

Evaluation of a large scale tuberculosis contact investigation  
in The Netherlands (2005).

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45

## **Abstract**

**Objective:** To evaluate yield and effectiveness of a large-scale contact

50 investigation around a supermarket employee with infectious tuberculosis.

**Methods:** Supermarket customers were screened by tuberculin skin test (TST) and/or X-ray depending on individual characteristics. We estimated the number of recent infections identified based on historical reference data after correction for false-positive TST results.

55 **Results:** TST screening (n=15,518) yielded 12 cases of tuberculosis disease as direct result of the investigation (1293 screenings per case identified). X-ray screening (n=5945) yielded no case. There were 359 (2.6%) positive TSTs; 117 (34%) were estimated to be due to recent exposure. The number of customers screened in order to find one case of recent infection was 114,  
60 varying from 43 for customers who visited the supermarket twice per week or more, to 4148 for customers who visited less than once per month.

**Conclusions:** Although this patient probably transmitted *M. tuberculosis* to at least 117 customers, the contact investigation was inefficient as large numbers of customers had to be screened and the majority of identified  
65 tuberculosis infections were probably not related to the index cases. The efficiency could have been improved by omitting X-ray screening and limiting TST screening to customers who reported frequent supermarket visits.

**Keywords (MESH):** control, efficiency, public health, tuberculosis

## 75 **Introduction**

Tuberculosis (TB) remains a major cause of morbidity and mortality worldwide [1]. Many industrialised countries have been able to implement effective control policies and thereby reduced the incidence to very low levels. Apart from treatment of passively detected cases, TB control in low-prevalence settings focuses on active case detection among high-risk groups and contacts of infectious TB cases, and identification and preventive treatment of latent tuberculosis infection (LTBI) [2-4]. These investigations are generally limited to household and other close (e.g. workplace) contacts [5-9]. A high prevalence of infection or multiple cases of disease suggests unusual bacterial virulence or duration of infectiousness of the source case and may be reason to expand the investigation to a larger number of casual contacts [9-11]. An important question when expanding TB investigations is how wide the net should be cast. The more casual contacts are included, the more infections will be detected, but also more false-positive tuberculin skin tests and remote infections unrelated to the source case with low probability of progression to disease [12].

In The Netherlands, the incidence of TB has been below 10/100,000 population over the past decade. There is no routine BCG vaccination program and the estimated prevalence of infection is below 5% in the indigenous Dutch population born after 1950 [13]. This makes the tuberculin skin test (TST) a suitable tool for detection of recent LTBI in contact investigations in the Dutch-born population [14,15]. Since among the foreign-born BCG vaccination is frequent and the prevalence of infection is higher, TST screening of foreign-born contacts is not routinely done. Contact

100 investigations are performed by Municipal Health Services (MHS) responsible  
for TB control, according to the “stone in the pond principle” [10]. Contacts are  
defined in concentric circles around the source case dependent on the  
frequency and intimacy of their contact. Individuals belonging to the innermost  
circle are investigated by TST and/or chest X-ray (CXR) depending on their  
105 age, BCG vaccination status and country of birth. If the observed prevalence  
of infection is deemed considerably above the expected value, the  
investigation is extended to the next circle until the prevalence of infection in  
the subsequent circle is expected to be not above the age-specific  
background prevalence [13]. In The Netherlands, large-scale contact  
110 investigations are not infrequent. From 1994-2004, 31 investigations involving  
more than 1000 individuals per investigation were performed. There have  
been no published evaluations of the effectiveness of these investigations and  
of their contribution to tuberculosis control in low-prevalence settings.

In 2005, a large-scale contact investigation including over 21,000  
115 customers of a supermarket in The Netherlands was carried out after an  
employee with cavitary TB had infected a large proportion of close contacts  
and co-workers. We here describe this investigation and evaluate its yield and  
effectiveness in order to advice on future approach in a similar situation.

## Methods

### 120 *Study population*

In November 2004, a 25-year old male, Dutch-born, full time supermarket employee in the city of Zeist (approx. 60,000 inhabitants) in The Netherlands was diagnosed with sputum smear-positive cavitary TB after a 12 months history of cough. Of 12 close contacts, three (25%) were diagnosed  
125 with active TB and seven (58%) with LTBI. Among 80 supermarket co-workers subsequently examined, TB infection was diagnosed in 47 (59%), including one case of TB disease. *Mycobacterium tuberculosis* isolates were shown to have the same IS6110 restriction fragment length polymorphism (RFLP) pattern as the index case. These results indicated that the source patient was  
130 highly infectious or had been infectious for a long period.

Early December, local authorities decided to expand the investigation to include the customers of the supermarket. The number of people eligible for investigation was estimated based on a telephone survey in an area of 4.4 square kilometres around the supermarket (approx. 23,700 inhabitants). An  
135 invitation letter was posted to all households in this area to announce the planned investigation among individuals who had been to this supermarket in the period between 1 January and 18 November 2004. Customers living outside the identified area were invited through locally distributed flyers, the internet and press releases.

140 The investigation took place during one week in early February 2005 in a local sports hall. Participants completed a short self-administered questionnaire on demographics, TB and BCG history, previously positive TST, and presence of any immunocompromising condition (defined as organ



transplant, HIV infection, or use of immunosuppressive medication). Because  
145 the questionnaire had to be limited in size and customers tend to visit at  
regular intervals, exposure was ascertained as categorised frequency of visits  
to the supermarket. An anteroposterior CXR was performed on all individuals  
born before 1945, or with a history of BCG vaccination after the first year of  
life, of TB or of positive TST. All other individuals had a TST according to the  
150 Mantoux method using two tuberculin units (TU) RT23 in tween-80 [State  
Serum Institute, Copenhagen, Denmark]. This tuberculin is bioequivalent to  
the international standard of 5TU PPD-S [16]. Skin reactions were read after  
72-120 hours [17].

The following definitions were used: *tuberculosis infection (TBI)*: TST  
155  $\geq 15\text{mm}$  or TST  $\geq 5\text{mm}$  if immunocompromised or  $< 5$  years of age, in  
accordance with Dutch guidelines [18], with or without TB disease; *latent  
tuberculosis infection (LTBI)*: TBI in the absence of TB disease; *culture  
confirmed TB*: CXR findings or symptoms suggestive of active TB and a  
positive culture for *M. tuberculosis*; *non-culture confirmed TB*: CXR findings,  
160 with or without symptoms, suggestive of active TB, with negative or not  
performed culture.

Participants diagnosed with TBI or suspected TB disease were referred  
to follow-up at the MHS. Follow-up consultations involved clinical examination,  
a CXR, sputum collection and referral for further diagnostic evaluation if  
165 indicated. Mycobacterial culture was performed on clinical materials. The *M.  
tuberculosis* isolates were DNA fingerprinted by IS6110 RFLP typing at the  
National Institute of Public Health and the Environment (Bilthoven,  
Netherlands) following standard procedures [19,20]. Participants diagnosed

with LTBI were offered a six-month course of isoniazid preventive therapy (IPT) or six-monthly follow-up with CXRs during two years, depending on age, co-medication and individual preference. Individuals not identified with TBI but with a TST reaction size of 10–14 mm were later invited for CXR examination. Initial diagnoses of TB with no or negative culture result were reviewed by an independent TB specialist. The yield of TB was classified by three of the authors not involved in the contact investigation as direct yield of the contact investigation if detected as result of the initial CXR screening, or as result of the CXR examination and additional investigations done because of TBI or because of a TST result of 10–14 mm. Cases of TB identified during IPT were classified as indirect yield.

### *Data analysis*

Data were validated and analysed using Stata (version 8, Stata Corp. College Station TX, USA). Individuals with a missing TST or CXR result were excluded from the analyses. Associations between TBI and frequency of visits to the supermarket and other variables were analyzed univariate and multivariate by logistic regression [21].

For the evaluation of yield and effectiveness of detection of LTBI, we estimated the proportion of detected TBI cases considered recently acquired, i.e. attributable to infection in the supermarket. We used historical reference data based on the infection prevalence measured among Dutch military conscripts from 1910-1980. Applying the estimated annual risk of infection as it decreased over time, these prevalence were extrapolated to yield the expected prevalence of TBI per 10-year age-group in 2005 [13]. Expected

prevalence for age groups born after 1960 were extrapolated assuming  
195 continuing proportional decline of the annual risk of infection. As the historical  
data had been collected using 1TU RT23 or a bioequivalent tuberculin at a  
cut-off of 10 mm, these expected age-specific prevalence of TBI in 2005 were  
adjusted for the difference in sensitivity with that of 2TU RT23 and cut-off 15  
mm used in this contact investigation [22]. The resulting prevalence were  
200 considered to represent the age-stratified background prevalence of remote  
TBI in the Dutch-born population, i.e. acquired in the more distant past. The  
prevalence of recently acquired TBI was calculated as the difference between  
the observed prevalence of TBI and the background prevalence of remote  
TBI. Among the participants considered to have recent TBI, the number of  
205 false-positive TSTs due to e.g. cross-reaction with atypical mycobacteria was  
estimated for each category of exposure based on the sensitivity and  
specificity of 2TU RT23 as observed previously in the Dutch population [15].  
From the resulting number of true positive TSTs we calculated the prevalence  
of recent TBI, the incremental yield in number of recent TBI cases by category  
210 of exposure (in diminishing order), and the number of people needed to be  
tested in order to detect one case of recent TBI.

To check the validity of our estimates, we also estimated the proportion  
of recent infections based on the reported frequency of visits to the  
supermarket, assuming that the additional risk of infection for individuals who  
215 had visited the supermarket less than once a month on average (i.e. the  
baseline category) was equal to zero. We calculated the attributable risk for  
the other categories of frequency of visits to the supermarket as  $AR_i = (OR_i - 1)/OR_i$  in which  $AR_i$  is the attributable risk for the  $i^{th}$  frequency category, and

OR<sub>*i*</sub> the adjusted odds ratio of TBI for the *i*<sup>th</sup> frequency category compared to  
220 the baseline category [23].

## Results

Approximately 15,000 people were estimated to be eligible for screening.

Eventually, 21,326 individuals were registered in the sports hall during the

week in February 2005 (FIGURE). Their median age was 37 years (range 0-

225 98), 44% were male and Zeist was the place of residence for 83%. Country of birth was reported as The Netherlands by 18,811 individuals (88%), 104 other countries were reported by 2224 individuals. Country of birth remained unknown for 291.

A TST result was available for 13,970/15,518 (90%) individuals (TABLE

230 1). Of these, 359 (2.6%) were diagnosed with TBI and further investigated, resulting in 11 cases of TB disease (FIGURE). The remaining 348 individuals (2.5%) were classified as LTBI, of whom 154 (44%) received IPT, 122 (35%) were assigned to CXR follow-up and 72 (21%) did not report after diagnosis.

Three cases of TB disease (0.9%) were later diagnosed among the LTBI

235 patients during IPT (FIGURE). Of 274 individuals with a TST of 10-14 mm invited for CXR examination later, 206 (75%) reported. Of these, one (0.5%) was diagnosed directly with TB disease (FIGURE), one (0.5%) was started on IPT, and 157 (76%) were assigned to CXR follow-up.

Of the 5,811 individuals with a result of the initial CXR examination,

240 444 (7.6%) had abnormal findings that warranted clinical evaluation. None of these were diagnosed with TB disease.

Fifteen cases of TB disease were thus identified as direct or indirect result of this contact investigation (TABLE 2). All 15 were born in The Netherlands, six were male and the median age was 31 years (range 2-58).

245 None reported an immunocompromising condition or any relation to each

other or contact with the index case, except during supermarket visits. Eight (53%) had visited the supermarket at least twice, and four (27%) at least once a week on average. Seven cases were culture positive for *M. tuberculosis*, from six an RFLP pattern was obtained, and for five of these (83%) the RFLP pattern was identical to that of the index case. Twelve cases of TB disease were classified as direct yield of the contact investigation (56/100,000; 95% CI 31-101/100,000). The remaining three cases were classified as indirect yield (14/100,000; 95% CI 4-45/100,000) (TABLE 2). All initial diagnoses of TB without culture result or with negative cultures were confirmed by the independent clinical review.

We obtained information on frequency of visits to the supermarket from 13,343 (96%) of the 13,970 individuals with a TST result. The prevalence of TBI was twice as high in customers visiting the supermarket at least twice a week on average as in those who visited the supermarket less than once a month (adjusted odds ratio 2.1, 95% CI 1.6-2.9) (TABLE 3). Compared to individuals with a TST reaction 0-4 mm, the proportion of individuals with a TST  $\geq 15$  mm or 10-14 mm increased with the frequency of supermarket visits (chi square test for trend,  $p < 0.001$  and  $p = 0.011$ , respectively).

The age-stratified background prevalence of remote infections among the customers screened by TST, as estimated from the historical reference data, was 1.5%, and the overall prevalence of TBI diagnosed in this investigation was 2.5% (95% CI 2.3-2.8%). Among 340 TBI cases who reported data on supermarket visits, the estimated proportion of remote infections was 58% (198/340, 95% CI 53-64%, TABLE 4). This proportion was 56% (95% CI 44-71%) when based on the average attributable risk. After

adjustment for false-positive TST reactions, the estimated number of detected cases of true recent TBI was 117, for an overall prevalence of 0.9%, and an estimated proportion of true-positive and recently acquired TBI of 34% (TABLE 4). The overall number needed to test by TST to identify one true recent TBI was 114. These indicators varied strongly with frequency of supermarket visits (TABLE 4). Among customers who reported at least two supermarket visits per week, the prevalence of detected true recent TBI was 2.3%, the estimated proportion of TBI that was true-positive and recently acquired 58%, and the number needed to test to identify one true case of recently acquired TBI 43. Among customers who reported one visit per month or less these figures were <0.1%, 1% and 4148, respectively.

## Discussion

This extensive contact investigation of more than 21,000 supermarket customers resulted in early detection and treatment of 15 TB patients and identification of 348 cases of LTBI. Despite this considerable yield, our evaluation shows that, in retrospect, this investigation could have been done in a more efficient way. No case of TB disease was found among 5,811 customers initially examined by chest X-ray and 114 customers needed to be skin tested to identify one true-positive case of recently acquired TBI. If treatment would be indicated for recently acquired LTBI only, as is the policy in the Netherlands [18], 66% of the LTBI cases eligible for prophylactic treatment would not have needed it.

Our results support that the index patient was the source of a considerable number of TB infections. The identical *M. tuberculosis* DNA

fingerprints in the index case and five of the seven customers with culture confirmed TB, indicate a direct transmission link. None of the TB cases reported to be related to each other and 80% reported at least one weekly visit to the supermarket. As 34% of the TBI cases were estimated to have a true positive TST due to recent infection, the source patient probably transmitted *M. tuberculosis* to at least 117 supermarket customers. From a TB control perspective, early detection and treatment of previously unrecognized, culture-positive TB cases is warranted and has in this case most likely prevented further transmission of TB to several others

From the perspective of monetary and non-monetary costs to society and the public health system, there are several disadvantages to such a large-scale investigation. Although no data were collected to allow cost-benefit analysis, we estimate that 500.000 Euro were spent on this investigation. In order to detect one case of TB disease, 1293 customers had to be investigated by TST. Moreover, we estimated that 56 to 58% of the detected TBI cases were due to remote infection and thus most likely unrelated to exposure in the supermarket. The estimated lifetime probability of progression from LTBI to TB disease without preventive treatment is 5 to 15%, of which 55-85% is estimated to occur in the first five years after infection, both depending on age at infection [24]. Thus, with remote LTBI this probability is low unless the individual becomes immunocompromised [25]. We estimated that 25 of 142 (18%) recent TBI cases had false-positive TSTs, most likely due to cross-reactions with non-tuberculous mycobacteria. This was despite a specificity of 99.8% for the TST cut-off of 15 mm applied for immunocompetent customers aged >5 years [15]. This illustrates the



phenomenon that even with high specificity the positive predictive value of a test will be affected when the prevalence of infection is low [26].

The TST cut-off for LTBI of 15 mm used in this contact investigation follows Dutch guidelines [18]. Different cut-off values are recommended for different target populations according to their expected risk of recent infection and a cut-off of 10 mm is used for immunocompetent individuals with documented contact with an infectious TB patient. In the periphery of a large contact investigation a cut-off of 15 mm is advised. With the low prevalence of LTBI in this study population, a cut-off of 10 mm would have given a higher sensitivity for detecting LTBI, but a lower specificity resulting in more false-positive TSTs [15]. For screening for TB disease a cut-off of 10 mm was nonetheless adopted, which yielded one additional case of TB disease. The prevalence of TB disease in this group (0.5%) was however lower than that among individuals with TST reactions  $\geq 15$  mm (3.9%,  $p=0.003$ ).

Our study has limitations. We used categorized frequency of visits to the supermarket as proxy for exposure to the index case and this might be prone to recall bias. Furthermore, we collected no data on socio-economic status that could have confounded our findings.

Our estimates of recent TBI were extrapolated from infection prevalence measured among male military conscripts from 1910-1980. They do not take into account possibly different infection prevalence among women, and we had to make assumptions about the infection prevalence for age groups born after the last age cohort that had been included in the military screening program. Nonetheless, our estimates of the background prevalence

of remote infection (1.48%) seems robust since it is close to the observed prevalence of infection in the lowest exposure category ( $70/4148 = 1.69\%$ ). The difference indicates that we underestimated the background prevalence by no more than 0.21%. The resulting bias would only decrease the proportion of infections that were due to transmission in the supermarket, thereby reinforcing our conclusion that this investigation was inefficient in finding cases of recent LTBI.

Could expansion of this contact investigation from occupational contacts to supermarket customers have been done more effectively?

First, X-ray screening without prior testing for TBI could have been omitted.

Second, testing could have been more selective without affecting the public health benefits. If skin testing had initially been limited to the customers who visited the supermarket at least once a week, more than half of the customers would not have been tested while 83% of the cases of TB disease, and 89% of the true-positive recent TBI cases would have been detected. Half of the cases identified as TBI would have been true-positive and recent, and the number needed to test to find one case of true-positive recent TBI would have been halved from 114 to 58. Interim analysis would then have suggested that further expansion of the investigation to customers with less exposure would result in low effectiveness. This approach would also have reduced the costs considerably, although acceptance of, and compliance with, such a selective approach needs to be tested.

370 Third, interferon-gamma release assays (IGRA) could have been used instead of, or as adjunct to, the TST to improve its positive predictive value and to allow testing for TBI of customers with a history of BCG vaccination [27]. Recent studies suggest that IGRA may even be more specific for recent than for remote infections [28,29].

375 Finally, an awareness raising campaign among general practitioners and medical specialists might have led to early detection and treatment of many of the recent TB cases and could be considered as an alternative to such a large contact investigation. The ethical implications of waiting for TB cases to occur must, however, be considered. A structured protocol for large-  
380 scale TB contact investigation is highly warranted in The Netherlands and is currently under development.

In conclusion, our study has two major implications. First, any rational and efficient approach to contact investigation will identify only a fraction of  
385 transmissions accomplished by a tuberculosis source patient who had opportunity to expose large numbers of individuals. Second, the optimal size of a contact investigation is setting-specific and, apart from available resources and logistical considerations, depends on the background prevalence of LTBI among the contacts. The estimated number of intensely  
390 exposed contacts that needed to be screened to identify one case of true-positive recent infection can be a useful indicator to guide the decision to expand an investigation to less exposed contacts.

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Individual contributions:

**Katrine Borgen** helped collecting the data, analyzed the data, and drafted the  
manuscript.

**Ben Koster** designed and organized the contact investigation, supervised the  
415 collection of the data and assisted in drafting of the manuscript.

**Hans Meijer** assisted in data collection, data analysis and drafting of the  
manuscript.

**Vincent Kuyvenhoven** advised on the contact investigation and designed the evaluation.

420 **Marianne van der Sande** assisted in data analysis and drafting of the manuscript.

**Frank Cobelens** designed the evaluation and assisted in data analysis and writing of the manuscript.

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Legend to figure.

**Figure.** Main outcome from testing of supermarket customers as part of a contact investigation around a supermarket employee diagnosed with sputum smear positive TB in Zeist, The Netherlands, February 2005.

CXR: chest x-ray, TST: tuberculin skin test.

Active TB Direct: TB disease diagnosed as result of the initial CXR screening from the CXR examination and additional investigations done because of TB infection including a TST result of 10 – 14 mm.

530 Active TB indirect: Diagnosed in individuals during the isoniazid preventive therapy.

**Table 1.** Characteristics of 19,716 supermarket customers exposed to an infectious tuberculosis patient, by availability of tuberculin skin test (TST) or initial chest X-ray (CXR) result.

		TST result available		CXR result available	
		N	(%)	n	(%)
<b>Total*</b>		13,970	(100)	5811	(100)
Male		6142	(44.0)	2592	(44.6)
Age group (y)	<5	1143	(8.1)	29	(0.5)
	5-14	2140	(15.3)	114	(2.0)
	15-24	2062	(14.8)	240	(4.1)
	25-34	2519	(18.0)	445	(7.7)
	35-44	2771	(19.8)	553	(9.5)
	45-54	2260	(16.2)	684	(11.8)
	55-64	1075	(7.7)	1418	(24.4)
	>64			2313	(39.8)
Dutch-born		13,355	(95.6)	4057	(69.8)
Previous BCG^				1350	(23.2)
Previous TB diagnosis				193	(3.3)
Previous positive TST				624	(10.7)
Immunocompromising condition		191	(1.4)	253	(4.4)

\* Totals may not add up because of missing values.

^ BCG vaccine reported after first year of life.

**Table 2.** Characteristics of the 15 cases of tuberculosis disease diagnosed as a result of the contact investigation.

Sex	Age (years)	symptoms	Chest X-ray findings	<i>M. tuberculosis</i> Culture	RFLP pattern	Yield	Remarks
Male	15	none	HL	ND	NA	Indirect	Developed during IPT
Female	14	cough	IL RUL	ND	NA	Direct	
Female	31	Fatigue	HL; IL LUL	Negative	NA	Direct	
Male	48	NA	NA	Positive	Same	Direct	
Male	2	Cough, fever, night sweats	HL	ND	NA	Direct	
Male	36	NA	HL, NL LUL	Negative	NA	Direct	
Male	6	none	HL	Negative	NA	Indirect	Developed during IPT
Female	14	cough	IL RUL	Positive	Same	Direct	
Male	58	cough	IL RUL	Negative	NA	Direct	PCR positive
Female	29	Night sweats	IL RCL	Positive	Different	Direct	different <i>M. tuberculosis</i> strain
Female	58	none	IL RUL	Positive	NA	Direct	
Female	50	Cough, night sweats	2 IL LUL; PT; PE	Positive	Same	Direct	TST 10-14 mm
Female	49	None	PE	Negative	NA	Direct	Pleural fluid, ZN positive
Female	2	Cough	None	Positive	Same	Indirect	During IPT, bronchial TB
Female	42	none	IL RUL	Positive	Same	Direct	

ND = not done, NA = not available, RFLP = restriction fragment length polymorphism, same = identical to index case, different = not identical to index case, ZN = microscopic examination of Ziehl-Neelsen stained clinical specimen, IPT = isoniazid preventive therapy.

Radiographic findings: IL: infiltrative lesion, NL: nodular lesion; HL: hilar lymphadenopathy; PT: pleural thickening; PE: pleural exsudate; RUL: right upper lobe; LUL: left upper lobe; RCL: right central lobe.

**Table 3.** Association between prevalence of tuberculosis infection and potential risk factors for infection among supermarket customers.

Variable	TBI/total TST	(%)	OR (95% CI)*	p-value†
Frequency supermarket visits				
<1/month	70/4148	(1.7)	Ref	
<1/week >1/month	65/3149	(2.1)	1.2 (0.9-1.7)	
1/week	98/3352	(2.9)	1.6 (1.2-2.2)	
≥2/week	107/2694	(4.0)	2.1 (1.6-2.9)	<0.001
Gender				
Female	212/7542	(2.8)	Ref	
Male	144/6142	(2.3)	0.9 (0.7-1.1)	0.431
Age group, yr				
<5	31/1143	(2.7)	Ref	
5-14	18/2140	(0.8)	0.3 (0.2-0.6)	
15-24	34/2062	(1.7)	0.6 (0.4-1.0)	
25-34	54/2519	(2.1)	0.8 (0.5-1.3)	
35-44	81/2771	(2.9)	1.0 (0.6-1.6)	
45-54	86/2260	(3.8)	1.2 (0.8-2.0)	
55-64	55/1075	(5.1)	1.7 (1.1-2.8)	<0.001
Immunocompromising condition				
No	342/13,524	(2.4)	Ref	
Yes	11/191	(5.8)	2.0 (1.0-3.7)	0.054
Country of birth				
Netherlands	338/13,355	(2.5)	Ref	
Non-Netherlands	18/424	(4.3)	1.5 (0.9-2.5)	0.168

\* Odds ratios (OR) adjusted for the other variables by logistic regression, CI = confidence interval, † p-values for log likelihood ratio test. Frequency supermarket visits: p for trend < 0.001

**Table 4.** Yield and effectiveness of screening for tuberculosis infection by tuberculin skin testing among 13,343<sup>\$</sup> supermarket customers, by reported frequency of visits to the supermarket.

	Frequency of supermarket visits				Total
	≥2/week	1/week	<1/week >1/month	≤1/month	
Number of TST <sup>¶</sup>					
TBI diagnosed (prevalence)	2694 (20%) 107/2694 (4.0%)*	3352 (25%) 98/3352 (2.9%)*	3149 (24%) 65/3149 (2.1%)*	4148 (31%) 70/4148 (1.7%)	13,343 (100%) 340/13,343 (2.5%)*
Expected age-adjusted prevalence of remote TBI	1.48%	1.48%	1.48%	1.48%	1.48%
Sensitivity TST [15]	79.8%	79.8%	79.8%	79.8%	79.8%
Specificity TST [15]	99.8%	99.8%	99.8%	99.8%	99.8%
Remote TBI	40/107 (37%)	50/98 (51%)	47/65 (73%)	61/70 (87%)	198/340 (58%)
Recent TBI, false-positive	5/107 (5%)	6/98 (6%)	6/65 (9%)	8/70 (11%)	25/340 (7%)
Recent TBI, true-positive	62/107 (58%)	42/98 (43%)	12/65 (19%)	1/70 (1%)	117/340 (34%)
Prevalence of true recent TBI	62/2694 (2.3%)	42/3352 (1.3%)	12/3149 (0.4%)	1/4148 (<0.1%)	117/13,343 (0.9%)
Proportion of all true recent infections <sup>¶</sup>	62/117 (53%)	42/117 (36%)	12/117 (10%)	1/117 (1%)	117/117 (100%)
Incremental yield	-	42/104 (40%)	12/116 (10%)	1/117 (1%)	-
Number needed to test <sup>†</sup>	43 (2649/62)	80 (3352/42)	262 (3149/12)	4148 (4148/1)	114 (13,343/117)

<sup>\$</sup>For 629 persons (4.5%: including 19 with positive TST) no exposure data were available.

TST = tuberculin skin test. TBI = tuberculosis infection, including both latent infections and infections with active disease. Remote TBI: number of cases calculated as (expected age-adjusted prevalence of remote TBI)\*(number of TST).

Incremental yield: proportion of true recent infections that was identified additionally by screening contacts in the exposure category indicated.

<sup>¶</sup> Row percentages given.

\*Significantly different from expected age-adjusted prevalence of remote infections (1.5%).

<sup>†</sup>Number of subjects needed to test by tuberculin skin testing to identify one true-positive case of recent tuberculosis infection



Figure

