

INFECTIOUS DISEASES

Choosing immunisation coverage indicators at the local level

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Abstract. *Background:* The reliability of information sources, as well as the precision of coverage indicators are open questions for immunisation coverage surveys. *Methods:* A sample survey of 323 children from two birth cohorts (1991–1992 and 1979–1981) was done. The sample was selected from seven health districts out of 51 in the Lazio region. The information was collected from vaccination cards or from parents, using a mail-in questionnaire. We computed three indicators of coverage at 24 months of age for polio, diphtheria–tetanus, pertussis (P), hepatitis B, and measles (M), depending on the value given to parental recall. We also compared up-to-date (UTD) (immunised children at 24 months) and age-appropriate (months at risk per child) indicators at the local level. *Results:* Response rate was 68.2%. The two birth cohorts were similarly immunised for polio (coverage 95%); the younger cohort had higher cov-

erage levels for diphtheria–tetanus (93% vs. 75%), for P (30% vs. 22%), for M (43% vs. 16%) than the older one, even on the basis of parental recall. In the older cohort, diphtheria–tetanus, P and M coverage levels were 75, 22 and 15%, respectively, on the basis of parental recall and 66, 17 and 4% on certification. The age-appropriate indicator revealed four districts that completed vaccinations significantly too late, while the UTD indicator showed only one district significantly below the threshold of 95% of immunized children at 24 months. *Conclusions:* Parental recall and data from cards are comparable sources, but the former is more sensitive than the latter in retrospective studies. Verbal recall should be accepted as reasonably reliable in the absence of cards. Age-appropriate indicators give a more complete evaluation of the susceptibility in the population, and are more precise at the local level.

Key words: Age-appropriate indicators, Immunisation coverage, Parental recall, Up-to-date indicators

Abbreviations: CDC = Centers for Diseases Control; CI = confidence intervals; DT = diphtheria vaccine and tetanus toxoid; HBV = hepatitis B vaccine; M = measles; OPV = oral polio vaccine; P = pertussis; UTD = up-to-date; UTD24 = up-to-date vaccinations at 24 months

Introduction

Monitoring vaccination coverage levels is an important aid in detecting under-vaccinated populations and in evaluating the effectiveness of health services [1, 2]. The results are essential in defining the parameters in modelling the occurrence of infectious diseases and epidemics [3]. The indicators used in monitoring vaccination coverage should reflect the adequacy of protection against infectious diseases as accurately as possible, describe the effectiveness of services from the local to the national level, and provide information that will help health services in their efforts to increase coverage. The most frequently used immunisation coverage indicators are currently those measured at a given age and termed “up-to-date” (UTD) [4–7]. What age to choose is an important question in the use of this indicator. Vaccination coverage at 24 months was proposed by the Centers for Diseases Control (CDC) as an early indicator of pre-school

immunisation coverage [4–5]. These indicators are used at both the national and the regional levels. Some authors [8–12] have proposed that immunisation indicators that account for timing (“age-appropriate”) reflect the adequacy of immunisation more accurately than UTD indicators, since the former consider the earliest possible protection. They have shown a very interesting relation between the two indicators in that the delay of first vaccination until after 3 months of age was the strongest predictor of inadequate vaccination at 24 months.

Another important question about immunisation coverage indicators concerns the sources of information. Some studies conclude that information given by parents cannot be relied on to provide accurate immunisation histories [13, 14], while others find that parents’ reports on children’s vaccination status are generally acceptable for research purposes and result in improved estimates of immunisation coverage [15, 16].

The results reported are from a survey on vaccination status for the most essential vaccinations (against poliomyelitis, diphtheria, tetanus, pertussis, measles, hepatitis B) from two different birth cohorts, in seven local health units to identify the most valid estimates of vaccination coverage at the local level. Specific objectives were to compare different sources of information and to compare one UTD vaccination coverage with one age-appropriate at the local level.

Methods

Study design

In 1997–98 a retrospective immunisation coverage survey was conducted in seven of the 51 health districts in the Lazio region, geographically representative. Lazio has about 5.2 million inhabitants (51,000 newborns per year), including the metropolitan area of Rome with about 3 million inhabitants. The sample size was determined by considering the immunisation status of the population as a binomial variable. We assumed a confidence interval of 95%, a proportion of vaccinated people with polio vaccine of 95%, and a precision of 5% for the entire region and of 10% for each of the seven districts. Then two samples of 323 people each were randomly selected from the Register's Offices: 9173 children born between 15 June 1991 and 30 September 1992 and 15,145 teen-agers born between 15 June 1979 and 14 June 1981. The children had to be residents in the area at the time of the interview (December 1997–September 1998). Deceased children were not included.

The sample's size was proportional to the district size and ranged from 26 to 71 children born in 1991–1992, and from 32 to 71 teen-agers born in 1979–1981. The subjects were 5–7 years old and 16–19 years old, respectively, at the time of the interview.

Both compulsory and recommended vaccinations were included in the study. The compulsory vaccinations for newborns in Italy in the 1980s and 1990s were: oral polio vaccine (OPV), diphtheria vaccine and tetanus toxoid (DT) and hepatitis B vaccine (HBV). Each were given in three doses, the first in the third month of life, the second 6–8 weeks later, the third during the 11th or 12th month. HBV has been compulsory since 1991. Recommended vaccinations were pertussis (P) and measles (M). The former was given in three doses, scheduled like DT, and the second in one dose at the age of 15–18 months.

Data sources

Information on vaccinations was obtained by a questionnaire sent to parents. Those who did not respond to the second mailing were contacted by telephone or in person, if a telephone number was

unavailable. Six attempts of phone contact or two home visits were attempted before the subject was classified as "lost". Although vaccinations, wherever they are administered, should be registered by the public health services, only 60% were registered in the time interval of the study [17]. There are no uniform requirements for recording data, nor is there a regional registry. Since so many vaccinations go unregistered, this source could not be used for the validation of questionnaires. Parents were asked to report the dates of polio, DT, HBV, P, and M vaccines received as registered on cards or in booklets. The form had spaces for up to four dates for each vaccine, except M which had two. If they had no certificates or if they remembered a vaccination administered that was not reported in the cards, parents were asked to report the vaccination according to their recall, without dates.

Definitions

Subjects were classified into four groups: (A) children immunised at 24 months with dates obtained from card or booklet only, (B) children immunised according to parental recall, (C) immunisation status not known, i.e. the parents reported "I don't remember" and the card was blank or missing and, (D) child not immunised at 24 months, including those partially immunised with two doses of OPV, DT, P and HBV.

UTD vaccinations at 24 months (UTD24) indicate receipt, by the 24th month of age, of the third dose of OPV, DTP and HBV vaccines and one dose of M vaccine, regardless of the interval between doses. For OPV, DTP and HBV vaccines, we use the confirming dose, one more than the protective one, because most currently published reports use this dose for analyses [8, 10]. We expressed the UTD vaccination coverage with three different rates, based on the groups of people included in the numerator and in the denominator, as reported below:

- (1) The first indicator was calculated as $A/(A + C + D)$. We excluded children whose vaccination dates were not registered on their own cards or booklets.
- (2) The second indicator was calculated as $A/(A + B + C + D)$. We considered as non-immunised those children whose vaccinations were established by parental recall only.
- (3) The third indicator was calculated as $(A + B)/(A + B + C + D)$. We considered immunised those children without cards but with substantiation by parental recall.

Age-appropriately immunised children are defined as those who received all scheduled vaccinations at the recommended age [10, 11]. We used the recommended age for the protective dose (i.e. fourth–fifth month for the second dose of OPV and DT vaccines, administered at least 4 weeks after the first dose). We calculated the oldest age still "appropriate", in

keeping with the Italian schedule, as 5 months for the second dose. We expressed the age-appropriate indicator as “*at-risk months*” per child as the time before receiving the protective dose; the at-risk months after the fifth month are considered preventable. A month was defined as 30.4 days. Children who did not receive the protective dose were considered as at risk for 60 months, approximately the age of the younger children at the time of the interview. The rationale of this choice is that the duration of a protective level of antibodies for DTP and HBV vaccines after the second dose is 5 years. If the second dose was administered before the four week interval we considered the third dose as protective.

Card/booklet contents, distribution policies of vaccines and/or practices did not differ between the older and younger age cohort.

Analysis

We computed response rates in the sample, and compared the distribution of respondents by mail, phone and home visit per birth cohort. The three UTD indicators were calculated weighing for response rate by district, for OPV, DT, HBV, P and M vaccinations. The 95% confidence intervals (95% CI) were calculated considering the design effect. We compared these three indicators in the two birth cohorts, and within each birth cohort, we compared the first UTD indicator ($A/(A+C+D)$) to the third ($(A+B)/(A+B+C+D)$) and the second UTD indi-

cator ($A/(A+B+C+D)$) to the third. The preventable months at risk per child and their 95% CI were calculated for OPV and DT vaccinations for the younger children, at the district level. For this birth cohort, we compared the age-appropriate and the UTD indicators according to the first definition, i.e. excluding children reported as immunised by parental recall only, at the district level. We used the Stata 6.0 package for the analysis [18].

Results

The proportion of male respondents in the older cohort was equivalent to that of the regional population born in 1979–1980 (53 vs. 51%), but in the younger cohort there were 60% male respondents vs. 51% in the corresponding regional population ($p = 0.2$).

We obtained an overall response rate of 68.2% with no difference between the two cohorts. Forty-eight percent of the sample responded by mail, 11% by phone and 9% in person (Table 1). The respondents for each district ranged from 54.8 to 76.9% in the younger cohort and from 53.3 to 77.5% in the older, showing no significant differences (Pearson $\chi^2 = 6.76$; $p = 0.34$ in the younger cohort and Pearson $\chi^2 = 11.43$; $p = 0.08$ in the older one). Immunisation against DT, P and M was less frequent among children whose parents had to be contacted by phone or in person at home (Table 2), the difference is statistically significant for P (χ^2 for linear trend = 4.38;

Table 1. Percentage of respondents by kind of surveying and non-respondents in the two cohorts

	1991–1992		1979–1981		Total	
	N	%	N	%	N	%
Respondents	222	68.5	219	67.8	441	68.2
Mail	154	47.5	158	48.9	312	48.2
Phone	49	15.1	20	6.2	69	10.7
home visit	19	5.9	41	12.7	60	9.3
Refusal	29	9.0	54	16.7	83	12.8
Unreachable	73	22.5	50	15.5	123	19.0
Total	324	100	323	100	647	100

Table 2. Number and percentage of immunized children for DT, P and M by kind of surveying, birth cohort 1991–1992.

	DT3 ^a		Pertussis 3 ^a		Measles ^b	
	N	%	N	%	N	%
Mail	143	94.7	49	32.5	76	49.4
Phone	43	87.8	12	24.5	16	32.7
Home visit	17	89.5	2	10.5	3	15.8
	203	92.9	63	29.3	95	43.4

^aAccording to the first UTD24 indicator, children reported by parents as vaccinated were excluded. χ^2 for linear trend for DT3 = 2.16; $p = 0.14$; for Pertussis 3 = 4.38; $p = 0.036$.

^bAccording to the third UTD24 indicator, children reported by parents as vaccinated were considered immunized. χ^2 for linear trend for M: 11.1, $p = 0.0009$.

$p = 0.14$) and measles (χ^2 for linear trend = 11.1; $p = 0.0009$).

The number of children with vaccinations verified by parental recall alone and those with unknown immunisation status is smaller in the younger cohort, for all the vaccinations (Table 3).

According to the first UTD24 indicator, which uses cards as source of vaccination data and excludes children reported as immunised only by their parents, about 95% of the children in each cohort received a third dose of polio vaccine by 24 months of age. There are important differences between cohorts for the other vaccinations: for DT 93% in the younger cohort and 72% in the older received three doses; for P 29 and 18%, respectively, received three doses, and for M 40 and 5%, respectively, received at least one dose (Figure 1). According to the second UTD24 indicator, which classifies those children whose vaccination were verified by parents' recall alone as "non-immunised", the coverage was lower than the first indicator for the younger cohort (maximum difference 2.5%) and even lower in the older one (maximum difference 10.3%), but coverage levels maintain the same pattern in each cohort (Figure 1). The third UTD24 indicator, based on parental recall, produced, in both cohorts, immunisation coverages similar to the first indicator for vaccinations with high coverage. It produced higher coverage for P and M in the older cohort (Figure 1). At the district level, the UTD24 for polio and DT vaccinations ranged between 85 and 100% in the younger population (Figure 2). Four districts reached the threshold of 95% of immunized children at 24 months for polio, but the confidence intervals included this threshold. Only one district was significantly under the threshold of 95% of 24 months coverage.

The preventable at-risk months for polio in the same cohort ranged from 4.8 to 8.1. In one district the average at-risk period was less than 5 months, while in four districts this period was significantly longer than 5 months (Figure 2). For the DT vac-

nation, two districts reached the threshold of 95% coverage, but again the CIs included the threshold. Only one district was significantly under the threshold of 95% of 24 month coverage. Four districts had at-risk periods significantly longer than 5 months for DT vaccination. All children who received the second dose of polio and DT by the 5th month had been vaccinated at the appropriate age with the first dose except for two children, who received their first dose during their second month of life, one other child received the second dose of OPV less than 4 weeks after the first dose.

Discussion

Respondents

Our response rate of 68.3% is comparable to the most recent National Immunisation Survey in the US, 1999 [2], which had a response rate of 66% with telephone interviews; other studies have reported up to 89% response rate with mail-in questionnaires [19]. The percentage of parents who explicitly refused to participate (13%) was near the 10% found in other studies [1]. Nevertheless, such a proportion affects the precision of our estimates of immunisation coverage levels, particularly for smaller districts. Most of the unreachable families were younger who could not be located at the address listed at the registry office, probably because of their greater mobility. The higher response rate for males in the younger cohort could be sign of the underlying differences between respondents and non-respondents, which affects results validity.

Immunisation coverage

The UTD24 vaccination coverage approaches 95% for polio and DT in the younger cohort. On the other hand, the coverage for P and M falls far short of an

Table 3. Number for children by immunization status at 24 months according to the two information sources for each vaccination

	1991–1992					1979–1981			
	Polio3	DT3	Pertussis3	Measles	HBV3	Polio3	DT3	Pertussis3	Measles
(A) Child immunized according to cards	207	203	63	81	173	185	145	36	9
(B) Child immunized according to parental recall only ^a	3	3	3	14	4	23	18	9	25
(C) Immunization status not known	0	0	0	0	1	1	3	11	6
(D) Child not immunized	12	16	156	127	44	10	53	163	179
Total	222	222	222	222	222	219	219	219	219

^aVaccinations recalled only by the parents but not documented by the card. The number of immunized children is given by the sum of (A) and (B).

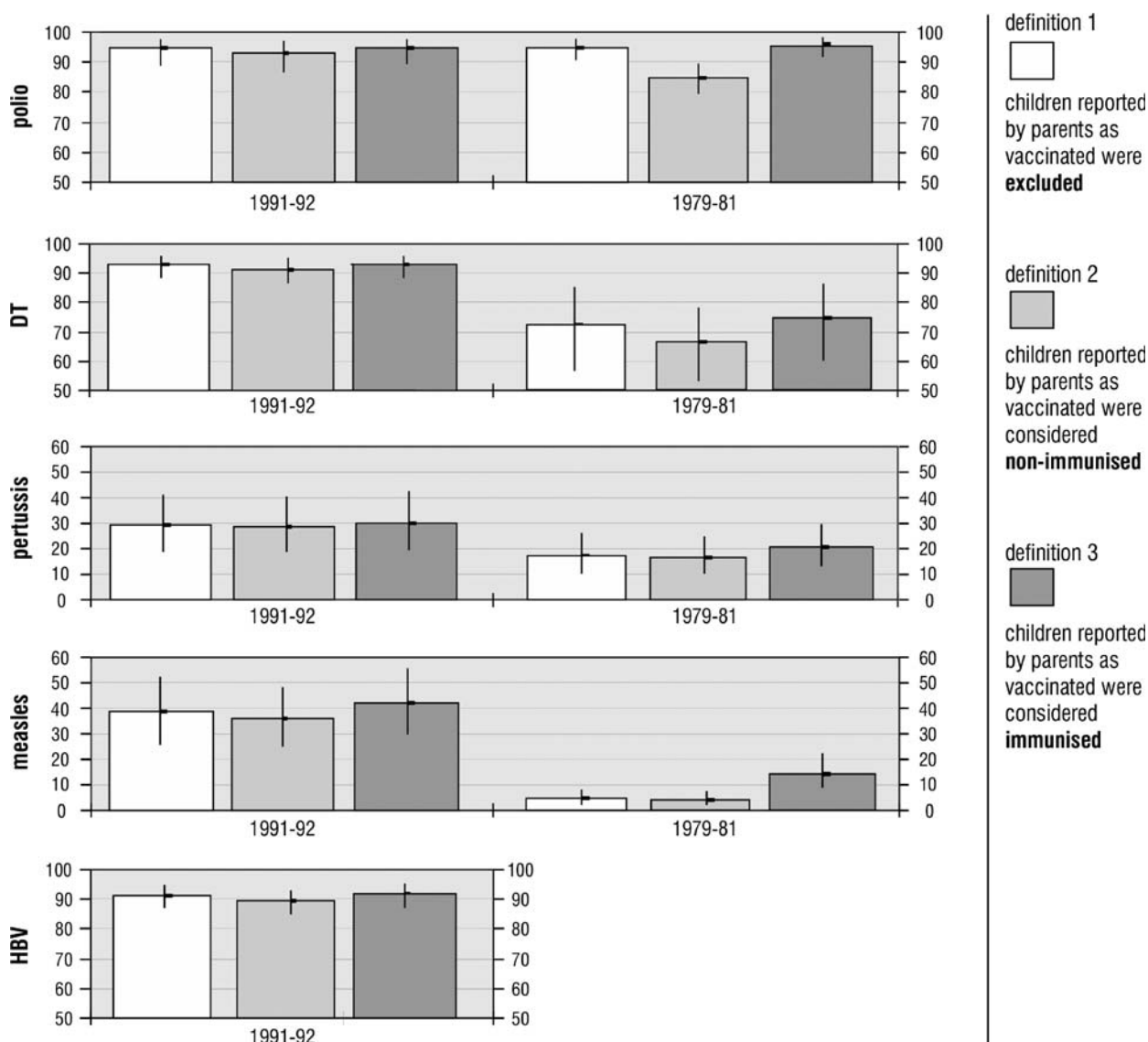


Figure 1. UTD indicators at 24 months according to the source of vaccination data for polio 3, DT 3, P 3, M and HBV 3 in the two birth cohorts: 1991–1992 and 1979–1981. The 1979–1981 birth cohort had not been vaccinated against HBV when they were newborns because the campaign started in 1991.

acceptable level of herd immunity. However, the higher proportion of non-immunised children in families who responded to the questionnaire only after two unsuccessful attempts of contact suggests that the non-respondents may have very low vaccination coverage (Table 2). There are no differences between the two cohorts in coverage for polio vaccination, but for DT, P and M however, immunisation coverage levels are lower in the older cohort. These results are consistent with Italian data from the National Survey by the Istituto Superiore di Sanità in the 1990s [20].

Sources of information

The value given to parental recall is the only difference between the three UTD24 indicators presented. These rates are very similar, this being due to the small number of children whose vaccinations were estab-

lished by parental recall alone (Table 3). The second one, which classifies parental recall as non-immunised, shows the lowest value, and probably underestimates the actual coverage. The second and third UTD24 indicators give nearly equal rates for polio and DT vaccinations in the younger cohort, showing no difference between sources of data. The older cohort shows lower coverage levels when children without documented dates are considered non-immunised than when these children are classified as immunised. This result could be due to the fact that teenagers often no longer have their vaccination cards. The similarity of sources for compulsory vaccinations in the younger cohort, for which a biased response could more readily be expected, gives us increased confidence in the reliability of parental recall.

The third indicator, that includes those children whose vaccinations were established by parental recall,

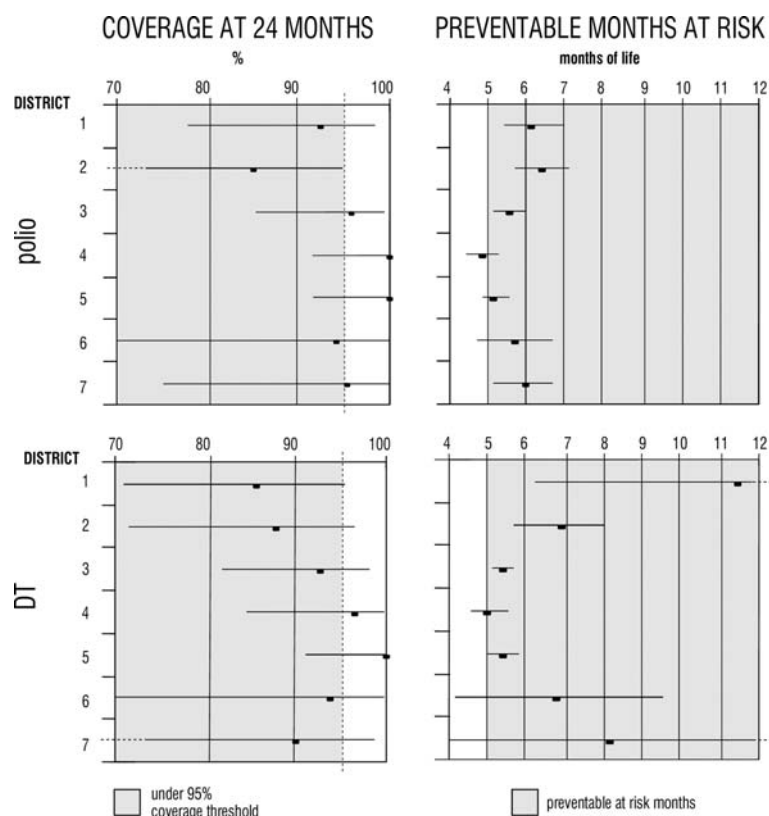


Figure 2. UTD and age-appropriate indicators for polio and DT in birth cohort 1991–1992, by health district.

shows higher coverage for measles than the second indicator in both cohorts, but especially in the older one. The greater influence of parental recall for measles can be explained by paediatricians not having registered the vaccination, for which a second dose was not recommended at that time. The differences observed between cohorts for measles, as for pertussis, reflect an actual increase in vaccination coverage, as mentioned above, but for the third indicator this gap is smaller.

We did not attempt to evaluate the accuracy of parental recall or of the data recorded on cards by comparing them to the immunisation records of the health services because these records were often unavailable or incomplete, particularly for vaccinations that were not compulsory. Other studies have verified self-reported immunisation dates and have found low error rates [1, 19] and, although parental recall of vaccination is considered not very reliable by some authors [13, 14], others have concluded that an acceptable or even a better estimation of coverage can be achieved by including parental recall [15, 16].

Which immunisation indicator at the local level

A discussion of the factors associated with the differences in immunisation coverage among districts is beyond the scope of this study. Instead we have compared the relative precision of an UTD and an age-appropriate indicator at the local level. The “preventable at-risk months” we used as an age-

appropriate indicator is more precise in estimating immunisation coverage. Because of its narrower confidence intervals, we can get a clearer view of the differences in coverage among districts, and can more easily evaluate how they compare to the optimal threshold. The two indicators (UTD and age-appropriate) for each districts are consistent with each other in our data, so we can conclude that the districts with higher coverage vaccinate new-borns at the proper time. The preventable at-risk months indicator gives more information about the quality of immunisation, because it gives an overall estimate of the population susceptible to disease.

Other authors compared UTD and age-appropriate indicators [8, 11] concluding that the latter ones more accurately reflect the adequacy of protection. We add here that the age-appropriate indicators provide more precise estimates of coverage at the local level. In computing the age-appropriate indicator, assuming a constant at-risk period of 60 months for non-immunised children presents an important limitation, as it overestimates the at-risk period for several reasons. In fact, it includes not vaccinated children who contracted the disease during this period (who are naturally immunized) in at-risk months and it does not consider the indirect protection due to immunised children because of the herd immunity, as for poliomyelitis. Another limitation of this choice is that it does consider the risk of infection in the entire period as constant while the

incidence of P varies in our region in children from birth to 5 years of age.

Conclusions

The results of this study hopefully will contribute to the understanding of methodological problems regarding sources of vaccination data and help determine which are the best indicators for future immunisation surveys.

- (1) Parental recall and dates reported on cards are comparable as sources of vaccination status in our setting. Using only vaccination data registered on cards, we might underestimate immunisation coverage for cohorts of teenagers in retrospective studies and overestimate the increase of coverage levels in younger cohorts.
- (2) The UTD indicators could be improved by adding age-appropriate measures, since the latter more accurately reflect the adequacy of protection. They also provide more precise estimates at the local level.

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