Active tuberculosis among Iraqi schoolchildren with positive skin tests and their household contacts

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السل الفعال بين أطفال المدارس ذوي الاختبار الجلدي الإيجابي ومخالطيهم في المنزل في العراق

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الخلاصة: أجريت دراسة أترابية استباقية على أطفال المدارس العراقيين المصابين بالسل الفعال ممن كان الاختبار الجلدي لديهم إيجابياً ضمن دراسة مسحيَّة أجريت على كامل القطر عام 2000 مع متابعتهم عام 2002 لمعرفة معدل انتشار العدوى بالسل الخافي، وعوامل الاختطار بين المخالطين في المنزل. وشملت الدراسة 205 أطفال بقي الاختبار الجلدي لدى 191 منهم إيجابياً حتى عام 2002. كان تسعة أطفال (4.4٪) يعانون من سل فعال شُخِّص استناداً إلى الصورة الشعاعية والفحص السريري. ومن بين المخالطين في المنازل والذين بلغ عددهم 834 كان هناك 144 حالة سل جديدة، مما يجعل معدل الوقوع التراكمي 17.3٪. وتتركَّز عوامل الخطورة للإصابة بالسل بين المخالطين للمصابين بالسل في منازلهم في ما يلي: سن الخامسة عشرة فما فوق؛ والعمل التقني أو الحرفي؛ والتدخين؛ وانخفاض مَنْسَب كتلة الجسم BMI؛ والسكري؛ والمعالجة بالستيروئيدات، والمخالطة الوثيقة لحالة دالة. واستناداً إلى سوابق الإصابة بالسل لدى حالات دالة بين الأطفال ومن يخالطهم فإن 77.2٪ من حالات السل تعزى إلى مخالطة الساكنين في المنزل.

ABSTRACT In a prospective cohort study in Iraq, schoolchildren with a positive tuberculin skin test during the nationwide survey in 2000 were followed up in 2002 to determine prevalence of latent tuberculosis (TB) infection and risk factors among household contacts. Of 205 children, 191 remained skin-test positive in 2002. Based on X-ray and clinical examination, 9 children (4.4%) were active TB cases. Among 834 household contacts, there were 144 new TB cases, giving a cumulative incidence of 17.3%. Risk factors for TB among household contacts were: age ≥ 15 years; technical/professional job; smoking; low body mass index; diabetes mellitus; steroid therapy; and closeness of contact with the index cases. Based on past history of TB in index children and their contacts, 77.2% of new TB cases were attributable to household contacts.

La tuberculose évolutive chez des écoliers ayant une intradermo-réaction positive et leurs contacts familiaux en Iraq

RESUME Lors d'une étude de cohorte prospective en Iraq, des écoliers ayant eu une intradermo-réaction à la tuberculine (IDR) positive lors de l'enquête nationale réalisée en 2000 ont fait l'objet d'un suivi en 2002 pour déterminer la prévalence de l'infection tuberculeuse latente et les facteurs de risque chez les contacts familiaux. Sur 205 enfants, 191 avaient toujours une IDR positive en 2002. Sur la base de la radiographie et de l'examen clinique, 9 enfants (4,4 %) étaient des cas de tuberculose évolutive. Parmi les 834 contacts familiaux, il y avait 144 nouveaux cas de tuberculose, ce qui donne une incidence cumulée de 17,3 %. Les facteurs de risque de tuberculose chez les contacts familiaux étaient les suivants : âge supérieur ou égal à 15 ans ; métier technique/emploi de professionnel ; tabagisme ; faible indice de Quételet ; diabète sucré ; traitement stéroïdien ; et contact étroit avec les cas index. Sur la base des antécédents de tuberculose chez les enfants index et leurs contacts, 77,2 % des nouveaux cas étaient attribuables aux contacts familiaux.

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Introduction

Tuberculosis (TB) is both preventable and curable. It is usually spread through close and prolonged contact with an infected family member or co-worker [*1*].

Persons with latent TB infection (LTBI) are considered at highest risk of developing active disease during the first 2 years of infection, during which time approximately 5% of persons develop active TB [*2*]. Therapy for recently infected persons may not only be beneficial to those treated but also serve as an effective TB epidemic control measure. Mathematical models have shown that the impact of therapy for early LTBI is greatest when treatment rates for active TB are lower [*3*]. They also demonstrate the effect of increasing treatment for early LTBI on TB incidence over time. If the treatment rate for active TB is increased from 50% to 60%, adding therapy for early LTBI substantially reduces TB incidence.

Identifying and treating persons with early LTBI who are contacts of active cases may require a substantial investment of resources. However, the benefit of treating these individuals is significant compared with therapy for those with long-term LTBI [*3*]. New recommendations for targeted tuberculin testing and treatment of LTBI have recently been published [*4*]. This was coupled with changes in nomenclature from screening to targeted tuberculin testing and from preventive therapy to treatment of LTBI by programmes and health care providers.

In spite of the scarcity of information about the treatment completion rates among recently infected contacts of TB cases, there is evidence of non-completion of treatment in a considerable proportion of these contacts, reaching two-thirds of contacts in one report [*5*]. Children are exposed to TB primarily through contact with infected adults. Failure of adults to complete treatment contributes significantly to the risk of TB for children [*6*]. Children with LTBI represent the next generation of TB cases [*6,7*].

Iraq ranks 44th in the world among countries with high TB burden and 7th among the countries of the Eastern Mediterranean Region. The estimated incidence of all TB cases was 135 per 100 000 population in 2001 [*8*]. A mandatory screening programme for all new students throughout Iraq was launched in 1989 and revealed positive skin tests for 1.3%, 1.7% and 2.3% of schoolchildren during 3 successive rounds (unpublished data). In view of these findings, the present study aimed to determine the incidence of active TB among the cohort of schoolchildren screened in the year 2000 and their household contacts, determine the prevalence of LTBI and identify the risk factors for active TB among the contacts.

Methods

A prospective follow-up study was conducted throughout the 16 Iraqi governorates during April to November 2002, tracing the 215 primary-school children who recorded a positive tuberculin skin test result during the year 2000 national tuberculin test survey. These schoolchildren and their household contacts were investigated for the presence of LTBI and active TB.

Data collection

Only 205 children (95.3%) could be observed and followed up. Each participant was interviewed using a structured questionnaire to record sociodemographic and clinical characteristics and other potential risk factors for TB infection and disease. Each participant was re-tested by tuberculin skin testing using the same solution used in the previous survey: 2 TU of tuberculin PPD RT23/Tween 80. As before, an indu-

ration reaction ≥ 10 mm was considered positive.

The 191 schoolchildren with confirmed positive tuberculin skin test results were given a chest X-ray and clinical examination. Their household contacts (n = 834) were interviewed using a structured questionnaire to collect information on sociodemographic and clinical features and history of TB and other diseases/medication, such as diabetes mellitus and steroids. In addition, they were clinically examined.

Household contacts under 15 years old were first given a tuberculin skin test, and positive cases (n = 133) were given a chest X-ray. Adults were all subjected to chest X-ray examination and 3 consecutive sputum smear examinations for the detection of acid-fast bacilli.

Classification and treatment

An adult was considered a TB case if he/she fulfilled 1 of the following diagnostic criteria [*8*]:

- positive chest X–ray with 1 or more direct positive sputum smears
- negative chest X-ray, but at least 2 direct positive sputum smears
- 3 consecutive negative sputum smears but strong evidence of TB by chest X-ray associated with clinical features.

According to the Iraqi National Guidelines for TB treatment, chemoprophylaxis treatment was given to all participants under 15 years old showing a positive tuberculin skin test, whether index cases or household members. Confirmed TB cases were given anti-TB therapy under the Iraqi National TB Programme.

Statistical analysis

Comparison across groups according to the collected variables was performed. Sociodemographic and other variables were presented as percentages of patients. Proportions were compared simultaneously by the chi-squared test. Fisher exact test was used when the chi-squared-test was not valid. Univariate analysis of the risk factors for contracting a LTBI or TB disease was performed using the odds ratio and its 95% confidence interval.

The 5% level of significance was used as a cut-off value for statistical significance and all tests were 2-sided. The analyses were conducted using the statistical packages *Epi-Info*, version 6.04 (Centers for Disease Control and Prevention, Atlanta, Georgia) and *SPSS*, version 9 (SPSS Inc., Chicago, Illinois).

Results

The mean age of the 205 schoolchildren in the original cohort was 8.3 ± 1.1 years ranging from 7 to 12 years, and 188 (81.8%) were younger than 10 years of age (Table1); 94 were males (45.9%). The mean body mass index (BMI) was 20.4 ± 5.1 kg/m^2, ranging from 11.9 to 33.3 20 kg/m^2. More than half (57.1%) of the cohort sample were malnourished (BMI < 20 kg/m^2), and more than half of their mothers were illiterate or could just read and write. The lowest TB infection rates were recorded among children with highly educated and working parents. The majority of the original cohort of children (72.2%) were living in nuclear families.

Follow-up of schoolchildren

Of the 205 schoolchildren with LTBI in 2000, 191 (93.2%) remained TST positive in 2002. At follow-up, children under 10 years old showed a higher infection rate (93.6% of the original cohort still infected) compared with older children (88.0%) (Table 1).

At follow-up, children living within extended families exhibited higher rates of TB infection (96.5% of the original cohort still infected) than those living in nuclear fami-

Table 1 **General characteristics of the 205 schoolchildren with tuberculosis infection during the national survey in 2000 and the cohort of 191 followed-up in 2002**

Characteristic	Infected in 2002		Infected in 2000	
	No.	(% of total)	No.	% of 2002 values
Age (years)				
< 10	188	(81.8)	176	93.6
≥ 10	17	(18.2)	15	88.0
Sex				
Male	94	(45.9)	88	93.6
Female	111	(54.1)	103	92.8
Body mass index (kg/m²)				
< 20	117	(57.1)	108	92.3
20–	49	(23.9)	46	93.8
25–	21	(10.2)	19	90.4
≥ 30	18	(8.8)	18	100.0
Maternal education				
Illiterate/just read and write	107	(52.2)	103	96.3
Primary/intermediate	49	(23.9)	44	89.8
Secondary	35	(17.1)	31	88.6
University and above	11	(5.4)	10	9.9
Not valid (dead)	3	(1.5)	3	100.0
Maternal occupation				
Housewife	175	(85.4)	163	93.1
Farmer/worker	8	(3.9)	8	100.0
Technical clerical	9	(4.4)	9	100.0
Professional	10	(4.9)	8	80.0
Not valid (dead)	3	(1.5)	3	100.0
Paternal education				
Illiterate/read and write	65	(31.7)	60	92.3
Primary/intermediate	64	(31.2)	59	92.2
Secondary	53	(25.9)	51	96.2
University and above	20	(9.8)	18	90.0
Not valid (dead)	3	(1.5)	3	100.0
Paternal occupation				
Unemployed	19	(9.3)	17	89.5
Farmer/worker	136	(66.3)	126	92.6
Technical clerical	22	(10.7)	22	100.0
Professional	25	(12.2)	23	92.0
Not valid (dead)	3	(1.5)	3	100.0
Family type				
Nuclear	148	(72.2)	136	91.9
Extended	57	(27.8)	55	96.5

Table 1 **General characteristics of the 205 schoolchildren with tuberculosis infection during the national survey in 2000 and the cohort of 191 followed-up in 2002** *(concluded)*

Characteristic	Infected in 2002		Infected in 2000	
	No.	(% of total)	No.	% of 2002 values
Household crowding index (no. of people per room)				
1	10	(4.9)	6	60.0
2	8	(3.9)	7	87.5
3	39	(19.0)	35	89.7
4	43	(21.0)	42	97.7
5	67	(32.7)	63	94.0
≥ 6	38	(18.5)	38	100.0

lies (91.9%) (Table 1). Moreover, the TB infection rate steadily increased with crowding index, with a strong positive correlation between the 2 variables ($r = 0.72$, $P < 0.05$)

A strong negative correlation was detected between the infection rate and BMI ($r = –0.74$, $P < 0.001$). All children presenting with fever, pallor, enlarged lymph nodes or an asthmatic attack (9, 13, 3 or 2 respectively) were infected with TB (induration ≥ 10 mm). In addition, the majority of children with sick appearance, cough and weakness (22/23, 13/32 and 9/10 respectively) were infected with TB.

Sputum was not obtained from children under 15 years old, but based on chest X-ray findings and clinical examination, 9 children were diagnosed as active TB cases. The distribution of their chest X-ray findings was: 5 children with bilateral hilar shadow, 2 with right plural effusion and 2 with segmental lesions. The incidence of TB among the original cohort was 9/205 (4.4%); hence the incidence of TB among the follow-up children was 9/191 (4.7%).

Household contacts

The household contacts of the schoolchildren in the study totalled 834 individuals, a mean of 4.3 for each index case. Their mean age was 22.0 ± 17.4 years, ranging from 1 to 80 years. Of these, 398 (47.7%) were younger than 15 years of age, and males constituted 56.0% (Table 2). Distribution of educational attainment showed that 329 (39.4%) had a primary school certificate compared with 24 (2.9%) for university degree. The majority of the cohort did not have a permanent job; 36.5% were students, 23.5% were unemployed and the remainder were farmers, workers, or technical/professionals.

A total of 146 TB cases were diagnosed among the 834 household contacts, (17.5%). Of these, 144 were new cases, hence the cumulative incidence among household contacts accounted for 17.3%. The criteria for diagnosing TB, and the categorization of cases into smear-positive and smear-negative is shown in Table 3.

Table 2 shows that the risk factors for TB infection among household contacts

Table 2 **General characteristics of household contacts and risk factors for tuberculosis infection among infected members**

Risk factor	Total	Not infected	Infected		χ^2-value	*P*-value	Crude OR (95% CI)
	No.	No.	No.	%			
Age (years)							
< 15[a]	398	390	8	2.0	126.58	< 0.0001	1
≥ 15	436	298	138	31.7			22.6 (10.53–50.49)*
Sex							
Male[a]	467	389	78	16.7	0.48	0.49	1
Female	367	299	68	18.5			1.13 (0.78–1.65)
Education							
Illiterate/read and write	306	238	68	22.2			0.57 (0.22–1.53)
Primary/intermediate	329	273	56	17.0	38.74	< 0.0001	0.41 (0.16–1.11)
Secondary	51	37	14	27.5			0.76 (0.24–2.45)
University[a]	24	16	8	33.3			1
Not valid (baby)	124	124	–	–			
Occupation							
Student	304	292	12	3.9	165.30	< 0.0001	0.03 (0.01–0.08)*
Unemployed	196	133	63	32.1			0.31 (0.13–0.74)*
Farmer	79	44	26	37.1			0.38 (0.14–1.03)
Worker	112	84	28	25.0			0.22 (0.08–0.56)*
Technical/clerical/ professional[a]	28	11	17	60.7			1
Not valid (baby)	124	124	–	–			
Smoking							
Never smoked[a]	736	644	92	12.5	152.50	< 0.0001	1
Ex-smoker	48	34	14	29.2			2.88 (1.41–5.82)*
Current smoker	50	10	40	80.0			28.0 (12.95–62.04)*
Body mass index (kg/m²)							
15–	644	530	947	64.1	46.85	< 0.0001	8.82 (5.85–13.36)*
25–[a]	190	158	32	16.9			1
Relation							
Father[a]	132	76	56	42.4	191.40	< 0.0001	1
Mother	138	84	54	39.1			0.87 (0.52–1.46)
Grandparent	20	8	12	60.0			2.04 (0.71–5.9)
Brothers/sisters	522	500	22	4.2			0.06 (0.03–0.11)*
Second-degree relative	22	20	2	9.1			0.14 (0.02–0.64)*
Past history of TB							
No[a]	800	656	144	18.0	3.32	0.06	1
Yes	34	32	2	5.9			0.28 (0.05–1.24)
Diabetes mellitus							
No[a]	814	677	137	16.8		0.004**	1
Yes	20	11	9	45.0			4.04 (1.51–10.74)*

Table 2 **General characteristics of household contacts and risk factors for tuberculosis infection among infected members** *(concluded)*

Risk factor	Total	Not infected	Infected		χ^2-value	*P*-value	Crude OR (95% CI)
	No.	No.	No.	%			
Bronchial asthma							
No[a]	830	684	146	17.6		1.00**	–
Yes	4	4	0	0.0			
Steroid therapy							
No[a]	828	684	144	17.4		0.28**	1
Yes	6	4	2	33.3			2.38 (0.30–15.19)*

*P < *0.05;* **P-*value of Fischer exact test.*
[a]*Reference category.*
OR = odds ratio; CI = confidence interval.

were: age ≥ 15 years (22.6-fold increased risk compared with those < 15 years); technical/professional job; smoking, whether ex- or current smoker (2.9- and 28-fold increased risk respectively); low body mass index (8.8-fold increased risk); diabetes mellitus (4-fold); and taking steroid therapy (2-fold). The closeness of contact of the household member with the index cases was also a significant determinant for the disease; grandparents had the highest risk for the disease (2-fold), although this did not reach statistical significance, probably due to the small sample size. Brothers and sisters and second-degree relatives were at a significantly lower risk for the disease compared with fathers (Table 2).

There was a significant association between the TB status and the following signs and symptoms: fever, cough, pallor, general weakness, sick appearance and chest pain, but not with the presence of enlarged lymph nodes. Interestingly, sick appearance and fever were more frequently encountered among TB cases than cough (84.6% and 78.9% compared with 55.9%) (Table 4).

Of the 398 household contacts under 15 years old, 133 (33.4%) had a positive tuberculin skin test; 19 (4.8%) recorded an induration size of 10–14 mm and 114 (28.6%) had induration > 15 mm. Of these, 8 had positive chest X-ray findings diagnostic for TB. The mean tuberculin skin test induration size of children with positive chest X-ray findings was significantly larger than the mean induration size of those

Table 3 **Tuberculosis diagnosis of household contacts according to the results of X-ray and sputum examination**

Diagnostic test	Infected	Not infected	Total
X-ray positive			
Sputum negative	93[a]	0	93
Sputum positive (× 1)	23	0	23
Sputum positive (× 2)	28	0	28
Sputum positive (× 3)	2	0	2
X-ray negative			
Sputum negative	0	423	423
No X-ray			
No sputum	0	265	265
Total	146	688	834

[a]*8 individuals aged < 15 years had positive tuberculin skin test.*

with negative findings (8.5 ± 2.45 versus 3.4 ± 5.1 mm respectively, $P = 0.005$).

The tuberculin skin test induration size was significantly associated with chest X-ray findings, sick appearance, presence of fever, cough, and pallor (Table 5).

A positive past history of TB was recorded in 34 of the 834 household contacts (4.1%).

Calculation of attributable risk

The primary attack rate of TB among the studied population (i.e. number of household contacts with history of TB/total number of studied population at risk) was 3.27% (34/1039 × 100), equivalent to the incidence among non-exposed persons. The secondary attack rate (i.e. number of newly diagnosed TB cases/population at risk) was 14.33% (144/1005 × 100), equivalent to the incidence among exposed persons.

The relative risk is therefore 4.38 (14.33/3.27) and the attributable risk is 77.2% (14.33–3.27/14.33 × 100). Therefore, 77.2% of the new TB cases (i.e. 144 cases) could be attributed to household contacts.

Table 4 **Clinical features of infected and uninfected household contacts in relation to tuberculosis status**

Clinical feature	Total	Not infected	Infected		$\div^2$-value	*P*-value
	No.	No.	No.	%		
Sick appearance						
Present	65	10	55	84.6	214.83	< 0.0001
Absent	769	678	91	11.8		
Fever						
Present	76	16	60	78.9	218.58	< 0.0001
Absent	758	672	86	11.3		
Cough						
Present	145	64	81	55.9	178.8	< 0.0001
Absent	689	624	65	9.4		
Enlarged lymph nodes						
Present	6	4	2	33.3	1.05	0.36
Absent	828	684	144	17.4		
Pallor						
Present	52	24	28	53.8	59.56	< 0.0001
Absent	782	664	118	15.1		
General weakness						
Present	14	4	10	71.4	37.63	< 0.0001
Absent	820	684	136	16.6		
Chest pain						
Present	11	4	7	63.6	22.69	< 0.0001
Absent	893	684	139	15.6		

Table 5 **Clinical features of household contacts under 15 years old according to positive or negative tuberculin skin test (TST) results**

Variable	TST positive				TST negative		χ^2-value	*P*-value
	10–14 mm		15+ mm		< 10 mm			
	No.	%	No.	%	No.	%		
Chest X-ray								
Positive (*n* = 8)	2	25.0	6	75.0	–	–	0.80	0.37
Negative (*n* = 390)	17	4.4	108	5.3	265	66.6		
Sick appearance								
Present (*n* = 13)	3	23.1	10	76.9	265	68.6	0.91	0.34
Absent (*n* = 385)	16	4.2	104	27.0	–	–		
Fever								
Present	3	16.7	11	61.1	4	22.2	18.1	< 0.0001
Absent	16	4.8	103	27.1	261	68.7		
Cough								
Present	2	4.1	25	51.0	22	44.9	13.7	< 0.001
Absent	17	4.9	89	25.5	243	69.6		
Enlarged lymph nodes								
Present	–	–	–	–	2	–		
Absent	19	4.8	114	28.8	263	66.4		
Pallor								
Present	1	6.3	10	62.5	5	31.3	10.18	0.0006
Absent	18	4.7	104	27.2	260	68.1		
Weakness								
Present	6	60.0	2	20.0	2	20.0	0.93	0.33
Absent	–	–	–	–	–	–		
Body mass index (kg/m^2)								
15–	16	64.0	73	26.8	183	–	Not valid	
20–	3	21.9	25	35.7	42	–		
25–	–	–	12	32.4	25	–		
30–	–	–	4	21.1	15	–		

Discussion

TB incidence varies considerably in different populations and population segments. Most of these differences are likely to be attributed to a difference in the underlying prevalence of infection with *Mycobacterium tuberculosis*. Nevertheless, some of the difference might be also attributed to a difference in the risk of developing TB given that infection has occurred [9]. The most important risk factor for TB is infection with tubercle bacilli. Tubercle bacilli are a necessary, but not a sufficient cause of TB while the risk of becoming infected is mainly exogenous in nature, determined by the characteristic of the source case, environment and duration of exposure. In most instances, it cannot be determined why a particular person does or does not develop TB after becoming infected with tubercle

bacilli. Several factors have been identified that increase the risk of progression from sub-clinical to overt TB [*10*]. Certain population groups are at an increased risk for developing TB such as close contacts of infectious TB cases, HIV-infected people and people with medical conditions that increase the risk of TB [*11*]. It has been suggested that TB in children can serve as an important public health marker for assessing the overall effectiveness of current control efforts [*12*].

Prevention and early detection of paediatric cases are essential tasks in TB control. While treatment of adults is in principle the best prevention of childhood disease, poor contact tracing can easily multiply the disease risk in children [*13*].

This study revealed that the TB infection rate of contacted children was 2.3 times higher than that among adults, a finding that is consistent with other studies [*14,15*], and could be explained by the weak immune system in children, who are more vulnerable to infection [*7,16*].

There is a suggestion that there is little difference in TB infection between boys and girls up to puberty and young childhood [*16*]. This statement was confirmed by the present study that reported a slightly higher TB infection rate among male children. Reports from Denmark [*14*] and India [*17*] showed that TB infection rate is increased in children of both sexes by approximately the same increment [*18*].

However, there appear to be differences between males and females later on in life [*18,19*]. This study showed that the rate of TB infection or disease is higher among female household contacts (18.5% compared to 16.7% in males), which is in agreement with other studies [*20,21*]. In contrast, other reports found that the risk of TB infection increases in males after childhood [*9,19*]. This variation between sexes could be attributed to genetic and hormonal factors that may play a role in the risk of contracting TB [*9*], as well as to socioeconomic and cultural factors [*21*]. It has been suggested that after 44 years of age TB infection is lower in females [*22*] and that men progress to disease at a higher rate than women after age 45 [*18*]. This is in agreement with the results obtained in our study where all grandfathers and only 50% of grandmothers contracted the disease. This variation in prevalence between the sexes within different communities is probably related to the degree of social interactions in different societies. In some countries, both sexes take part in almost all public activities, while in others, women's lives are very secluded, and the chance of becoming exposed to an infectious case inside and outside the home therefore differs according to the sex of the individual. Traditional and religious customs as well as political climate may also play a role in exposure [*18*].

This study also showed that adults are at a significantly higher risk of contracting TB compared with children. This finding is in agreement with other reports that also showed great variability in the risk of infection and disease by age [*21,23,24*]. This may be attributed to differences in the risk or prevalence of infection, or differences in disease risk once infected, or both. The commonly observed trend of a higher rate of disease with increasing age can be partly explained by the cumulative increase in the prevalence of TB infection. Adolescents and young adults appear to be especially prone to progression from latent infection to disease, whereas children around the age of 10 years appear to be least prone [*25*].

There is considerable evidence that TB incidence is strongly associated with body build, and that the incidence of TB among persons below ideal body weight is 2.2–4

times greater than among person with normal weight for height [*26,27*]. A significant association between BMI and TB incidence was found in the present study. This can be attributed to the adverse effects of malnutrition on the immune system. Malnutrition was detected among 41% of the study population (BMI < 20 kg/m^2), and among 57% and 37% of index cases and household contacts respectively. This could be explained by reduced meat or fish consumption [*28*], as a result of the international sanctions on trade with Iraq which lasted for 12 years.

In addition, poor socioeconomic indicators result in crowded living conditions that are conducive to increased transmission of TB. Successful transmission requires that airborne infectious particles remain suspended in the air for several hours by the effect of temperature and humidity. Ventilation dilutes the concentration of airborne particles and thus TB exposure decreases with smaller family size. Higher exposure is likely to occur among people who share the same household or who spend long periods of time in the same room. These known risk factors for TB are also confirmed by the significant correlation between crowding index and TB infection rate among the index cases in our study. Moreover, the rate of TB infection was higher among children living within extended families compared with those living within nuclear families. Similarly, smoking is a well-known risk factor for TB and this was confirmed in the present study.

Even among household contacts, there is a difference in the prevalence of TB infection among very close, close regular and not close contacts [*29*]. Several authors have suggested that the proportion of positive tuberculin skin tests increases in relation to the degree of the relationship [*30*]. Other reports have shown that the proportion of infected and diseased contacts was significantly higher for those in contact with the TB patients [*25*]. Interestingly, in our study 100% of grandfathers and 50% of grandmothers of TB-infected children were diseased, followed by fathers and mothers. This is consistent with several authors who suggested that the age of TB patients is increased by 30 years moving from the generation of parents to that of grandparents [*16,31*]. Children may have more close contact with their grandparents than their parents. Other studies using multivariate analysis, have found that a close relationship is an important factor for TB infection [*25,30*]. This may be attributed to low socioeconomic status resulting in the crowded living conditions that contribute to increased transmission of TB bacilli.

Poverty may lead to bad housing or poor working conditions coupled with malnutrition; all of which favour the transmission of infection. Poverty may also reduce access to health care services, hence prolonging the period of infectivity of the TB patients and further increasing the risk of infection among their contacts

TB disease was significantly higher among patients with diabetes. This finding is similar to several studies suggesting that incidence of TB among individuals with diabetes is 2 to 3 times that of the general population [*32–34*]. There was also an increased risk of TB with corticosteroid therapy but this was not statistically significant, probably due to the small sample size.

In studying the clinical presentation, we found that persistent cough, unexplained fever, low body weight, weakness and pallor are all associated with TB infection among children. These signs could be considered as predictive signs for TB infection, particularly the first 3 signs, which are

used as a scoring method in screening for childhood TB [*24*].

The tuberculin skin test was positive in 133 (33.4%) of 398 household contacts over 15 years old. This rate is lower than that reported from Pakistan (49.4%) and the USA (36%) among close contacts of skin-test positive household members [*35*,*36*]. However, this discrepancy in skin test results is most probably related to the characteristics of the studied population and the type of skin test solution used as well as the cut-off point used for positive results [*30*,*37*].

The rate of paediatric TB found in our study was 1.3%, which is considerably lower than the rates reported in the literature [*38*]. The variation could be related to several factors: environmental, genetic, nutritional or HIV infection.

The incidence of TB reported in the present study (14.3%) is higher than that reported from Spain (3.7%–6.3%), Taiwan (6.2%), Japan (1%), USA (1%) and Finland (0.7%) [*16*,*18*,*27*,*29*,*39–41*] but lower than the rate in Haiti (16.1%) [*42*]. This high reported incidence among household contacts was mainly attributed to index cases within households, as 77.2% of the new TB cases were attributed to household contacts. This uncovers a major gap in the contact tracing mechanisms and treatment of LTBI among the household contacts of active TB cases, or at least non-adherence to treatment completion. Achieving high rates of completion of therapy for LTBI in recently infected contacts of active cases of pulmonary TB is essential to maximize public health prevention efforts aimed at eliminating the disease.

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