DTP)-containing vaccines, *Haemophilus influenzae* type b (Hib)-containing vaccines, measles-containing vaccines (MCV) and rubella-containing vaccines (RCV). Concordance, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and the Kappa statistic were used for the assessment of caregivers' recall versus HBRs. Even though, neither recall nor HBR can be considered as the "gold standard" for vaccination status, we used HBRs as the reference to which recall was compared, as done by other authors [5]. The definitions for all statistical measures used are presented in Table 1. Concordance was defined as the percentage of children with "accurate" caregivers' recall, as compared to the HBR.

**Table 1**
Definitions of statistical measures used to assess agreement.

| | Vaccine dose present on home-based vaccination record (VDP) | Vaccine dose absent on home-based vaccination record (VDA) | |
|---|---|---|---|
| Caregivers' recall positive (CRP) | True positive (A) | False positive (B) | Positive Predictive Value = $\frac{A}{CRP}$ |
| Caregivers' recall negative (CRN) | False negative (C) | True negative (D) | Negative Predictive Value = $\frac{D}{CRN}$ |
| | Sensitivity = $\frac{A}{VDP}$ | Specificity = $\frac{D}{VDA}$ | Concordance = $\frac{A+D}{Total}$ |

### 2.4. Ethical considerations

All participants were informed about the voluntary nature of their participation and the confidentiality measures taken prior to their participation in the survey. Each child's caregiver consented orally before each interview and before HBR pictures were taken and for confidentiality, only the study team handled the database and pictures. The Institutional Review Board at Sagesse University of Lebanon reviewed and approved the study.

## 3. Results

### 3.1. Picture quality

Table 2 presents the image quality assessment of 500 randomly selected photographed HBRs. Image quality was high, with only a few pictures obstructed by a foreign body and less than 3% of pictures considered so blurred, overexposed or distorted as to be unreadable despite the fact that less than 10% of the pictures captured the complete HBR. Kappa statistics ranged from substantial to an almost perfect agreement between the two readers.

### 3.2. HBR content and design quality

The 500 HBRs in the sample were classified into three types. Type 1 (N = 206, 41.2%) represents the MoPH's Carnet de Santé, which may be used in both public and private sectors. Type 2 (N = 171, 34.2%) refers to other cards from the public sector. Type 3 (N = 123, 24.6%) were all other cards seen that do not fit into the two previous categories, coming from private sector, other countries, etc. (Fig. 1).

The assessment of HBRs' content and design quality was done for the 28 distinct HBRs seen (Fig. 2). The majority of cards had a higher score on core content criteria than design criteria. All cards included information about recommended vaccines per national immunization schedule (100.0%), had enough available space for the date of receipt of each vaccine and each dose (78.6%) as well as the health workers signature or authorization stamp for each vaccination received (46.5%). Regarding available space for the next routine vaccination visit and space for health worker narrative notes, only some cards included this. The vast majority of cards neither had a flexible design layout that accommodates future changes to the national immunization schedule, nor the card had a structured data input field format, nor had the national immunization schedule and recommended age for vaccination provided separately on the vaccination card. None of the cards prominently displayed the next date of vaccination. However, the majority of cards (55.4%) were neither written in at least two of Lebanon's official languages.

### 3.3. HBR quality

This analysis included 460 and 453 HBRs, as per the pictures that each reader considered of sufficient quality to go further to the card quality assessment (Table 3). Over 85% of cards did not have any visible physical damage, nor obstruction in the form of marks, hole punches or staples that would obstruct the ability to read information on the vaccination record. Handwriting on the form was assessed as fair for more than half of the sampled cards; however, for about one in five cards, the lowest categorization "poor" was given. Similarly, only in one in about five cards all responses fit in the space given on the card, but often this did not obstruct the readability of the information. Less than 15% of cards had evident corrections. If errors or corrections were made, these were often marked.

### 3.4. Agreement between caregivers' recall and HBRs

Out of 9315 surveyed caregivers of Lebanese and Syrian children, 8407 (90.3%) caregivers reported that the child ever had received a HBR, yet only 5713 (61.4%) of them were able to present vaccination cards. For 3375 (36.2%) children, only caregivers' recall was available to assess the vaccination status of the child. Only 227 children (2.4%) had never received any vaccination and did not have any available record.

Table 4 presents all statistical measures used to assess the agreement of caregivers' recall in comparison to HBRs (N = 5713). Agreement ranged between 47% for the third dose of Hib up to 93% for the first dose of polio. Concordance between sources decreased for all vaccines from first to last dose. Sensitivity of recall was above 80% for half of all vaccine doses evaluated, but it was lower the second and third dose of DTP, the first, second and third dose of HepB and all doses of Hib. Specificity did not reach 80% for any of the tested doses and was lowest for HepB birth dose and all doses of polio (<30%). The PPV was >75%, while the NPV was <60% for all doses of vaccines. Kappa statistic suggested slight to poor agreement for all HepB doses, all Hib doses and the second and third doses of polio (<0.20). All other doses, including the first dose of polio, all doses of DTP, MCV and RCV scored fair agreement between recall and HBR data.

**Table 2**
Quality of photographed home-based vaccination cards (N = 500), Lebanon CES 2016.

| Image Features | Criteria fulfillment status | | | | |
|---|---|---|---|---|---|
| | 1st Reader | | 2nd Reader | | Kappa |
| | Number | Percentage | Number | Percentage | |
| Is the image blurred, overexposed or distorted to a degree that you cannot read text within the image? | | | | | |
| No blur/distortion | 397 | 79.4 | 392 | 78.4 | 0.88 |
| Mild blur/distortion: still readable | 75 | 15.0 | 72 | 14.4 | |
| Moderate blur/distortion: portions are unreadable | 22 | 4.4 | 22 | 4.4 | |
| Severe blur/distortion: unreadable | 6 | 1.2 | 14 | 2.8 | |
| Is information lost because a foreign body is obstructing the image? | | | | | |
| No foreign body is obstructing the image | 481 | 96.2 | 476 | 95.2 | 0.83 |
| A foreign body is obstructing the image, but no information is lost | 5 | 1.0 | 11 | 2.2 | |
| A foreign body is obstructing the image, little information is lost | 4 | 0.8 | 2 | 0.4 | |
| A foreign body is obstructing the image, a lot of information is lost | 10 | 2.0 | 11 | 2.2 | |
| Images have been provided for the complete record (i.e., the vaccine page and cover page). | | | | | |
| Yes | 26 | 5.2 | 42 | 8.4 | 0.74 |
| No | 474 | 94.8 | 458 | 91.6 | |

**1.A.** Type 1 (Private/Public) – High quality

**1.B.** Type 1 (Private/Public) – Low quality

**1.C.** Type 2 (Public) – High quality

**1.D.** Type 2 (Public) – Low quality

**1.E.** Type 3 (All others) – High quality

**1.F.** Type 3 (All others) – Low quality

**Fig. 1.** Types of collected vaccination cards by image quality, Lebanon CES 2016.

## 4. Discussion

Our study is one of the first studies assessing the quality of HBRs using pictures collected during a vaccination coverage survey. It also adds to the scarce literature available on the validity of caregiver recall for vaccination compared to documented vaccination evidence in a middle-income country. First, the study illustrates that taking pictures of HBRs during a survey and extracting these data extemporaneously is feasible and that these images are useful to assess vaccination status by card and to assess the HBRs themselves.

This HBR quality assessment in Lebanon showed that most sampled cards fulfill core content criteria, yet a multiplicity of types of HBRs exist and they rarely satisfied the design criteria. Shortcomings exist with regards to the space given to write vaccine information as well as the health workers' handwriting on the cards. Another issue identified was that cards often lack the space for follow-up visits or additional notes which can jeopardize the continuity and accurate administration of vaccines to a child, particularly in the context of multiple existing entry points to receive vaccinations, high mobility of the child's family and absent electronic monitoring practices [7]. Given these findings, it is advisable to modify the design of the HBRs used in Lebanon to provide sufficient space for additional information.

In a pluralistic health system such as Lebanon's, the empowerment of caregivers to manage and actively participate in their child's vaccination can be a crucial determinant in ensuring that a child is vaccinated completely and timely, and HBRs are a key tool to accomplish this [7]. Raising caregivers' awareness about the importance of HBRs can be achieved through awareness efforts, starting with the promotion and use of HBRs by all providers of vaccines.

The agreement assessment between recall and HBR data suggested that not all caregivers were able to accurately recall their child's vaccination status, and that this may be worse for vaccines that require multiple doses. Thus, caregivers' recall may not be an accurate source of information for vaccination status, at least in the Lebanese context. While sensitivity was high, meaning that most caregivers correctly recalled their child's received vaccine doses, specificity was moderate or low depending on the type and dose

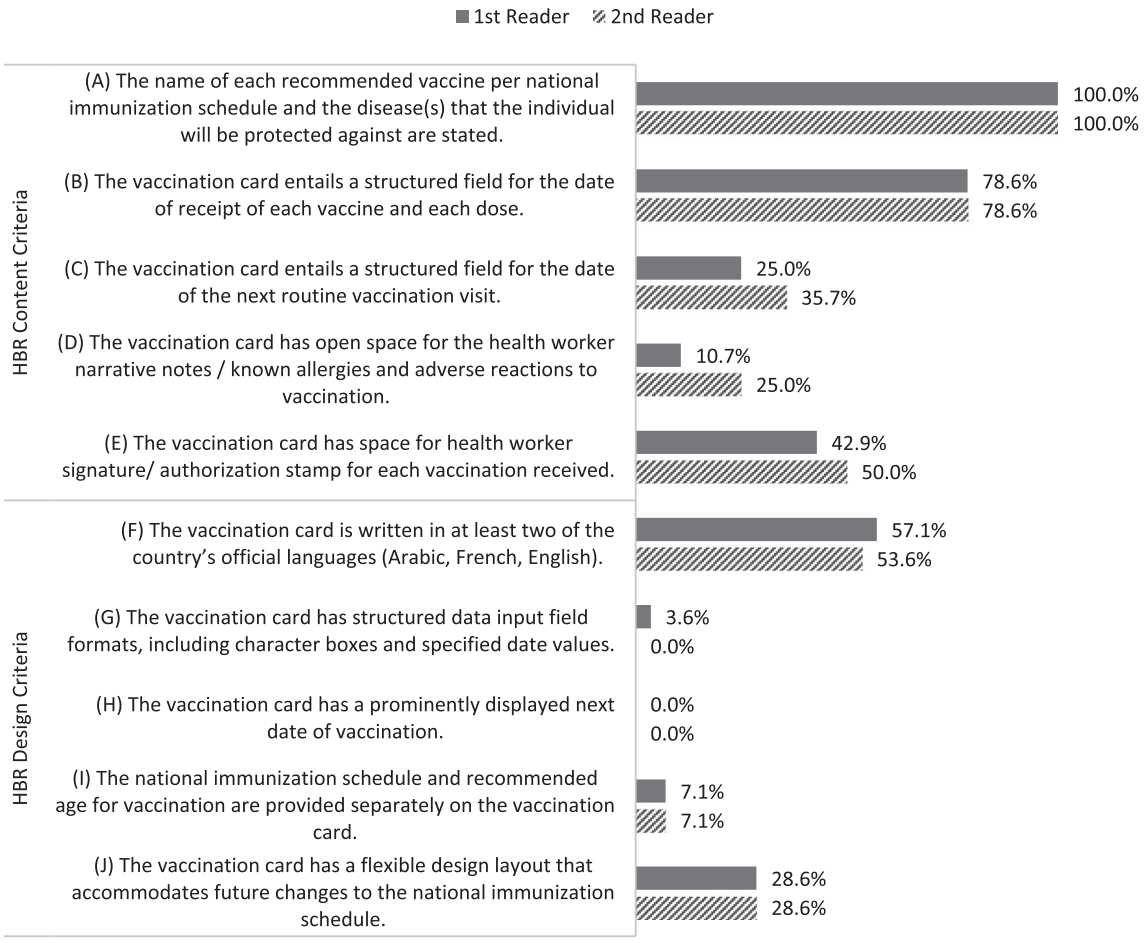


**Fig. 2.** Card content (A–E) and design quality (F–J) by reader, Lebanon CES 2016.

of vaccine; the latter suggesting that caregivers were not able to correctly recall if their child was not vaccinated with a particular vaccine. As the PPV was high overall, children whose caregivers reported that their child was vaccinated had actually received the vaccine dose. However, caregivers' reports were inaccurate with regards to under-vaccination. The lower NPV indicated that a substantial proportion of caregivers underestimated their children's vaccination status. These findings are worrisome, as relying on recall can introduce information bias to a vaccination coverage survey, particularly for vaccines that require multiple doses.

The results of this study have to be reflected upon in light of the following limitations. First, the card quality assessment was done regardless of the distribution of different card types in the randomly selected sample of 500 cards. Since some card quality criteria are related to the card type, the results are susceptible to selection bias because the assessment did not account for certain card types being more frequently assessed than others. Moreover, the definition of HBR quality was based on the qualitative assessment of two independent researchers, which potentially introduced misclassification bias, for example, the definition of a picture capturing the entire HBR may have been interpreted differently by each researcher. Nevertheless, Kappa statistics suggested high agreement in their assessments for most of the criteria used. Second, given that there is no gold standard, we had to assume that HBR information is more reliable than recall and used HBR as the comparator, when comparing two imperfect sources of data [5]. Unfortunately, medical records were not available as an additional reference point for comparison. Third, sample population characteristics such as nationality, age and sex were not used to better understand issues with HBRs and recall, as this was beyond the scope of our analyses. For example, Lebanese and Syrian children included in the assessment may behave differently affecting both availability of HBRs as well as caregivers' recall. Syrians are likely to have more mobility, are reached at an increasing number of used entry points to receive vaccinations, and may have a higher likelihood of losing a card and having less complete and timely vaccination for their children [15,18].

In spite of the above described limitations, our results have large public health implications. Other international studies have shown mixed results with regards to caregivers' recall, yet results of this study support that it is not advisable to rely on caregivers' recall to estimate vaccination coverage [19]. Inaccurate ascertainment of vaccination status lead to misinformation. Overestimation of vaccine coverage is dangerous, as pockets with under-vaccinated children may not be easily detected resulting in the risk of disease outbreaks and under-estimation may lead to unnecessary revaccination.

## 5. Conclusion and recommendations

This study illustrates that taking pictures of HBRs in a coverage survey is feasible and useful to conduct secondary analyses related to HBRs, such as assessing their quality and comparing recall with HBRs when both sources of data are available. There is a need to maintain health workers' awareness about the importance of understandable and standardized record keeping, as well as reminding parents to keep HBRs. The standardized usage will

**Table 3**
Quality of the home-based vaccination cards, Lebanon CES 2016.

| Criteria | Criteria Fulfillment Status | | | | |
|---|---|---|---|---|---|
| | 1st Reader (N = 460)* | | 2nd Reader (N = 453)* | | Kappa (N = 452)* |
| | Number | Percentage | Number | Percentage | |
| **Physical Condition** | | | | | |
| Is there evidence of physical damage (fading, tearing, creasing, water or liquid damage, mildew or mold, rodent, fire) to the extent that you cannot read all information on the vaccination card? | | | | | |
| No damage | 404 | 87.8 | 388 | 85.7 | 0.76 |
| Mild damage, but no information is lost | 37 | 8.0 | 37 | 8.2 | |
| Moderate damage, little information is lost | 12 | 2.6 | 17 | 3.8 | |
| Severe damage, a lot of information is lost | 7 | 1.5 | 11 | 2.4 | |
| Highlighting marks, hole punches or staples obstruct ability to read information on the form. | | | | | |
| No, no obstruction exists | 440 | 96.7 | 439 | 96.9 | 0.81 |
| Yes, mild obstruction exists | 12 | 2.6 | 6 | 1.3 | |
| Yes, moderate obstruction exists | 4 | 0.9 | 4 | 0.9 | |
| Yes, severe obstruction exists | 4 | 0.9 | 4 | 0.9 | |
| **Legibility** | | | | | |
| Handwriting on the form is clear and can be read. | | | | | |
| Excellent | 2 | 0.4 | 13 | 2.9 | 0.86 |
| Good | 78 | 17.0 | 87 | 19.2 | |
| Fair | 290 | 63.0 | 265 | 58.5 | |
| Poor | 90 | 19.6 | 88 | 19.4 | |
| Responses consistently fit in the space provided and do not infringe on other entry fields or require that information is written in margins or provided on attachments. | | | | | |
| Yes, all responses fit in the space | 99 | 21.5 | 119 | 26.3 | 0.81 |
| No, a few responses do not fit the space: still readable | 334 | 72.6 | 298 | 65.8 | |
| No, a few responses do not fit the space: portions are unreadable | 21 | 4.6 | 24 | 5.3 | |
| No, a lot of responses do not fit the space: unreadable | 3 | 0.7 | 11 | 2.4 | |
| Don't know | 3 | 0.7 | 1 | 0.2 | |
| Errors and corrections are clearly noted. | | | | | |
| Marked and new value legible, initialed | 44 | 9.6 | 42 | 9.3 | 0.97 |
| Marked and new value legible, not initialed | 2 | 0.4 | 4 | 0.9 | |
| Correction not clear/legible | 17 | 3.7 | 16 | 3.5 | |
| Non-applicable: no corrections evident | 397 | 86.3 | 391 | 86.3 | |

* When the image quality was defined as low by the two independent researchers (moderate or severe blur/distortion and/or little or a lot of information is lost because the picture is obstructed by a foreign body), the HBR was excluded from the card quality assessment.

**Table 4**
Agreement of vaccination status between caregivers' recall and vaccination home-based record per vaccine dose (N = 5,713), Lebanon CES 2016.

| Vaccine | Concordance (%) | Kappa (for agreement between recall and card) | Sensitivity (%) | Specificity (%) | Positive predictive value (%) | Negative predictive value (%) |
|---|---|---|---|---|---|---|
| HepB 0 dose | 75.7 | 0.17 | 87.7 | 27.8 | 82.9 | 36.1 |
| Polio 1st dose | 92.8 | 0.21 | 95.9 | 27.1 | 96.6 | 23.4 |
| Polio 2nd dose | 85.8 | 0.18 | 92.9 | 23.9 | 91.4 | 27.9 |
| Polio 3rd dose | 79.0 | 0.18 | 88.3 | 29.1 | 87.0 | 31.6 |
| DTP 1st dose | 81.2 | 0.22 | 83.1 | 56.5 | 96.0 | 21.1 |
| DTP 2nd dose | 72.3 | 0.23 | 72.9 | 67.3 | 94.5 | 24.2 |
| DTP 3rd dose | 67.0 | 0.25 | 65.6 | 74.0 | 92.8 | 29.7 |
| HepB 1st dose | 72.4 | 0.10 | 74.9 | 44.5 | 93.8 | 13.6 |
| HepB 2nd dose | 60.9 | 0.09 | 61.5 | 56.4 | 91.0 | 17.0 |
| HepB 3rd dose | 55.1 | 0.08 | 54.3 | 58.3 | 83.4 | 24.8 |
| Hib 1st dose | 53.3 | 0.04 | 52.5 | 62.1 | 94.2 | 10.1 |
| Hib 2nd dose | 48.0 | 0.06 | 45.1 | 70.1 | 91.9 | 14.5 |
| Hib 3rd dose | 46.7 | 0.07 | 41.2 | 74.0 | 88.7 | 20.3 |
| MCV 1st dose | 84.0 | 0.35 | 91.5 | 42.2 | 89.8 | 47.2 |
| MCV 2nd dose | 70.6 | 0.32 | 82.5 | 48.3 | 75.0 | 59.4 |
| RCV 1st dose | 69.7 | 0.21 | 83.5 | 36.3 | 76.0 | 47.7 |

HepB: hepatitis B.
DTP: diphtheria, tetanus, pertussis-containing vaccine.
Hib: *Haemophilus influenzae* type b.
MCV: measles-containing vaccine.
RCV: rubella-containing vaccine.

facilitate the utilization of cards by different health workers and will prevent potential misunderstandings on card content and more card availability will result in more accurate coverage evaluation survey results. Therefore, future studies are needed to examine the extent to which HBR content and design may be associated with improved utilization and retention of the record.

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## Conflict of interest

The authors do not have any competing interest.

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## Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2019.05.032.

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