

**Immunization coverage in young children:
A study nested into a health and demographic surveillance system
in Burkina Faso**

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Summary

Background: Reliable estimates of immunization coverage are the basis for rational policy making, program implementation and evaluation. Vaccination coverage is usually measured using administrative data or surveys, both having a number of methodological problems.

Methods: We estimated vaccination coverage using a dataset of 11,906 under five years children from an existing Health and Demographic Surveillance System (HDSS) in north-western Burkina Faso. Data was collected from September 2008 to December 2009.

Results: Vaccination coverage based on information from existing vaccination cards ranged from 80% (measles) to 94% (OPV1). When taking into consideration all information available (including BCG scars in children with and without vaccination card), full coverage in children aged 12-23 months was around 75%, with a significantly higher coverage in rural compared to urban areas. There were no differences in vaccination coverage between boys and girls.

Conclusion: The study supports other studies which found vaccination coverage improvement in Burkina Faso recently. In addition, our study found slightly better vaccination coverage in rural compared to urban areas, which needs further consideration.

Keywords: Immunization coverage, children under five, health and demographic surveillance system, Burkina Faso, West Africa

Introduction

Vaccination is an important tool for the control and elimination of infectious diseases [1, 2]. However, vaccine-preventable diseases remain a major cause of morbidity and mortality particularly among children under five years of age living in low income countries [3]. The large-scale application of available vaccinations with proven safety and efficacy against major childhood diseases is especially critical for achieving the fourth Millennium Development Goal [4].

In 1980 only a small proportion of children in low income countries was fully immunized with vaccines recommended by the World Health Organization (WHO), namely one dose of bacilli Calmette-Guérin vaccine (BCG), three doses of diphtheria-tetanus-pertussis vaccine (DTP), three doses of oral polio vaccine (OPV), and one dose of measles vaccine [5]. Immunization coverage has increased markedly over the last three decades. By 2009, 109 countries had achieved and maintained coverage with three doses of DTP vaccines at or above 90% for the previous three years [6]. There remain, however, large inequalities with regard to vaccination coverage, and these are particularly pronounced in sub-Saharan Africa (SSA) [5, 6].

Reliable estimates of vaccination coverage are the basis for rational policy making, program implementation and evaluation. Vaccination coverage is usually measured using administrative data (e.g. number of vaccine doses administered to a population), but this is often not correct due to problems with measuring population size and incomplete reporting of vaccinations [5, 6, 7, 8, 9]. Representative surveys such as the Expanded Program of Immunization (EPI) Cluster Survey, the UNICEF Multiple Indicators Cluster Survey (MICS) and the Demographic and Health Survey (DHS) are considered more reliable but are also having problems: they provide information only on previous birth cohorts, and the quality of data depends on training and supervision of teams [5]. Moreover, survey-based coverage estimates depend on documentation of data on vaccination cards and/or parental recall.

Thus, the availability of these cards and the quality of the information provided on such cards are the key for the reliability of data, and recall biases of unknown direction may play an important role [5]. The latest WHO and UNICEF immunization coverage estimates are based on a country-by-country review process considering administrative and survey data complemented by additional information and local expert opinion [5].

In Burkina Faso, high vaccination coverage ranging from 87.6% for measles to 98.7% for BCG in children aged between 12-23 months was reported in 2009 [10]. In this study we estimate vaccination coverage in young children of rural Burkina Faso through an existing health and demographic surveillance system (HDSS).

Methods

Study area

The HDSS of the *Centre de Recherche en Santé de Nouna* (CRSN) is situated in the Nouna Health District in north-western Burkina Faso. This HDSS area includes the town of Nouna and 58 surrounding villages. It covers a subset of the district with a multi-ethnic population of about 78.000, estimated in 2007 [11]. It is a very poor population consisting mainly of subsistence farmers. The education level is very low with 80% of adult women being illiterate [12]. Malaria is the main cause of morbidity and mortality particularly in young children, and access to health services is limited [13]. Formal health services are provided through 15 village-based health centres and the district hospital in Nouna town [14].

The expanded programme of immunizations (EPI) started in the early 1980s in Burkina Faso. Since the 1990s, the programme was based on following vaccines: Bacillus Calmette-Guérin (BCG), Diphtheria, Tetanus, Pertussis (DTP), Oral Polio Vaccine (OPV), measles and yellow fever. In 2006, the trivalent DTP regimen was replaced by the pentavalent (DTPHibHepB) regimen. The nationally recommended time frame is now BCG + OPV0 at birth,

DTPHibHepB1 + OPV1 at eight weeks, DTPHibHepB2 + OPV2 at 12 weeks, DTPHibHepB3 + OPV3 at 16 weeks, and measles + yellow fever vaccination at 9 months [10]. The EPI in Burkina Faso has set the goal to ensure complete and timely immunization for at least 80% of eligible children in the country [15].

Study design and procedures

This is a study nested into the existing Nouna HDSS. It is part of an EU-funded multi-country study on the determination of unspecific effects of EPI vaccines in children of West Africa (OPTIMUNISE Study).

The Nouna HDSS performs regular household visits to collect data on vital events [11]. Over the period September 2008 to December 2009, a questionnaire on vaccination details concerning children less than five years of age was added to the routine HDSS procedures. This questionnaire was filled in every household of the study area by the HDSS team. During these visits, the following procedures took place: First, the mother or the father (or other household members when parents were not available) of children under five living in the HDSS area were asked whether their child had been vaccinated at least once and whether a vaccination card had been issued. If a vaccination card was available, it was reviewed and all data on EPI vaccinations and related information (e.g. vaccines received through campaigns, vitamin A supplementation) were recorded. Third, the interviewers examined all children regarding the presence or absence of a BCG scar on the left upper arm and measured the size if existing. Thus, the survey aimed at children within the Nouna HDSS born between September 2003 and March 2009.

Data analysis

The parental response to the question if the child had ever been vaccinated, the parental response on the availability of vaccination cards, the assertion of the field worker whether the vaccination card has been seen or not, the availability of the exact date of vaccine

administration, the sex and the age of the child at visit and the place of household (urban, rural) were considered in analysis. Data were analyzed using Stata MP 11.

According to the assertion of the field worker whether a vaccination card existed, we defined two groups of children for the determination of vaccination coverage: First, children whose vaccination cards had not been seen by the interviewer; second, children whose vaccination cards had been seen by the interviewer. Vaccine coverage was calculated for the latter group and the following descriptions were performed:

- Vaccination coverage according to specific vaccines (BCG, OPV, DTP, Haemophilus influenzae type B vaccine (Hib), Hepatitis B vaccine (HBV), measles vaccine and yellow fever vaccine)
- Fully immunized children (children aged between 12-23 months) and fully immunized children before one year of age who have received one dose of BCG; three doses of OPV, three doses of DTP, Hib, HBV, and one dose of measles vaccine

Finally, we analyzed if there were differences in vaccination coverage with respect to sex, age and locality.

Statistical analysis

The chi-square test was used for comparing proportions in vaccination coverage between males and females and between rural and urban locality.

Ethical aspects

The protocol for this study was approved by the local Ethical Committee in Burkina Faso. Informed community consent was sought for the implementation of the additional survey questionnaire during routine HDSS procedures.

Results

Characteristics of the study population

Table 1 provides the overall demographic and the vaccination characteristics of the study population. Roughly 90% of the respondents were the mothers of the study children and the majority (80%) of the study population was living in rural areas.

The study population consisted of 11,906 children under five born between September 2003 and March 2009. At time of the survey, there were 2,129 (18%) children between 0 and 11 months, 2,593 (22%) children between 12 and 23 months, 2,364 (20%) children between 24 and 35 months, 2,326 (19%) children between 36 and 47 months and 2,494 (21%) children between 48 and 59 months. About 50% of the all children were boys.

	Age group					Total
	Age < 1 year	1 ≥ age < 2 years	2 ≥ age < 3 years	3 ≥ age < 4 years	4 ≥ age < 5 years	
Study population						
Boys	1,064 (17.94%)	1,278 (21.54%)	1,165 (19.64%)	1,167 (19.67%)	1,258 (21.21%)	5,974 (50.20%)
Girls	1,065 (17.83%)	1,315 (22.01%)	1,199 (20.07%)	1,159 (19.40%)	1,236 (20.69%)	5,932 (49.80%)
Place of living						
Urban (Nouna town)	386 (18.13%)	482 (18.59%)	479 (20.26%)	511 (21.97%)	541 (21.69%)	2,399 (20.15%)
Rural	1,743 (81.87%)	2,111 (81.41%)	1,885 (79.74)	1,815 (78.03%)	1,953 (78.31%)	9,507 (79.85)
Type of respondent						
Mother	2,036 (95.53%)	2,403 (92.67%)	2,143 (90.65%)	2,058 (88.48%)	2,177 (87.29%)	10,817 (90.85%)
Oder household members	93 (4.37%)	190 (7.33%)	221 (9.35%)	268 (11.52%)	317 (12.71%)	1,086 (9.15)
Availability of vaccine card (parental recall)						
Yes	1,844	2,077	1,654	1,347	1,265	8,187

	(86.61%)	(80.10%)	(69.97%)	(57.10%)	(50.72%)	(68.76%)
No	280 (13.15%)	508 (19.59%)	703 (29.74%)	956 (41.10%)	1,213 (48.64%)	3,660 (30.74%)
Don't know	5 (0.23%)	8 (0.31%)	7 (0.30%)	23 (0.99%)	16 (0.64%)	59 (0.50%)
Availability of vaccine card (Card seen)						
Yes	1,794 (84.26%)	2,006 (77.36%)	1,524 (64.47%)	1,207 (51.89%)	1,113 (44.63%)	7,644 (64.20%)
No	335 (15.74%)	587 (22.64%)	840 (35.53%)	1,119 (48.11%)	1,381 (55.37%)	4,262 (35.80%)
Vaccination status (parental recall)						
Has received at least one vaccine	1,926 (90.47%)	2,442 (94.18%)	2,189 (92.60%)	2,111 (90.76%)	2,250 (90.22%)	10,918 (91.70%)
Has never received vaccine	198 (9.30%)	144 (5.55%)	165 (6.98%)	196 (8.43%)	226 (9.06%)	929 (7.80%)
Don't know	5 (0.23%)	7 (0.27%)	10 (0.42%)	19 (0.82%)	18 (0.72%)	59 (0.50%)
BCG scar visible (fieldworker)						
Yes	1,303 (61.20%)	1,659 (63.98%)	1,569 (66.37%)	1,480 (63.63%)	1,474 (59.10%)	7,485 (62.87%)
No	621 (29.17%)	714 (27.54%)	573 (24.24%)	624 (26.83%)	753 (30.19%)	3,285 (27.59%)
Missing	205 (9.63%)	220 (8.48%)	222 (9.39%)	222 (9.54%)	267 (10.71%)	1,136 (9.54%)
Total	2,129 (17.87%)	2,593 (21.78%)	2,364 (19.86%)	2,326 (19.54%)	2,494 (20.95%)	11,906 (100%)

Table 1: Characteristics of the study population in north-western Burkina Faso

Roughly two thirds (69%) of the respondents asserted that a vaccination card had been issued for their children. The proportion of vaccination cards seen by interviewer was slightly lower (64%). The proportion of vaccination cards reported as existing and of vaccination cards seen diminished progressively with increasing age, from 84% in infants to 45% in children aged between four and five years, and this difference is highly significant ($p < 0.001$)

(figure 1). In the age group 12-23 months, the proportion of available vaccination cards was 77%. There were no differences between boys and girls regarding the availability of vaccination cards but these documents were more frequently seen in the urban compared to the rural study area (73% vs. 62%, $p < 0.0001$).

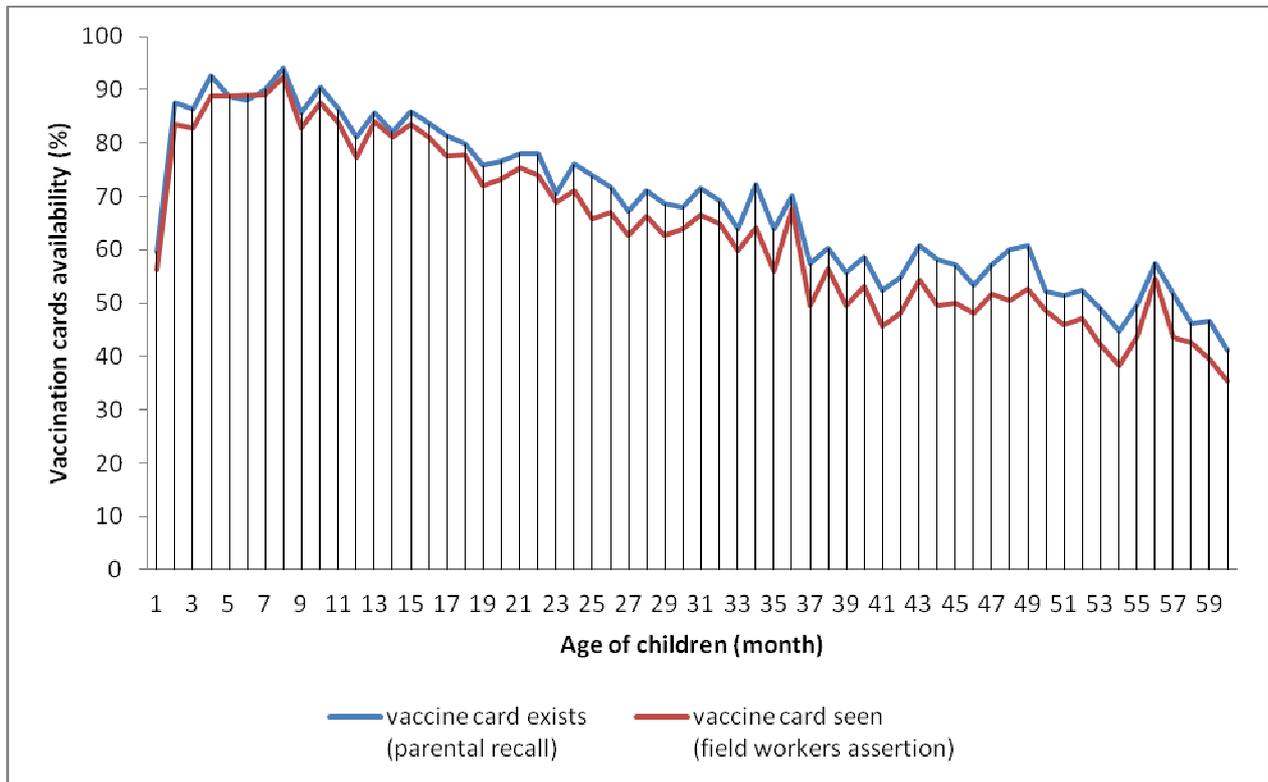


Figure 1: Associations between availability of vaccination cards and age of study children in north-western Burkina Faso

A total of 92% of children in the study area had received at least one vaccination according to parental recall. This rate is even higher (94%) if only mother's responses are considered, and substantially lower (62%) if only the responses of other household members are taken into consideration. A BCG scar was seen by the fieldworkers in 63% of the study children without major differences between age groups.

Vaccination coverage of study children

Children without vaccination cards

The proportion of children in this group who received at least one vaccination according to parental recall was 78%, and the proportion of children with BCG scar was 49%. A BCG scar was seen more frequently in urban as compared to rural children (50% vs. 44%, $p < 0.0001$).

Children with vaccination cards

Table 2 shows the findings in the group of children with a verified vaccination card. In this group, the proportion of children who received at least one vaccine according to parental recall was 99%, without differences between girls and boys and without differences between rural and urban areas. The proportion of children with a BCG scar was 71%, without significant differences between urban and rural or male and female.

Vaccination status (parental recall)	Sex		Place of living		Total
	Girls	Boys	Urban	Rural	
Has received at least one vaccine	3,763 (99.26%)	3,814 (99.01%)	1,719 (98.68%)	5,858 (99.25%)	7,577 (99.13%)
Has never received vaccine	27 (0.71%)	38 (0.99%)	23 (1.32%)	43 (0.73%)	66 (0.86%)
Don't know	1 (0.03%)	0 (0.00%)	0 (0.00%)	1 (0.02%)	1 (0.01%)
BCG scar					
Yes	2,665 (70.30%)	2,736 (71.03%)	1,227 (70.44%)	4,174 (70.72%)	5,401 (70.66%)
No	981 (25.88%)	984 (25.55%)	448 (25.72%)	1,518 (25.72%)	1,966 (25.72%)
Missing data	145 (3.82%)	132 (3.43%)	67 (3.85%)	210 (3.56%)	277 (3.62%)
Total	3,971 (100%)	3,852 (100%)	1,742 (100%)	5,902 (100%)	7,644 (100%)
Vaccination coverage					
BCG	3,558 (93.83%)	3,582 (92.99%)	1,649 (94.66%)	5,491 (93.04%)	7,140 (93.41%)
Polio 0	3,501 (92.33%)	3,545 (92.03%)	1,625 (93.28)	5,421 (91.85%)	7,046 (92.18%)
Polio 1*	3,464 (94.34%)	3,494 (94.10%)	1,577 (94.04%)	5,381 (94.27%)	6,958 (94.22%)
Polio 2**	3,308 (90.09%)	3,344 (90.06%)	1,465 (88.95%)	5,178 (92.71%)	6,643 (91.86%)
Polio 3***	3,121 (88.77%)	3,120 (88.26%)	1,312 (81.44%)	4,929 (90.61)	6,241 (88.51%)
All polio 1-3 doses****	3,115 (88.59%)	3,111 (88.01%)	1,309 (81.25%)	4,917 (90.39%)	6,226 (88.30%)
Tetra/pentavalent1*	3,422 (93.19%)	3,448 (92.86%)	1,550 (92.43%)	5,320 (93.20%)	6,870 (93.03%)

Tetra/pentavalent2**	3,290 (91.34%)	3,311 (91.21%)	1,454 (88.28%)	5,147 (92.16%)	6,601 (91.27%)
Tetra/pentavalent3***	3,096 (88.05%)	3,084 (87.24%)	1,306 (81.07%)	4,874 (89.60%)	6,180 (87.65%)
All tetra/pentavalent 1-3 doses***	3,086 (87.77%)	3,076 (87.02)	1,301 (80.76%)	4,861 (89.36%)	6,162 (87.39%)
Measles****	2,468 (79.38%)	2,475 (79.63%)	1,039 (71.26%)	3,904 (82.03%)	4,943 (79.51%)
Yellow Fever*****	2,479 (79.74%)	2,488 (80.05%)	1,045 (71.67%)	3,922 (82.41%)	4,967 (79.89%)
Vaccination coverage (campaign)					
Measles	272 (7.17%)	274 (7.11%)	95 (5.45%)	541 (7.64%)	546 (7.14%)
Yellow fever	12 (0.32%)	14 (0.36%)	5 (0.29%)	21 (0.36%)	26 (0.35%)
Meningitis	8 (0.21%)	9 (0.23%)	4 (0.23%)	13 (0.22%)	17 (0.22%)
Fully immunization coverage					
Fully immunized (12-23 months)	803 (81.00%)	812 (80%)	313 (76.50%)	1,302 (81.50%)	1,615 (80.51%)
Partially immunized(12-23 months)	169 (17.00%)	176 (17.30%)	83 (20.30)	262 (16.40%)	345 (17.20%)
Not immunized(12-23 months)	19 (2.00%)	27 (2.70%)	13 (3.20)	33 (2.10%)	46 (2.30%)
Fully immunized before one year of age	747 (75.40%)	762 (75.00%)	286 (70.00%)	1,223 (76.60%)	1,509 (75%)
Full immunization (12-59 months)	2,282 (78.66%)	2,292 (77.72%)	956 (68.88%)	3,618 (81.08%)	4,574 (78.19%)

Table 2: Vaccination coverage in study children based on verified information on vaccination cards in north-western Burkina Faso

*Only children aged more than the recommended age (2 months) of polio 1 or tetra/pentavalent1

**Only children aged more than the recommended age (3 months) of polio 2 or tetra/pentavalent2

***Only children aged more than the recommended age (4 months) of polio 3 or tetra/pentavalent3

****Only children aged more than the recommended age (9 months) of measles and yellow fever

Vaccination coverage for the individual antigens based on the verified information on routine EPI vaccinations was very high for BCG, OPV and DTP/DTPHibHepB vaccinations ranging from 94% polio1 to 87% DTP/DTPHibHepB3, and high for measles and yellow fever vaccination (80%). There were no differences in vaccination coverage between boys and girls, but there was a tendency towards higher vaccination coverage in rural as compared to

urban areas, which reached significance for OPV2 and 3 (93% vs. 89%, $p < 0.0001$; 91% vs. 81%, $p < 0.0001$) or for DTP/DTPHibHepB2 and 3 (92% vs. 88%, $p < 0.0001$; 90% vs. 81%, $p < 0.0001$) as well for all three doses of OPV and DTP/DTPHibHepB (90% vs. 81%, $p < 0.0001$; 89% vs. 81%, $p < 0.0001$). Information on vaccines received during campaigns was not (polio campaigns) or rarely (meningitis, yellow fever and measles campaigns) recorded. According to the data from vaccination cards, only 7% of our study population had received additional measles vaccination during such campaigns.

Full vaccination coverage among children aged 12-23 months

Based on the vaccination card-verified information regarding routine EPI vaccine coverage, the proportion of children aged 12-23 months who were fully immunized was 81% (1,615/2006) and the proportion of children fully immunized already before one year of age was 75% (1,509/2006). In both cases, more children were fully immunized in rural as compared to urban areas (82% vs. 75% and 77% vs. 70%; $p < 0.01$ and $p < 0.01$).

In the population of the children aged 12-23 months, 77% had a vaccination card and 68% had a BCG scar. In this group 81% were fully vaccinated. Among the 23% of children without a card, 47% had a BCG scar. We assume that the ratio of the prevalence of BCG scars between those with or without vaccination card is the same as the ratio of fully vaccinated between those with or without vaccination card. This yields an estimate of $47 \cdot 81 / 68 = 56\%$ of children fully vaccinated but without a card. Therefore, the actual full vaccination coverage in the whole population of children aged 23-23 months is likely around ($81\% \cdot 0.77 + 56\% \cdot 0.23 = 75.25\%$) 75% with a significant difference between rural and urban area (76% in rural vs. 72% in urban, $p < 0.01$) (table 3).

		Place of residence		
		Urban	Rural	All study area
Vaccination cards available	Yes	417/491 (85%)	1,589/2102 (76%)	2,006/2,593 (77%)
	No	74/491 (15%)	513/2102 (24%)	587/2,593 (23%)

Prevalence of BCG scar	Among children with vaccination card	280/417 (67%)	1,091/1,589 (69%)	1,371/2,006 (68%)
	Among children without vaccination card	35/74 (49%)	241/513 (47%)	276/587 (47%)
Full immunization	Among children with vaccination card	313/417 (75%)	1,302/1,589 (82%)	1,615/2006 (81%)
	Among children without vaccination card	55%	56%	56%
	All children	72%	76%	75%

Table 3: Full vaccination coverage and prevalence of BCG scar (12-23 months old children which have received routine vaccinations)

Discussion

Survey-based vaccination coverage estimates depend on documentation of data on vaccination cards and/or parental recall [5, 16]. In this study, about 90% of the respondents were mothers of study children. According to respondents, overall 92% of children had received at least one vaccination (99% with and 78% without a verified vaccination card). However, vaccinations were not specified and answers may likely be confused with vaccinations received during campaigns. On the other hand, campaign vaccinations are not regularly documented on vaccination cards, which concerns in particular polio campaigns. However, campaigns were rather frequent during the study period (2 measles campaigns and 17 polio campaigns from 2004 until 2009) [10]. As parental recall can be considered to be rather imprecise in a largely rural population with a very low education level, the coverage estimates of this survey are primarily based on children with verified vaccination cards.

The main finding of this study is rather high vaccination coverage of young children in an area of north-western Burkina Faso, which has always been characterized by coverage rates significantly below the national average [17, 18, 19]. Based on verified information from existing vaccination cards, the coverage in children aged 12-23 months was 93%, 89%, 88% and 80% for BCG, OPV3, DTP/DTPHibHepB3 and measles/yellow fever vaccination, respectively. This supports similar findings from a national MICS conducted between 2005

and 2007 and from a national EPI Cluster Survey conducted in 2009 in Burkina Faso [10, 20]. Mean national BCG vaccination coverage, for example, ranged from 89.7% to 98.1% [20].

When taking into consideration all information available (including BCG scars in children with and without vaccination card), full immunization coverage in children aged 12-23 months was 75% with a significantly higher coverage in the rural as compared to the urban study area. This finding documents an important increase in the proportion of children fully immunized since the proportion of fully immunized children aged 12-23 months was only 50% in 2003 in this area [21].

About a quarter of children aged 12-23 months could not show a vaccination card, and this group was characterized by lower vaccination coverage according to parental recall and by lower prevalence of BCG scars compared to children with verified vaccination card. This corresponds well to the latest national DHS data from Burkina Faso reporting an overall 17% of children not having a vaccination card [22]. Our findings do not support suggestions [23] to consider all children without an available vaccination card as unvaccinated. However, previous study in the Nouna area reported that children with vaccination cards in bad condition or who had lost their cards were sometimes refused to be vaccinated [23]. Thus, the estimates for vaccination coverage in the Nouna study area have to be corrected slightly downwards.

For some vaccinations as well as for the full vaccination coverage, coverage was lower in the urban as compared to the rural study area. This supports findings from a former study conducted in the same study area which provided socio-demographic and socio-economic differences between urban and rural populations as an explanation [19]. In contrast and for unknown reasons, vaccination card availability was slightly higher in urban as compared to rural areas. Vaccination card availability clearly decreased with age both in urban and in rural

areas which is most likely explained by a combination of increased vaccination coverage and losses of cards over time.

In this study there were no difference in the vaccination coverage between boys and girls, which is in contrast to lower immunization coverage in girls reported from South Asia [25]. The finding of this study supports the results of preceding studies in the same area, at the national level in Burkina Faso or in Mali, a neighbouring country [19, 26, 27, 28].

The strength of this study is that it has been carried out in a large population of children under five years, and that the data have been collected from a very experienced field team in the frame of an HDSS. The main study limitation is that it is confined to one health district of the country and that data are thus not representative for the whole of Burkina Faso.

In conclusion, the results from this study confirm the achievement of high EPI vaccination coverage in recent years in Burkina Faso, with a demonstration of slightly higher coverage rates in rural as compared to urban areas.

Conflict of interests

We declare that we have no conflicts of interest.

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