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Risk of infection and estimated incidence of tuberculosis in Northern Uganda

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ABSTRACT: The main goals of our study were to evaluate: 1) the annual risk of tuberculosis infection (ARTI) and its annual decrease in Uganda; 2) the expected incidence of new tuberculosis cases and the notification rate; and 3) the role of incentives given to children tested in increasing compliance with the survey procedures.

The methodology is based on performing the standard World Health Organization (WHO) tuberculin test on children of the same age groups at intervals of 10–15 yrs, identifying infected persons by induration distribution analysis, and converting the prevalence rates detected into risk rates according to the ARTI model. Two thousand six hundred and twenty one school children aged 10 yrs old and bacilli Calmette-Guérin (BCG) nonvaccinated, in six study areas, were injected with two tuberculin units (TU) of purified protein derivative (PPD) RT 23 Copenhagen.

The detected prevalence was 14±1.4% (prevalence ±95% confidence interval (95% CI)) and the ARTI value 1.2±0.9%, with an estimated annual decrease of 0.83% from 1958 to 1970 and 2.9% in the 1970–1987 period. The estimated expected incidence of new cases in Uganda was 59 smear positive and 75 smear negative/extrapulmonary cases per 100,000 population in 1987, and 53 and 65, respectively, in 1990, with an overall 68% notification coverage. No significant improvement in children returning for reading was observed in the group receiving incentives.

We conclude that the average decrease (2.9%) probably represents the natural decline of tuberculosis in Uganda. The coverage appears encouraging, although the ARTI detected could be underestimated, since the existing ARTI model was developed and validated before the human immunodeficiency virus (HIV) era. The importance of implementing adequate surveillance measures needs to be stressed. *Eur Respir J., 1994, 7, 946–953.*

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Evaluation of the incidence of tuberculosis (TB) and the annual risk of tuberculosis infection (ARTI) is an essential part of a TB control programme [1–3]. Several epidemiological indices can be derived from ARTI, in particular the estimated incidence of smear positive TB cases [1–3]. Its value in the TB field is relevant in planning interventions and evaluating case findings of control programmes.

TB incidence has rapidly decreased in many developed countries over the past decades, as a combined effect of improved economic conditions and efficient control programmes, including the high cure rate obtained with short-course chemotherapy regimens [1–4]. Nevertheless, the human immunodeficiency virus (HIV) pandemic has been considered responsible for increased notifications of TB cases in the United States [5–7]. In several western European countries, an alarming increase of TB notifications was recently observed. However, a high incidence among the immigrant population appears to be the main cause for the increase [8, 9].

In developing countries, where high TB infection and HIV infection rates coexist in young cohorts, the HIV epidemic dramatically contributed to increasing TB notifications. This is affecting public health services, both in terms of costs and efficiency [10, 11]. In Uganda, ARTI was carefully studied by the World Health Organization (WHO)/British Medical Research Council (BMRC) National Tuberculin Surveys performed in 1958 (ARTI=2.4±0.39), and in 1970 (ARTI=2.3±0.31), which resulted in the estimation of the incidence of smear positive cases as: 1958=118 out of 100,000 population; 1970=113 out of 100,000 population [12, 13]. The HIV pandemic explosion in East Africa resulted in the need for a well-studied model country, where epidemiological projections might be carried out and validation of intervention strategies performed.

The aim of the present study was to update previous ARTI projections by means of a tuberculin survey, and to estimate TB incidence rates from the existing notification data in Uganda, as the preliminary part of a

forthcoming evaluation on HIV-associated TB impact in the years to come. In addition, the role of incentives given to the pupils tested in increasing compliance with the survey procedures was evaluated.

Materials and methods

Methods of previous surveys

The 1958 tuberculosis survey was performed in Uganda, using 10 randomly selected clusters of about 600 people each, and consisted of tuberculin testing, chest X-ray and sputum examination [12, 13]. For surveillance purposes, the 1958 tuberculin testing component was repeated in 1970 with the same procedures [12, 13]. In each survey, the sample size represented 4–5% of the population from which it was drawn (total population tested: 1958=6,055; 1970=8,653; 10 year old populations tested: 1958=456; 1970=681).

In both surveys bacille Calmette-Guérin (BCG) vaccinated and nonvaccinated persons of different ages were tested according to the WHO guidelines [14, 15]. The tuberculin reaction sizes in BCG nonvaccinated individuals were carefully evaluated: (fig. 1a and b).

Study design, cluster selection and protocol

The organization and planning of previous surveys were followed to prepare the present study design [12, 13]. Although the present survey was planned to be comparable with the 1958 and 1970 studies, several differences must be emphasized:

1. A significant sample of BCG nonvaccinated 10 year old children was chosen to increase the accuracy of the ARTI estimate [16]. All children were carefully examined, and those with a BCG vaccination scar on the right/left shoulder and forearm were excluded from the study.
2. Schools were selected as clusters having easy and economical access to the planned sample.
3. The "stratification" approach was excluded, because of the practical impossibility of reaching and operating in all districts of the country.
4. Study areas were selected, considering local availability of health co-operation projects by international agencies and excluding "*a priori* "areas that were either completely inaccessible, had exceptionally low population density, or presented security problems [16].
5. For each study area, the sample size was defined and the clusters selected. Thirty children were skin tested to ensure at least 20 children for reading in each cluster

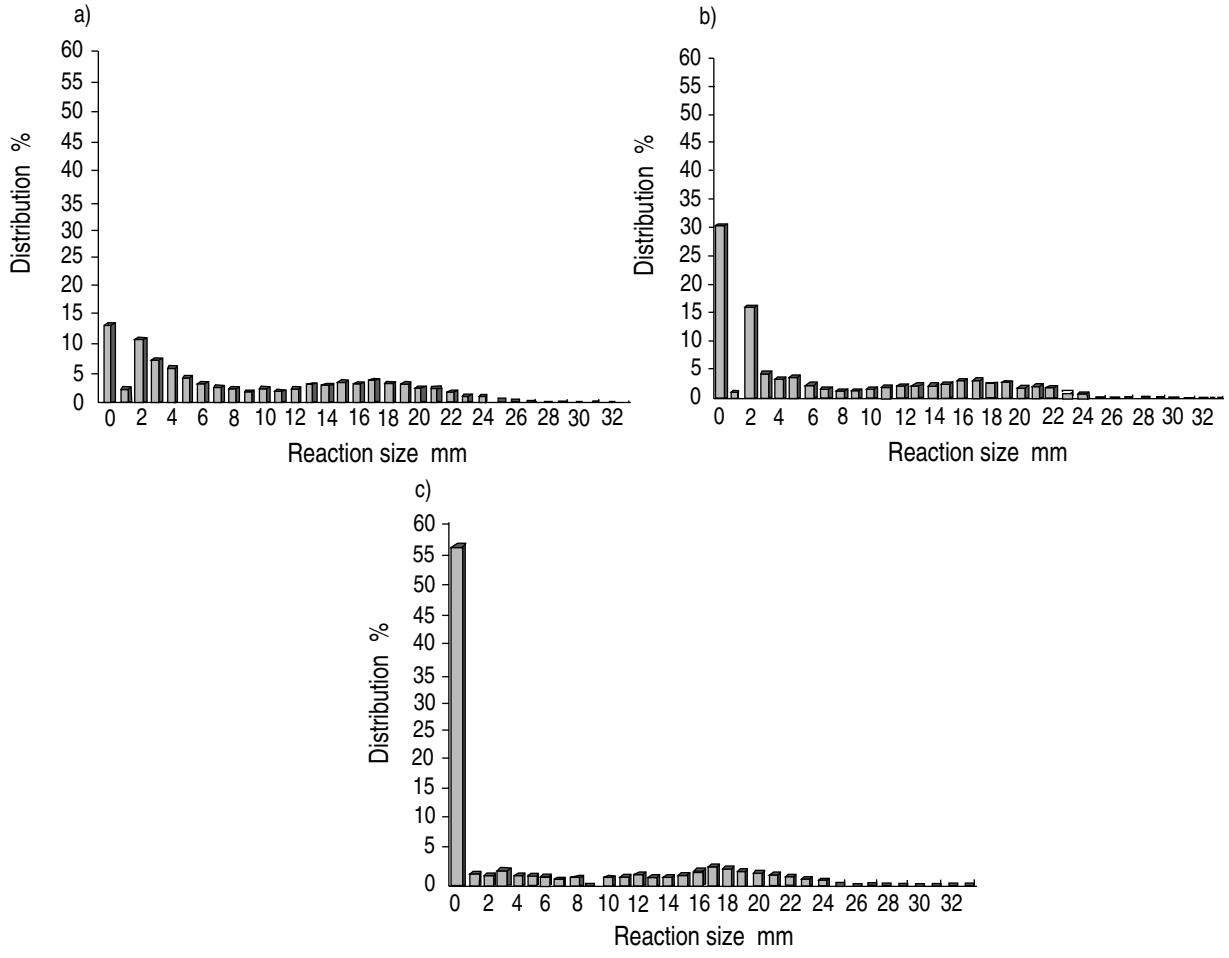

Fig. 1. – Percentage distribution of tuberculin reaction sizes among unvaccinated subjects, Uganda: a) 1958; b) 1970; and c) 1987.

(a relevant number of small clusters gives more information than a small number of large ones [16]).
6. Clusters were selected according to the systematic random sampling technique [15, 16]. Schools were listed for each study area and a proportion of them selected in order to reach the planned sample size [15, 16]. The larger confidence intervals of ARTI expected by the randomization technique were balanced by an increased sample size in comparison with previous surveys [16].
7. The representativeness of clusters was considered sufficient for the study purposes, taking into account the good school system operating in Uganda and the literacy rate reported in a recent study [17].
8. Selection of urban and rural clusters was made, taking into account both Ugandan standards (>80% of the national population lives in rural settings) [17], and logistical problems. One urban and four rural study areas were selected (fig. 2).

Demographic calculations were based on the 1987 United Nations estimate [18], projected from the 1980 national census (table 1).

Sample size determination

The minimum sample size was calculated with the following formula: $4\ p\ c\ (100 - p)/e^2$ where p=estimated prevalence of TB infection, c=cluster factor, e=95% confidence intervals desired [16]. Considering p=20, c=2 and e=2 the minimum sample size is 3,200, reduced to 1,600 if the cluster factor is not included in the sample size calculation. In previous surveys, the sample studied was <5% of the population. In order to increase significance, it was decided to test at least 6% of the 10 yr old population in the study areas selected. As cluster sampling was used, at least 2,000 pupils (corresponding to 7% of the estimated 10 year old population of the areas studied and to 0.49% of the estimated Ugandan populations of the same age) were expected for reading, in 83 clusters [18]. Sample size, and percentage of the population studied are presented in table 1.

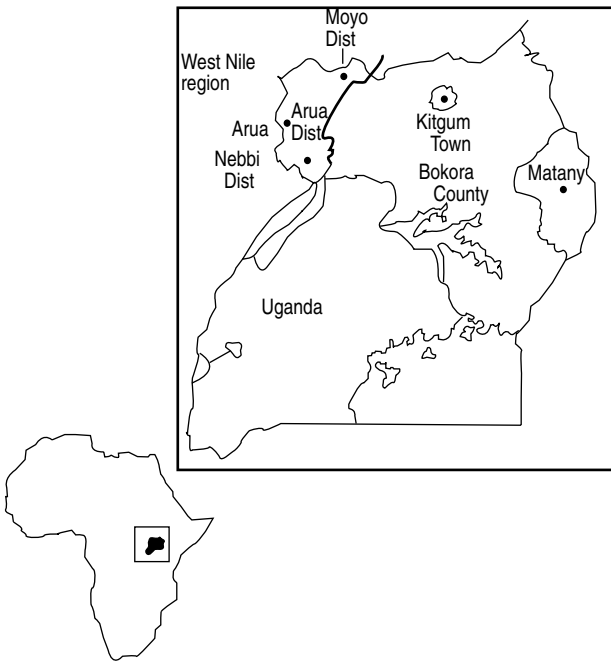

Fig. 2. – Selected study areas, 1987 tuberculin survey, Uganda.

Table 1. – Demographic parameters in the 1958, 1970 and 1987 surveys

	1958	1970	1987
Uganda population	6541880	9806000	15975000
Estimated 10 year old population	169400	240800	418600
Total sample tested	6055	8653	2299
10 year old sample tested	456†	681†	2299
10 year old sample %*	0.27	0.28	0.55
Study areas population	141993	189059	1087110

*: percentage value of the estimated 10 year old Uganda population; †: 10–14 year old children tested.

Pilot studies

In order to reduce inter- and intraobserver variation as much as possible and to obtain accurate and consistent readings, a general pilot study was organized in the central office to standardize Mantoux test techniques, induration reading and registration. A similar pilot study was repeated in each study area by different teams, each comprising a medical officer, a health educator and a registration clerk with previous experience in tuberculosis testing [16]. A self-explanatory registration form was adopted, including cluster and team identification data, pupil name and age, tuberculin injection and reading data and induration size in millimetres [14–16].

Testing procedures

Consecutive non-BCG-vaccinated 10 yr old children were enrolled in each cluster, until the minimum established sample size was reached. The age was determined together with teachers and headmasters by means of school registers, religious (birth certificates) and health documents (vaccination cards, child health cards). The calculated age was compared with anthropometrical parameters (teeth eruption).

As in previous surveys, pupils were intradermally injected with 0.1 ml of Tuberculin (RT 23; two tuberculin units (TU), corresponding to 5 International Units, (Statens Serum Institut-Tuberculin Department, Copenhagen, containing 0.04 μg of purified protein

derivative (PPD) from *M. tuberculosis* 0.01% chinosol and 0.005% Tween 80 polyoxyethylene sorbitan monooleate) by Mantoux technique on the anterior surface of the right forearm, until a raised but flat anaemic weal with an "orange peel" aspect of about 7 mm appeared [14–16]. Disposable syringes and needles were used (sterile polypropylene syringe B-D Plastipak, 1 ml, 26 G 3/8; 0.45×10).

The reaction size was measured 72 h later. The induration was considered positive when the mean value of the two diameters exceeded 10 mm [14–16]. The final judgement of positive induration was performed *a posteriori* by analysing the right-hand tail of the distribution obtained when plotting induration sizes on the"X" axis and the corresponding percentages on the "Y" axis. A cold chain was guaranteed in order to keep tuberculin at the proper temperature (4–8°C). As an incentive, a small present (exercise books, pens and pencils) was shown to the pupils before testing and given to them after reading in 3 of the 5 study areas.

Statistical analysis

Statistical analysis was performed using the following methods:

1. The 95% confidence interval (95% CI) was calculated for detected ARTI according to the following formula: $CI=p\pm1.96\ \sqrt{\sum i\ (pi-p)^2}/k\ (k-1)$ where p= percentage found in the entire sample; pi=percentage found in the cluster i; k=number of clusters [15, 16].
2. A comparison between 1958/1970 and 1970/1978 prevalences was performed according to the following formula [15, 16]: $CI=p1-p2\pm1/2\ \sqrt{W1^2+W2^2}$ where p1-p2=prevalence observed; W1-W2=widths of their 95% confidence intervals. A 5% difference was considered significant [6].
3. The tuberculin distribution was studied for skewness and kurtosis by Statgraphics Statistical Package, version 4.0.
4. To determine the infection rate, the ARTI model was applied, to represent the proportion of a population that will be infected or reinfected by tubercle bacilli during a calendar year [2, 19, 20]. ARTI were calculated in accordance with the two steps procedure developed by STYBLO *et al.* [19]: the ARTI percentage decrease was estimated first (dividing the entry in the appendix table C [19], determined by the intersection of the columns of prevalence in the previous and later survey, by the interval in years between the two surveys); then the level of the risk of infection in specific years was determined intersecting the column of the ARTI percentage decrease with the column of prevalence (appendix table B) [19].

In using the appendix tables by STYBLO *et al.* [19] the following criteria were adopted: i) prevalence figures with decimals were approximated to the nearer entire value (*e.g.*14.1=14, 33.7=34); ii) the corresponding ARTI value was chosen without adjusting for decimals; and iii) the estimated average 3% annual decrease of the risk was used to calculate ARTI in the different study areas (1987 survey) with the above mentioned technique.

The detected ARTI values were plotted in a semi-logarithmic scale as follows: A) 1958–1970 projection; B) 1970–1987 projection; and C) 1958–1987 projection.

Considering the exponential behaviour of the infection rate decrease [19], the linear regression between the dependent variable (derived as logarithmic transformation of p=IR/100; where p=probability to be infected by tubercle bacilli; IR=infection rate) and the independent variable (time course in years) was calculated.

The detected prevalences were compared to those detected by another tuberculin survey performed in Uganda in 1972 [21], with the same methodology as our study (704 children aged 10 yrs tested; prevalence of positives with cut-off point 10 mm=8.2%) and the corresponding ARTI was calculated as described above.

Unfortunately, the national health information system became operational from late 1989, and no figures concerning 1987 TB notification rates in Uganda were available. The estimated TB incidence rate projections deriving from the ARTI model were compared with the available notified rates from 1990, obtained from WHO sources. From the ARTI value, incidence of smear positive cases and other related parameters could be evaluated.

The following equation was considered: ARTI=1%; incidence of smear positive cases=49 (confidence intervals; 39–59) per 100,000 inhabitants [22]. According to MURRAY *et al.* [23] we estimated 1.22 new cases of smear negative and extrapulmonary TB for every case of smear positive TB, under the following assumptions: i) Uganda is a developing country with an estimated ARTI between 1–2%; and ii) the overall Ugandan age-distribution is similar to that of Tanzania [18].

5. To evaluate the role of incentives in improving compliance, the figures of pupils returning for induration reading who had received or not received presents were compared using 2×2 contingency tables with the uncorrected chi-squared test. A p-value <0.05 was considered statistically significant.

Results

The following areas were included in the study (fig. 2): Arua District, Moyo District, Bokora County, Nebbi District, Kitgum Town. Nine out of 83 clusters (corresponding to 12% of the sample size) were selected in urban settings. Cluster selection was made considering logistical resources, with a distribution into rural and urban settings similar to the Ugandan reality. Only non-BCG-vaccinated pupils of 10 yrs of age were tested. Out of 2,621 tuberculin skin tested pupils, 2,299 (87%) underwent readings procedures (1218 males, 53%). Out of 1,652 children tested after having been promised a present, 1,495 returned for reading. In the two study areas where no present was given, 969 children were tested and 804 read (91 *versus* 83%; NS, chi-squared test).

Table 2. – BCG vaccination coverage, total and estimated 10 year old population, and number of clusters by study area in 1987 survey

Study area	BCG coverage %	Total popn	Estimated 10 yr old popn	Clusters
Moyo District	26	85320	2215	14
Arua District	64	577799	15185	41
Bokora County	69	63176	1623	7
Nebbi District	20	319945	8424	12
Kitgum Town	84	40870	1035	9
Total		1087110	28482	83

popn: population.

Table 3. – Summary of prevalence data and ARTI values by study area in the 1987 survey

Study area	Pupils		Positives		ARTI % ±CI
	Tested n	Read n	n	(%)	
Moyo District	528	426	67	(16)	1.40±0.25
Arua District	1110	1016	125	(12)	1.03±0.19
Bokora County	204	199	67	(34)	3.31±0.66
Nebbi District	441	378	43	(11)	0.94±0.32
Kitgum Town	338	280	23	(8)	0.67±0.32
Total	2621	2299	325	(14)	1.21±0.91

ARTI: annual risk of tuberculosis infection; CI: confidence interval.

Table 4. – Comparative summary of results in 1958, 1970 and 1987 surveys

	1958	1970	1987
Prevalence of positives %	24 (20–28)	23 (19–25)	14 (13–16)
ARTI %	2.4 (2.0–2.8)	2.3 (2.0–2.6)	1.2 (0.3–2.1)
Decreasing prevalence between 2 surveys %		1 (0–3.5)*	8.8 (7.1–10.6)
ARTI annual decrease %		0.8 (0.5–1.1)	2.9 (2.6–3.2)

95% confidence intervals are given in parenthesis. *: negative values of the decrease were not considered. ARTI: annual risk of tuberculosis infection.

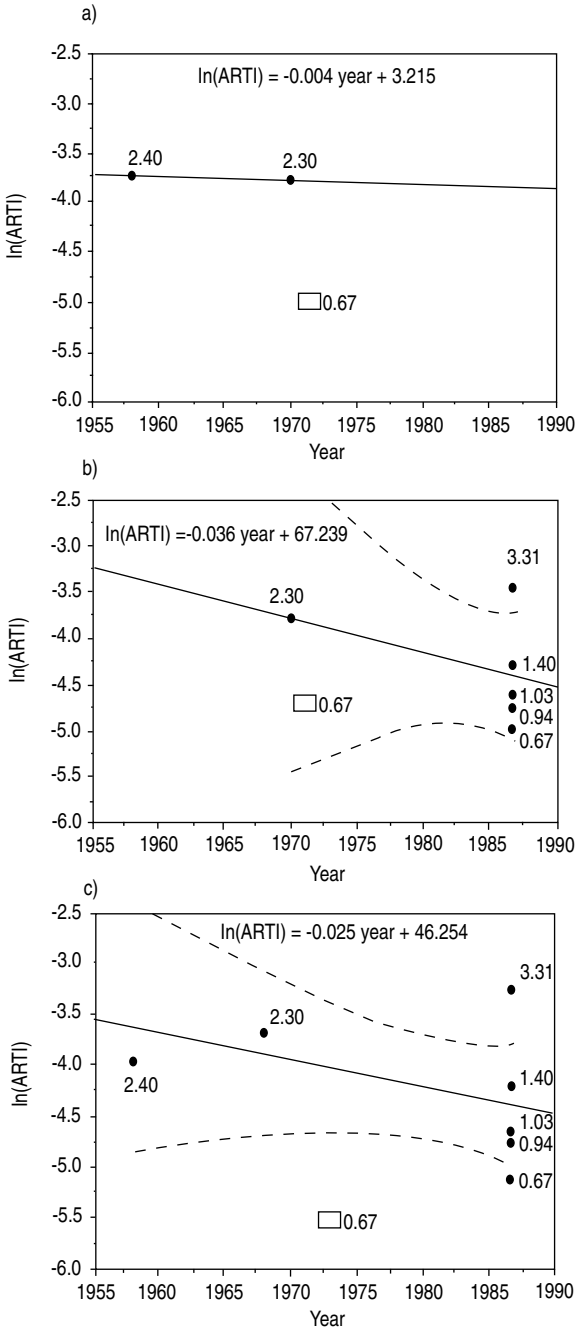

Fig. 3. – Annual risk of tuberculosis infection (ARTI) values plotted in semilogarithmic scale with 95% confidence intervals for the true mean: a) 1958–1970 projection; b) 1970–1987 projection; c) 1958–1987 projection; ARTI% values are reported close to their respective points (●). At the top of each regression figure, the formula of the respective straight line is indicated: ln (ARTI) S×year+K; where S=slope and K=constant.

A summary of survey results is reported in tables 2–4. The number of pupils whose test was read (2,299) corresponds to 8.1% of the estimated 10 year old population of the areas studied (28,482) and to 0.55% of estimated Ugandan children of the same age (418,600) (tables 1 and 2). A total sample of 325 children was found with a positive skin test (≥10 mm of induration; 160 males, 49%), with a calculated infection rate of 1.2±0.9% according to the ARTI model [19]. ARTI values detected in the different study areas ranged between 0.67–3.31%, their confidence intervals ranging from 0.19–0.66 (tables 2 and 3). A comparison with 1958 (ARTI=2.4±0.4%) and 1970 (ARTI=2.3±0,3%) values was made (table 4). A decreasing prevalence was detected in the 1958–1970 period (1±2.5%) and in the 1970–1987 period (8.8±1.7%). The decrease observed during the second period appears to be significant: the 1987 prevalence is from 7.1 to 10.6% lower than the 1970 prevalence [15].

Table 5. – Estimated incidence of smear positive (M+), smear negative (M-)/extrapulmonary (EP) tuberculosis deriving from the application of the ARTI model, Uganda 1987 and 1990, compared with the national tuberculosis notification figures and the estimated diagnostic coverage in 1990

		Estimated incidence		Notified
		1987	1990	1990
Per 100,000 inhabitants	M+	59	53	37
	M-/EP	75	65	43
	Total	134	118	80
Total number (coverage %)	M+	9425	9307 (70)	6556
	M-/EP	11948	11354 (66)	7492
	Total	20923	20662 (68)	14048

1987: ARTI=1.2%, population=15,975,000; 1990: ARTI=1.1%, population=17,560,000; MP-/EP=M+ × 1.22; M+=49 when ARTI=1%. ARTI: annual risk of tuberculosis infection.

In figure 1, the percentage distribution of tuberculin reaction sizes is reported for the three surveys [12–13]. A sufficiently clear antimode may be observed at 7 mm and a mode at 17 mm in the 1987 histogram [15, 16], (fig. 1c).

In figure 3, ARTI values and confidence intervals of the different periods considered (1958–1970, 1970–1987 and 1958–1987) are plotted in semilogarithmic scale, in comparison with the result of the survey performed by others in 1972 (ARTI=0.7%) [21].

In table 5, the infection rate model was applied for Uganda, where 59 new smear positive and 75 new smear negative/extrapulmonary cases per 100,000 population might be expected in 1987. According to WHO notifications, 6,556 new smear positive and 7,492 smear negative/extrapulmonary cases were reported in Uganda in 1990. Extrapolating ARTI value and population in 1990 ARTI=1.09%; population=17,560,000), 9,307 smear positive and 11,354 smear negative/extrapulmonary cases should be expected, corresponding to an overall 118 per 100,000 notification rate.

The overall estimated diagnostic coverage in 1990 is 68%.

Discussion

The methodology used in this study was similar to that suggested by others [27], and was based on recruitment of children of the same age groups at intervals of 10–15 yrs, to study the risk of infection from two sets of prevalence data.

According to our results, the ARTI value in Northern Uganda is 1.2%, with an estimated annual decrease of 0.8% from 1958 to 1970, and 2.9% in the 1970–1987 period. The estimated expected incidence of new cases in Uganda was 59 smear positive and 75 smear negative/extrapulmonary cases per 100,000 population in 1987, and 53 and 65, respectively, in 1990. According to 1990 notified cases, the estimated overall notification coverage is 68%. No significant improvement in children returning for reading was observed in the group that received incentives. Therefore, a high reading rate can be achieved by accurately preparing school visits with the education department through the active involvement of teachers, headmasters and local authorities in the organization of the survey.

According to the ARTI value and the estimated incidence detected, TB remains a top level health priority in Uganda, as it was during the 1950s and the 1970s [12, 13]. Until more representative and accurate data are available for the whole country, our estimates could be of help in determining the trend of the TB problem in Uganda for planning and evaluation purposes.

To evaluate the reliability of the data resulting from the study, the induration distribution features are first examined, and the possible sampling biases are then discussed.

The analysis of the percentage reaction sizes distribution suggests the following: 1) The distribution is bimodal, with detectable mode and antimode. The evaluation for normality (skewness=0.327; kurtosis=-0.805) of reaction sizes between 7 and 30 mm, suggests, as expected, a right tailed, flat distribution. The mode, as observed in both previous surveys, corresponds to 17 mm induration size (fig. 1, a–c); 2) Chances of misclassification of truly infected pupils is small [15]; 3) Chances of inclusion of nonspecific reactions among infected pupils also seem very small. All reactions greater than the antimode (7 mm) may be regarded as specific [15]; 4) According to previous suggestions [15], the pattern is that of a country with low/moderate prevalence of atypical mycobacterial infection; and 5) The suggested 10 mm cut-off point appears to be correctly chosen. This approach could be supported by doubling the prevalence of infection at the 17 mm mode (3.6%×2=7.2) [15]. The cut-off point should lie between 7 and 9 mm, where the antimode is placed. At 8 mm the overlapping between the right tail of the nonspecific reactions distribution with the left tail of the specific one can be observed. The 10 mm cut-off point privileges specificity more than sensitivity. However, it should be pointed out that moving the cut-off point from 10 to 8 mm results in a very limited increase of the prevalence (+1.3%).

A tuberculin survey, though cheaper than a complete survey based on chest X-ray and direct microscopy procedures, might still be a financial burden for a low-income country. The choice of systematic random sampling, suggested by the Uganda TB Control Programme, was made in order to obtain sufficiently reliable data at an affordable cost. Some concern arose from the possible under representativeness of schools selected in clustering [16]. The infection rates detected in West Nile (Arua 1.03%; Moyo 1.4%), where recent movement of refugees was described [17], are higher than in Acholi (Kitgum) and Alur (Nebbi). This observation suggests that school clustering is a cost-effective procedure in developing countries with reliable education departments, where students are likely to represent the general population of the same age group [15, 16].

Our study was limited to north-eastern Uganda, and the comparison with 1958 and 1970 national findings might be biased. Thus, the importance of performing

similar surveys in the southern and western parts of the country can not be overemphasized. In addition, in the north-eastern areas selected for the survey, the HIV epidemic has different patterns, with seroprevalences in Arua District (acquired immune deficiency syndrome (AIDS) prevalence rate (APR) per 10,000 population=5.7) and Moyo District (APR=1.1) lower than in Nebbi District (APR=12.2) and Bokora County (APR=11.2); and Kitgum Town (APR=12.2) [24–26]. The question of whether the need to choose study areas with ongoing health co-operation projects could have significantly accelerated the downward trend in ARTI may arise. This kind of bias is probably reshuffled, observing that all these projects were recently implemented, and placed in some of the less developed areas in Uganda (in terms of security, economic situation and access to health services) [17].

The ARTI values reported in table 3 fit well with the regression lines drawn in figure 3, with the notable exceptions of Kitgum and Bokora. Both of these study areas presented security problems and, as a result, a reduced sample size with increased confidence limit widths was used. Whilst the figures from Kitgum might have resulted in an underestimation, the estimates from Bokora appear more convincing, considering the historically well-known high prevalence of TB in Karamoja [13].

Taking into account the partially different sampling methods used in the three surveys, the following should be pointed out: i) since in the 1958/1979 surveys a 10–14 year old sample was considered, a modest overestimation of the ARTI decrease between 1970 and 1987 is possible; ii) in spite of an increased sample size in our study, the use of the systematic random sampling determined larger confidence intervals (table 1); and iii) though minimized by a general pilot study, the intra-observer group variation might in part explain some of the differences in prevalence figures among 1987 study areas.

The ARTI estimated trend probably represents the natural dynamics of the disease [27, 28]. It was recently suggested that in India a 2.3% annual downward trend of the ARTI might be obtained if the TB Control Programme efficiency was only about 30% [27].

Unfortunately, no reliable national estimates of the efficiency of the Uganda TB Control Programme are available. However, a recent study from West Nile [29] suggests that the performance of the Uganda Programme is roughly similar to that found in India [27], if one assumes that the patient cure rate is about 55% (comparable to that of other programmes adopting the standard long course regimen of 12 months of isoniazid and thioacetazone with streptomycin given for the first 2 months). New regimens, combining rifampicin at least during the intensive phase, are likely to accelerate the currently observed downward trend.

The estimated overall 68% notification coverage appears encouraging if one considers the political instability of this country over the last few years. Recently, the case finding efficiency (and the notification coverage) was reported to have increased from 48% in 1987 to 69% in 1990 in West Nile [29]. Those values might have been even higher, because the ARTI considered in that study was 2%, resulting in an overestimation of expected new smear positive cases.

A study in Tanzania showed that the increasing number of notifications during the period 1983–1988 was accompanied by a stable infection prevalence, in spite of the HIV epidemic [30]. The observed trend, corresponding to the initial phase of the HIV pandemic explosion in sub-Saharan Africa, might have reversed in the following years due to the expected increase in number of HIV-related TB cases [31]. Nonetheless, recent data from Tanzania indicate that, under good programme conditions, the TB infection prevalence may not increase in spite of the HIV pandemic [32]. However, because of the poor conditions of the programme and the growing number of HIV-associated TB cases, it is possible that the ARTI in Uganda has increased during the period 1987–1990. In addition, it is likely that the ARTI detected in our study (1.2%) is lower than one could expect (fig. 3), as the existing ARTI model was developed and validated before the HIV era [19, 22]. Unfortunately, the unreliable reports of TB and AIDS cases available at national level before 1990 make it difficult to evaluate.

Even if the problems encountered in planning, organizing and running the survey might have in some way affected the results, our study provided the following answers: 1) the ARTI in Uganda is 1.2% for 1987 and 1.1% for 1990, with an annual decrease from 0.8% (1958–1970) to 2.94% (1970–1987); 2) the estimated incidence of smear positive TB cases in 1990 is 53 per 100,000 population, while the smear negative/extrapulmonary TB cases incidence is 65 per 100,000; and 3) the overall notification rate in 1990 is 68%. A good surveillance system is, therefore, an essential instrument in monitoring the TB situation, with the ultimate goal of achieving TB control [24]. In view of the impact of the HIV pandemic on TB prevalence in Uganda, adequate surveillance remains a basic step to limit the spread of TB in sub-Saharan Africa [33].

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