Community-based evaluation survey of immunizations in Burkina Faso

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A cluster sample survey was conducted in January 1989 in 3 provinces of Burkina Faso to evaluate an immunization programme (based on two contacts, providing inactivated poliomyelitis vaccine plus DPT) that had been launched in 1982–84. The objectives were to estimate neonatal tetanus (NNT) mortality and poliomyelitis prevalence in the study area. The target population (using the same sample of households comprised 2107 live infants born during the preceding year for the NNT survey, and 17 154 children aged 0–9 years for the poliomyelitis survey.

The NNT mortality rate was 3.3 per 1000 live births, and the poliomyelitis prevalence rate was 2.8 per 1000 children aged 5–9 years. Dates of onset of poliomyelitis cases among children aged 0–9 years and the numbers of children at risk during the 10-year recall period, reconstituted with demographic indicators taken from standardized life-tables, were used to calculate the incidence rates of poliomyelitis. These rates could be compared in the 5-year period preceding the survey, and showed a decreasing trend consistent with routine surveillance data.

Introduction

Evaluations of immunization programmes tend to focus mainly on operational issues and use vaccination coverage as the principal indicator of the success of the programme. Surveys using the WHO/EPI cluster sampling method (1) are routinely used to provide estimates of coverage. Frequency and trends of target diseases, though essential for the evaluation of the programme, are often difficult to obtain through routine surveillance in countries where access to health services is difficult and the health information system is still weak. To meet the need for obtaining information on the outcomes of vaccination programmes, guidelines on community-based surveys on poliomyelitis prevalence (2) and neonatal tetanus mortality (3) have been developed by WHO, which can be used to estimate the baseline incidence of these diseases.

Since 1982 a Dutch Foundation, Stichting Redt de Kinderen (SRK), has provided funding for an immunization programme in four provinces of Burkina Faso, with technical support from the Association pour la Promotion de la Médecine Préventive (APMP). Coverage surveys conducted in 1987 in the three provinces where the programme first started indicated a 38% prevalence of children immunized according to the adopted schedule in one of the provinces and 52% in the other two, placing them in the top 25% of the 29 provinces of the country. (4) The

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The impact of the programme was difficult to assess, since neonatal tetanus (NNT) cases had been reported separately from tetanus cases in other age groups only after 1985, and since the number of reported cases of poliomyelitis and neonatal tetanus was believed to considerably underestimate the true incidence. As part of the evaluation of its immunization programme which included a survey of coverage in each province, SRK, together with APMP, the Organisation de Coordination et de Coopération pour la Lutte contre les Grandes Endémies (OCCGE), the Ministry of Health of Burkina Faso, and the Rijksinstituut voor Volksgezondheid en Milieuhygiène (RIVM) carried out a survey to estimate the incidence of neonatal tetanus and the prevalence of poliomyelitis in the three provinces where the immunization programme had been launched between 1982 and 1984.

The survey, which was conducted in January 1989, was designed to obtain cross-sectional estimates of the two diseases. However, since baseline incidence was not available for either of them, it was decided to test whether this survey could also indicate the trend of poliomyelitis incidence over a ten-year period.

**Materials and methods**

**Survey area and population**

The three provinces (Bam, Sanmatenga and Namen-tenga), which are contiguous and situated in the north-central part of the country, are essentially rural. More than 95% of the population belongs to the Mossi ethnic group and uses the language called More.

The immunization programme was based on a simplified immunization schedule using the enhanced inactivated poliovirus vaccine (eIPV) combined with diphtheria-pertussis-tetanus (DPT) vaccine (3), produced by the RIVM (Bilthoven, Netherlands). Health centres were responsible for providing immunizations to the population living within a radius of 10 km (48% of the population at the time of the survey), either in the centre or during outreach activities. BCG and DPT1 (first dose of DPT and poliovirus vaccines), were scheduled at 3 months, and DPT2 (second dose), measles and yellow fever (YF) vaccines at 9 months; a minimum interval of 2 months was required between DPT1 and DPT2. Mobile teams, which covered the more remote population (52%), visited each village every 6 months, and delivered BCG and DPT1 vaccines at 3–8 months, and DPT2, measles and YF vaccines at 9–14 months. Women aged 15–44 years received up to 5 doses of tetanus toxoid (TT) following the WHO-recommended schedule.

The target population comprised all children born between 1/1/79 and 31/12/88. The NNT mortality survey was limited to all babies born from 1 to 13 months before the survey, i.e., between 1/12/87 and 30/11/88, thus allowing each infant to have been at risk of contracting NNT during its entire neonatal period. All children born during the ten-year study interval were included in the poliomyelitis prevalence survey.

**Sampling method**

The WHO/EPI cluster sampling method for estimating disease incidence was used (4). Sample size calculations were based on the number of children needed to get a reasonable estimate of the incidence of NNT. A sample of 2100 live births was chosen based on an expected NNT mortality rate of 10 per 1000 and a design effect of 1.7, i.e., 70 live births in each cluster. It was estimated that the households visited for completing this sample would also provide approximately 15,000 children aged 0–9 years. This sample size was considered adequate to estimate with sufficient precision a poliomyelitis prevalence of 5 per 1000.

A single sample of 30 clusters representative of all three provinces was selected by systematic sampling using the list of village populations available from the last census (1985). In each cluster selected, interviewers verified on site the administrative limits of the village with the village leader. Starting from the geographical centre of the village, a direction was randomly chosen. Houses along this direction were numbered up to the limits of the village, and one was randomly selected. From there, interviewers proceeded to the nearest houses until 70 live births were included.

**Case ascertainment.** Mothers were asked whether they had given birth to a live baby in the past ten years. For those children born from 1 to 13 months before the survey (NNT sample), potential cases of NNT were screened by registering neonatal deaths with the aid of a calendar of traditional events. Subsequently, the diagnosis of NNT was ascertained by one of the 7 participating physicians during a second visit to the family, using a standardized questionnaire. Blood samples were taken from those mothers of potential NNT cases who had evidence of having received TT injections, and the tetanus antibody titres were measured blindly at the RIVM using a toxin-binding inhibition assay. Results of this test correlate well with the standard mouse neutralization test (5, 6). Titres of 0.1 IU/ml and more were considered as protective.

* See footnote b, page 563.
From among the children born during the 10-year recall period (poliomyelitis sample), potential cases of poliomyelitis were screened by asking for those with any “walking disability”. These children were examined by one of the authors (G.F.D.), a paediatrician with tropical experience. Dates of onset of poliomyelitis were estimated by asking for the child’s age at onset.

Case definitions are summarized in Table 1.

**Rate calculations**

The NNT mortality rate was calculated using the total number of live births registered in the NNT sample as a denominator. The poliomyelitis prevalence rate was calculated for living children aged 5–9 years and compared with those of other surveys that usually use this age group as a target population.

Incidence rates for each of the ten years of the recall period were calculated using all cases enumerated in the survey. As denominators, we used the number of children at risk (aged 0–4), in person-years, reconstituted with life tables for each calendar year. Calculating these numbers directly would have been possible if the date of birth and age at death had been recorded for each child of the sample. However, these data were not collected because they were considered as too unreliable. Instead, indicators taken from standardized life tables prepared by the United Nations (7) (West model, infant mortality rate of 140 per 1000, life expectancy at 47.2 years) were used. The annual number of births between 1979 and 1987 was first calculated using the number of live births in 1988 in the sample and the population growth rate. Next, for each of the birth cohorts, the probabilities of dying at ages 0 to 9 were applied, and the number of person-years-lived below the age of 5 years in each calendar year was calculated. Total number of person-years-lived was finally obtained by summing up figures from each cohort for each calendar year. The annual incidence rates obtained were then multiplied by two correction factors: 1.33 to account for lethal forms of poliomyelitis and complete recoveries, and 1.25 to account for forms involving only the upper limb (2).

Confidence intervals around the observed rates were obtained from tables for binomial proportions, after adjusting denominators for the design effect introduced by the cluster sampling method (4). The χ²-test for trend was used to assess trends of incidence rates calculated under the life table model.

**Logistics and costs**

The three provinces were surveyed within 17 days by 30 local interviewers organized in teams of 2, with one vehicle for 2 teams. Among the 11 supervisors, 6 were physicians who interviewed the mothers of potential NNT cases. Additionally, an independent team (the paediatrician and a medical student) examined all potential cases of poliomyelitis. The teams progressed in the same direction, which made it easier for the paediatrician who had to visit each team every 2 or 3 days. Field work, including training of interviewers, involved a total of 1292 person-days (714 for interviewers and 578 for supervisors and other personnel).

The total costs were approximately US $77 000 (300 CFA = $1): $17 000 (22%) on supplies, vehicle maintenance and petrol during the survey; $20 000 (26%) on salaries and expenses for local staff; and $40 000 (52%) for survey preparation, data collection and analysis, report preparation, international travel, and salaries and expenses for expatriate supervisors, physicians, logistic officers and statisticians.

**Results**

**Neonatal tetanus**

Among the 2107 live births enumerated in the sample, 63 neonatal deaths were reported (neonatal mortality rate = 30 per 1000; 95% CI = 22–43 per 1000), among which 7 (11%) had signs and symptoms compatible with neonatal tetanus. NNT mortality rate was 3.3 per 1000, with 95% CI of 1.3–7.0 per 1000. The design effect introduced by the cluster sampling method (4) was 1.03, and was thus negligible. The male-to-female sex ratio was 1.03 for all neonatal deaths, and 0.75 for NNT cases. Three of the 7 mothers of NNT cases had received TT injections before the estimated date of birth of the child (respectively 2, 3 and 3 doses that met the criteria of a minimum interval between injections) and were...
tested for antibody titres. Two had protective antibody titres (≥0.1 IU/ml).

**Poliomyelitis**

Among the 17 154 children born between 1/1/79 and 31/12/88 enumerated in the sample, 109 had a walking disability, of whom 24 (22%) were ascertained to be poliomyelitis cases (Table 1). Three cases had been contracted outside the study provinces and were eliminated from further analysis. Of the remaining 21 cases, 19 were observed in children aged 5–9 years. The prevalence rate of lameness due to poliomyelitis was 2.8 per 1000 (95% CI = 1.7–4.6) in this age group. The design effect due to cluster sampling was 1.35.

Fourteen of the 21 children with poliomyelitis were male (M:F ratio = 2:1), 20 (95%) were under 3 years old at onset of the disease, 52% were under 2 years. Five children had received 2 doses of DPTP. Of these, three had received the 2 doses after the reported year of disease onset while the other two may have received the 2 doses before disease onset (in the same year as the first reported symptoms).

Calculations of the annual number of children at risk, i.e., all children aged 0–4 years, with the life-table model, showed that this number increased between 1979 and 1983, whereas from 1984 to 1988 both the size and the age structure of the population at risk remained fairly stable (Table 2).

Using these numbers as denominators, annual incidence rates were calculated. During the first 5-year recall period (1979 to 1983), the variability of the age structure of the population at risk did not permit any comparison of rates from one year to another. However, in the second 5-year period (1984 to 1988), during which the age structure was relatively stable, incidence rates ranged from 0.7 in 1984 to 0 per 1000 person-years in 1987 and 1988 (Table 2 and Fig. 1), demonstrating a significant decreasing trend \( P = 0.034, \chi^2\)-test for trend).

**Discussion**

**Neonatal tetanus**

The NNT mortality rate found in this study was 3.3 per 1000 with a 95% confidence interval of 1.3 to 7.0 per 1000. For the same year, the incidence of neonatal tetanus reported through the national surveillance system of Burkina Faso was only 0.5 per 1000, which confirms the frequent observation that routine surveillance data usually underestimate the extent of NNT incidence (8). Although the estimate from this survey is somewhat imprecise, it can nonetheless be considered as relatively low compared with rates reported in similar surveys conducted in other countries (8) and is one-third of the estimated rate for Africa (9). Two major protective factors are known to be effective in preventing NNT: sterile delivery practice and immunization of the mother with tetanus toxoid. Although we lack precise information on the conditions of deliveries in this area, we know that in 1986 only 17%, 24% and 27% of these deliveries, respectively in the 3 provinces, were attended by qualified personnel (Ministère de la Santé et de l’Action Sociale du Burkina Faso, unpublished data). By contrast, the immunization programme was effective in reaching a substantial part of the women of reproductive age, as was shown by the vaccination coverage survey conducted in January 1989 in the same three provinces. In this survey, 34–61% of women aged 15–44 years had documented evidence of at least two doses of tetanus toxoid. Therefore it is probable that the low rate of NNT can be attributed to the protection of a large proportion of newborns by the vaccination of their mothers.

Nevertheless, the number of cases may represent an underestimation. We found a neonatal mortality rate (NMR) of 30 per 1000. If we assume that the infant mortality rate (IMR) in Burkina Faso was 134 per 1000, and that neonatal deaths accounted for 30% of infant deaths (10), the NMR should have been 40 per 1000. It is known that in such surveys, mothers may underreport their infant deaths. This is

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Fig. 1. Poliomyelitis incidence rates calculated in the survey sample and reported in Burkina Faso, 1979–88.

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Table 2: Study children at risk of poliomyelitis, in person-years (N), number of cases of poliomyelitis (n), and incidence rates by year, Burkina Faso, 1979–88

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* Multiplied by 1.33 and 1.25 to take into account lethal forms, complete recoveries and forms involving only the upper limb.

less likely to be due to recall failures than to cultural conceptions about the point at which life is really starting; when a child dies very young, particularly in the neonatal period, both birth and death may be omitted (/1/).

The low rate observed could also have been due to the failure of mothers to identify NNT as the cause of death of their infant. Indeed, standardized questions seemed difficult for some mothers to answer, but the sensitivity of the case definition would be very difficult to assess. With regard to the specificity, we observed that three out of 7 mothers of NNT cases had documented evidence of TT immunization before the estimated date of birth of the child, with two of them having protective levels of antibodies at the time of the survey. Because it is very unlikely, although still possible, that these antibodies were due to doses received after the birth of the child (but not recorded on the vaccination card), it is most probable that these two cases were false positive cases. While the validity of a diagnosis of NNT based on interviewing the mothers is believed to be excellent in areas where the incidence of neonatal tetanus is high and the disease is well known in the community (/2, /3/), such a method is likely to become less reliable in regions like our survey area with a low NNT incidence. Nevertheless, the NNT mortality rate found in our study is unlikely to have been substantially underestimated, and this result confirmed the impact of the immunization programme in the area.

Poliomyelitis

The prevalence rate of 2.8 per 1000 that we observed in children aged 5–9 years is relatively low compared with the rates reported in other lameness surveys conducted between 1979 and 1981 in several African countries. In these studies, the rate ranged from 2.4 to 13.2 per 1000 in the same age group (/4/).
Important factors in the prevention of poliomyelitis are a safe water supply, adequate sanitation, and immunization. Undeniable improvements in terms of safe water delivery have been made in Burkina Faso within the last ten years, where now a substantial number of villages are equipped with boreholes, but improvements in sanitation have been slow. On the other hand, the moderate prevalence rate found in this study seems consistent with an impact due to the immunization programme, which had been launched in the three provinces between 1982 and 1984. In 1987, the coverage of children aged 12–23 months with two doses of eIPV ranged from 47% to 65%, although it fell to 38% in 1989. We can estimate that after 1983 approximately half of each cohort of children below the age of 2 years were vaccinated. It has been shown (15) that two doses of eIPV have a vaccine efficacy close to 90%. The expected impact of the programme in terms of cases of poliomyelitis prevented is therefore substantial.

The WHO lameness survey method is designed to give an estimate of the prevalence rate of poliomyelitis in children aged 5–9 years, which is a summary figure representing the result of risks encountered by this cohort over the preceding 10 years. It can give no indication of the trend of the disease incidence, and if a major change such as an effective vaccination programme had taken place in recent years, the effect on this measure would have been limited (2). However, the reconstitution of the population at risk (in person-years) made it possible to compare incidence rates of poliomyelitis within the 5 preceding years, assuming that children at risk were those aged 0–4 years. A decreasing trend was observed in poliomyelitis incidence, which paralleled the decrease in cases reported in the whole country (Fig. 1). Although the period (after 1983), during which very few cases were observed, could have been a period of low incidence independently of the immunization programme, our results seem consistent with an impact of vaccination in the area.

There are however several limitations to the method used. When the target age group of the survey is extended to children aged 0–9 years, new difficulties appear in identifying cases in younger children. The screening method, i.e., asking for any "walking disability", may have missed cases in children below 12–18 months of age. Indeed the interviewers spontaneously modified the question into a question about "any problem of the leg", which made the screening method very sensitive. On the other hand, our method of case ascertainment could be considered as very specific because the same experienced paediatrician examined all suspected cases, which reduced the number of false positive diagnoses to a minimum.

Estimation of annual incidence rates in the last 5 years is subject to other additional limitations. It was based on the correct identification by the mother of the child's age at onset of the disease, which was probably not very reliable. However, concerning cases within the last 5 years only, it could be expected to be more accurate. As for the denominator used, the calculation of the annual number of children at risk in person-years was made with a model based on the assumptions that natality and mortality remained stable during the period. Assumptions regarding the stability of mortality may be challenged. Indeed the infant mortality rate in Burkina Faso is believed to have decreased from 167 per 1000 in 1975 to 134 per 1000 in 1985 (Ministry of Health data). However, no events that could cause an acute increase in mortality or decrease in natality were observed in the survey area within the last ten years, leading us to believe that relatively stable mortality and natality could reasonably be assumed.

The cost-effectiveness of such large surveys has been challenged on the basis of their sample sizes, the cost, and their inability to provide information on trends (16). However, widening the age range of the children surveyed slightly increased the time and cost of the survey; the major part of the time was devoted to moving from house to house and to identifying all the members in each household. This additional effort enabled us to collect valuable information on the trends of the disease in the recent 5 years which could not have been provided by the classic lameness survey method.

Conclusion

The neonatal tetanus mortality surveys and poliomyelitis lameness surveys provide information on the extent of these two diseases, which cannot be obtained through routine surveillance data. By combining the two in a single survey using the same sample of households, we greatly reduced the costs involved in conducting two separate surveys. In addition, by extending our poliomyelitis sample to children aged 0–9 years, we obtained information on the trends of this disease during the preceding 5 years.

In areas where the incidence of the two diseases is still high or moderate, and where data cannot be obtained through other sources, the combined survey can provide useful information on their incidence.
and help evaluate the impact of immunization programmes.

Acknowledgements

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Résumé

Enquête au niveau communautaire pour l'évaluation de la vaccination au Burkina Faso

Pour évaluer les programmes de vaccination, il est essentiel de connaître les niveaux d'incidence des maladies cibles et leurs tendances. Lorsque cette information est absente ou peu fiable, des enquêtes au niveau communautaire sur la prévalence de la poliomyélite et sur la mortalité imputable au tétanos néonatal peuvent fournir des données de base pour estimer l'incidence de ces maladies. Toutefois, ce type d'enquête n'a pas été conçu pour fournir des informations sur les tendances.

Un programme de vaccination (administration de deux doses de vaccin antipoliomyélite inac- tivé associé au DTC) lancé entre 1982 et 1984 dans trois provinces du Burkina Faso (Bam, Sanmatenga et Namentenga) a fait l'objet d'une telle évaluation en janvier 1989. L'enquête, menée selon la technique de l'échantillonnage par grappes, avait pour principal objectif d'estimer la mortalité imputable au tétanos néonatal et la prévalence de la poliomyélite dans la région. En outre, les données ont été analysées pour voir s'il était possible d'en extraire des informations sur l'évolution de l'incidence de la poliomyélite au cours des années précédentes. Les populations cibles étaient constituées des enfants nés vivants au cours de l'année précédente en ce qui concer- ne l'enquête sur le tétanos néonatal et des enfants âgés de 0 à 9 ans pour la poliomyélite. Le même échantillon de ménages a fourni le nombre de sujets nécessaire à la réalisation des deux enquêtes (respectivement 2107 naissances vivantes et 17 154 enfants).

Le taux de mortalité imputable au tétanos néonatal a été évalué à 3,3 pour 1000 naissances vivantes et le taux de prévalence de la poliomyélite à 2,8 pour 1000 enfants âgés de 5 à 9 ans. Ces taux sont faibles si on les compare aux taux relevés dans des enquêtes similaires pratiquées dans la même région. Toutefois, compte tenu des titres d'anticorps trouvés chez certaines mères, on peut s'interroger sur la spécificité du diagnostic rétrospectif de tétanos néonatal fondé sur l'interro- gatoire des mères.

Pour calculer les taux d'incidence de la poliomyélite, on a noté la date d'apparition de la mala- die chez les enfants âgés de 0 à 9 ans et on a estimé le nombre d'enfants à risque au cours des dix années précédentes en reconstituant rétrospectivement des cohortes grâce aux indicateurs démographiques des tables standard de mortalité. Ce n'est qu'au cours des cinq années précédant l'enquête que la structure d'âge de la population d'enfants à risque a été suffisamment stable pour que l'on puisse comparer les taux d'incidence. Au cours de cette période, l'incidence de la poliomyélite a présenté une tendance à la baisse significative, passant de 0,7 à 0 pour 1000 personnes-année ($P = 0,034$), ce qui est en accord avec les données de surveillance nationale.

Le fait d'utiliser le même échantillon de popu- lation pour évaluer la mortalité imputable au téta- nos néonatal et la prévalence de la poliomyélite s'est révélé à la fois pratique et économique. En outre, des informations utiles ont été recueillies sur l'évolution de l'incidence de la poliomyélite au cours des cinq années précédentes en incluant les enfants âgés de 0 à 9 ans dans la population cible de l'enquête et en notant la date approxima- tive de l'apparition de la maladie chez ces enfants.

References


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