This cross-sectional survey aimed to examine the epidemiology of tuberculosis (TB) in European Union (EU) and European Economic Area (EEA) cities with populations greater than 500,000. National TB programme managers were asked to provide data on big city population size, total number of notified TB cases in big cities and national notification rate for 2009. A rate ratio was calculated using the big city TB notification rate as a numerator and country TB notification rate, excluding big city TB cases and population, as a denominator. Twenty of the 30 EU/EEA countries had at least one big city. Pooled rate ratios were 2.5, 1.0, and 0.7 in low-, intermediate- and high-incidence countries respectively. In 15 big cities, all in low-incidence countries, rate ratios were twice the national notification rate. These data illustrate the TB epidemiology transition, a situation whereby TB disease concentrates in big cities as national incidence falls, most likely as a result of the higher concentration of risk groups found there. This situation requires targeted interventions and we recommend that big city TB data, including information about patients’ risk factors, are collected and analysed systematically, and that successful interventions are shared.

Introduction

Tuberculosis (TB) notification rates in the European Union (EU) have been declining at a mean annual rate of 4.4% since 2006, and in 2010 there were 73,996 TB cases reported by the 27 EU Member States and the three European Economic Area (EEA) countries (Iceland, Liechtenstein and Norway) [1]. This resulted in notification rates below 100 per 100,000 population in all EU Member States for the first time in 2010. These national and EU-wide figures demonstrate the progress made towards the target of elimination, defined as less than one infectious (sputum smear-positive) case per 1,000,000 population [2]. However, they hide some of the wide variations that exist between and within countries.

Several publications have highlighted the higher notification and incidence rates in EU/EEA big cities or metropolitan areas, compared to non-urban areas, which is particularly evident among certain high-risk groups for TB overrepresented in big cities, including migrants from high-incidence countries, homeless people and drug and alcohol users [3–14]. The nomenclature used to describe major urban conurbations is variable within the literature, and includes big or large city, metropolis or metropolitan area, urban area. The definition is often based on population size or density criteria. Cities are administrative areas (municipalities), while metropolitan areas usually combine urban agglomeration with peripheral zones that are not necessarily urban in character, but are closely bound to the centre by employment or commerce [15]. Urban and suburban areas can also share the general big city social structures underpinning the congregation of urban high-risk groups.

TB surveillance in Europe does not provide specific information on the epidemiology of TB in big cities, and data are only available routinely within countries and not readily accessible for international comparison. To inform the preparation of the consensus statement, which examined the structural determinants of TB in EU/EEA big cities, as well as provided
recommendations for big city TB control [16], a survey
of national TB programme managers was conducted.
This cross-sectional survey aimed to provide detailed
information of the epidemiology of TB in EU/EEA big
cities, allowing an analysis of the case distribution and
infection rates within low-, intermediate- and high-inci-
dence EU/EEA countries and their big cities.

Methods

Cross-sectional survey among national
tuberculosis programme managers

For the purpose of this work we defined a big city as
any municipality in the EU/EEA which had more than
500,000 inhabitants in 2009.

World Health Organization (WHO) national TB pro-
gramme managers in EU/EEA countries were emailed
by one of the authors (GdV) during the period from
April 2011 to October 2012 using a list provided by
the WHO Regional Office for Europe. TB programme
managers received a form containing big city population
size data, the total number of national notified TB
cases, and national notification rate for their country
in 2009. These pre-populated data were taken from
various sources. City population estimates were taken
from the Eurostat Population and living conditions in
Urban Audit cities (core city) [17] or where not avail-
able other Internet sources such as Wikipedia were
used. Country population sizes were taken from the
Tuberculosis Surveillance in Europe 2009 report [18].
The total number of national notified TB cases in 2009
and the national notification rate were taken from the
Tuberculosis Surveillance and monitoring in Europe
2012 report [1]. National TB programme managers were
asked to verify (or change as necessary) this pre-pop-
ulated data, or to send this information on to appropri-
tate public health officials responsible for TB control in
the big city under consideration. They were also asked
to provide the number of TB cases for each big city
identified within their country in 2009. Data received
back from the national TB programme managers, or
public health authorities responsible for TB control in
these big cities, were collated in an Excel spreadsheet.

To examine the effect of big cities on TB incidence, we
calculated rate ratios using the big city TB notification
rate as a numerator and the country TB notification
rate, excluding big city TB cases and population, as a
denominator. National and big city TB notification rates
and rate ratios were calculated in Stata (StataCorp LP,
College Station, TX, USA) version 12.

Data were presented separately for low-, intermedi-
ate- and high-incidence EU/EEA countries and their
big cities. Various definitions for low-incidence and
high-incidence countries exist. The European Centre
for Disease Prevention and Control (ECDC) defines
countries with a TB incidence rate of <20 TB cases per
100,000 population as low-incidence countries enter-
ing the phase of elimination [1]. For this study we
classified countries into low-incidence countries (<20
notifications per 100,000 population), mainly in western
EU/EEA, and intermediate (20-50 notifications per
100,000) and high-incidence countries (>50 notifica-
tions per 100,000), mainly in the central and eastern
EU.

Data from the tuberculosis control in European
Union big cities working group

Annual notification rates for six selected big cities,
available for the last 20 years, were collected in order
to examine and exemplify time trends within these cit-
ties. Selection was based on participation in the work-
ing group, availability of data and its illustrative power
to show a stable, declining or increasing trend. Two of
these big cities with five-year inner city data available
were selected to demonstrate the variation of TB notifi-
cation rates within their big cities.

Results

Current epidemiology of tuberculosis in big
cities – cross-sectional survey results

From the 30 EU/EEA countries, 20 had at least one big
city (15/23 low-incidence, 3/5 intermediate and 2/2
high-incidence countries), with 54 big cities in total,
45 in low-incidence, seven in intermediate and two in
high-incidence countries. All national TB programme
managers or public health authorities from these big
cities responded.

The population in big cities represented 12.4% of the
total EU/EEA population. The highest notification rates
in big cities in low-incidence countries were observed
in Birmingham and London, United Kingdom (58.0,
44.4 respectively), followed by Brussels, Belgium
(29.9), and Barcelona, Spain (27.0), all higher or con-
siderably higher compared to their national TB notifi-
cation rates (Table 1). The highest notification rates in
big cities in intermediate and high-incidence countries
were observed in Bucharest, Romania (87.1) and Riga,
Latvia (43.0), followed by Sofia, Bulgaria (36.6) and
Vilnius, Lithuania (31.9), all lower than their national
TB notification rates.

The highest rate ratios (big city notification rate more
than twice the national notification rate) were found in
15 big cities, all in low-incidence countries. Birmingham
had the highest rate ratio followed by Brussels;
London; and Rotterdam, the Netherlands (4.0, 3.2, 3.0
and 3.0 respectively); Copenhagen, Denmark; Milan,
Italy; Oslo, Norway; Paris, France; and Turin, Italy (all
2.8); Amsterdam, the Netherlands (2.7); Rome, Italy
(2.5);; Frankfurt, Germany (2.4); Cologne, Germany
(2.3); Athens, Greece (2.2); and Genoa, Italy (2.0).

Table 2 shows the aggregated population size, TB
caseload and notification rates in EU/EEA countries
and big cities according to notification rate at country
level. In 2009, the TB notification rate across the EU/
EEA was 15.8 per 100,000 inhabitants and 22.3 in big
### Table 1
Population size, tuberculosis cases and notification rates in low-, intermediate- and high-incidence European Union/European Economic Area countries and their big cities (>500,000 population), and rate ratio for big cities, 2009 (20 countries, 54 cities)

<table>
<thead>
<tr>
<th>Country</th>
<th>Population</th>
<th>TB cases</th>
<th>Notification rate</th>
<th>Big city</th>
<th>Population</th>
<th>TB cases</th>
<th>Notification rate</th>
<th>Rate ratio a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>8,355,260</td>
<td>698</td>
<td>8.4</td>
<td>Vienna</td>
<td>1,698,957</td>
<td>256</td>
<td>15.1</td>
<td>1.8</td>
</tr>
<tr>
<td>Belgium</td>
<td>10,666,866</td>
<td>994</td>
<td>9.3</td>
<td>Brussels</td>
<td>1,068,532</td>
<td>320</td>
<td>29.9</td>
<td>3.2</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>10,467,542</td>
<td>695</td>
<td>6.6</td>
<td>Prague</td>
<td>1,233,211</td>
<td>128</td>
<td>10.4</td>
<td>1.6</td>
</tr>
<tr>
<td>Denmark</td>
<td>5,511,451</td>
<td>337</td>
<td>6.1</td>
<td>Copenhagen</td>
<td>667,228</td>
<td>113</td>
<td>16.9</td>
<td>2.8</td>
</tr>
<tr>
<td>Finland</td>
<td>5,326,314</td>
<td>417</td>
<td>7.8</td>
<td>Helsinki</td>
<td>583,350</td>
<td>58</td>
<td>9.9</td>
<td>1.3</td>
</tr>
<tr>
<td>France</td>
<td>62,131,000</td>
<td>5,114 b</td>
<td>8.2</td>
<td>Paris</td>
<td>2,199,500</td>
<td>515</td>
<td>23.4</td>
<td>2.8</td>
</tr>
<tr>
<td>Germany</td>
<td>82,002,356</td>
<td>4,419</td>
<td>5.4</td>
<td>Berlin</td>
<td>1,274,224</td>
<td>178</td>
<td>10.0</td>
<td>1.9</td>
</tr>
<tr>
<td>Greece</td>
<td>11,260,402</td>
<td>594</td>
<td>5.3</td>
<td>Athens</td>
<td>7,45,545</td>
<td>91</td>
<td>11.6</td>
<td>2.2</td>
</tr>
<tr>
<td>Hungary</td>
<td>10,030,975</td>
<td>1,407</td>
<td>14.0</td>
<td>Budapest</td>
<td>1,695,000</td>
<td>321</td>
<td>18.9</td>
<td>1.4</td>
</tr>
<tr>
<td>Italy</td>
<td>60,045,068</td>
<td>4,244</td>
<td>7.1</td>
<td>Rome</td>
<td>2,724,347</td>
<td>487</td>
<td>17.9</td>
<td>2.5</td>
</tr>
<tr>
<td>Netherlands</td>
<td>16,485,787</td>
<td>1,157</td>
<td>7.0</td>
<td>Amsterdam</td>
<td>755,605</td>
<td>143</td>
<td>18.9</td>
<td>2.7</td>
</tr>
<tr>
<td>Norway</td>
<td>4,799,252</td>
<td>358</td>
<td>7.5</td>
<td>Oslo</td>
<td>575,475</td>
<td>121</td>
<td>21.0</td>
<td>2.8</td>
</tr>
<tr>
<td>Spain</td>
<td>45,828,172</td>
<td>7,552</td>
<td>16.6</td>
<td>Madrid</td>
<td>3,255,944</td>
<td>580</td>
<td>17.8</td>
<td>1.1</td>
</tr>
<tr>
<td>Sweden</td>
<td>9,256,347</td>
<td>617</td>
<td>6.7</td>
<td>Stockholm</td>
<td>810,120</td>
<td>39</td>
<td>4.8</td>
<td>0.7</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>61,179,256</td>
<td>8,917</td>
<td>14.6</td>
<td>London</td>
<td>7,753,555</td>
<td>3,440</td>
<td>44.4</td>
<td>3.0</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>7,605,551</td>
<td>2,910</td>
<td>38.3</td>
<td>Sofia</td>
<td>1,249,798</td>
<td>457</td>
<td>36.6</td>
<td>1.0</td>
</tr>
<tr>
<td>Latvia</td>
<td>2,261,294</td>
<td>978</td>
<td>43.2</td>
<td>Riga</td>
<td>709,145</td>
<td>305</td>
<td>43.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Poland</td>
<td>38,135,876</td>
<td>8,236</td>
<td>21.6</td>
<td>Warsaw</td>
<td>1,711,466</td>
<td>304</td>
<td>17.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Lithuania</td>
<td>3,349,872</td>
<td>2,081</td>
<td>62.1</td>
<td>Vilnius</td>
<td>558,165</td>
<td>178</td>
<td>31.9</td>
<td>0.5</td>
</tr>
<tr>
<td>Romania</td>
<td>21,498,616</td>
<td>23,164</td>
<td>107.7</td>
<td>Bucharest</td>
<td>1,944,226</td>
<td>1,694</td>
<td>87.1</td>
<td>0.8</td>
</tr>
</tbody>
</table>

TB: tuberculosis.

a Rate ratio calculated using the big city TB notification rate as a numerator and country TB notification rate, excluding big city TB cases and population, as a denominator.

b Excluding overseas districts of France.

c Populations of Hannover and Milan are for the greater municipal area/conglomerate.

Cities shown in blue are those with a rate ratio greater than or equal to 2.0.
cities, resulting in a rate ratio of 1.5. Pooled rate ratios were 2.5, 1.0, and 0.7 in low-, intermediate-, and high-incidence countries respectively. Big cities of EU/EEA low-incidence countries accounted for 27.0% (10,493 of 38,868) of the notified TB cases while only 12.8% of the general population lived in these cities.

Discussion
This study presents the results of a cross-sectional survey of national and big city TB programme managers, examining the distribution of TB cases and rates within EU/EEA countries and big cities. In 2009, 15 out of 54 EU/EEA big cities had a notification rate two times greater than the national notification rate and all were in low-incidence countries. The TB notification rate across the EU/EEA was 15.8 per 100,000 population (excluding overseas districts of France) compared to 22.3 in the big cities. In low-incidence EU/EEA countries, 27.0% of TB cases lived in big cities, compared to only 12.8% of the general population residing there. These data illustrate the high levels of TB found in EU/EEA big cities that are not obvious when examining national data alone. Analysis of available long-term data for EU/EEA big cities show that while there is a general downward trend, some big cities such as London have seen an increase in notifications over recent years.

In the United States (US) a study examined all incident cases of TB reported to the Centers for Disease Control and Prevention’s National Tuberculosis Surveillance System (NTSS) from 2000 to 2007 [19]. This study found that a significant TB burden occurs in large US cities with 36% of all US TB patients living in 48 cities compared with only 15% of the general US population. TB incidence rates in these cities (12.1/100,000) were four times higher than that in the US when excluding the cities (3.8/100,000).
A European study conducted in 1999–2000 contacted national TB coordinators in western European countries (or their public health counterparts in the appropriate cities) and asked them to provide TB epidemiological data [5]. Notification rates in cities were found to range from less than 10 per 100,000 population to 70. Notification rates were more than double the overall rate for the country in eight of the cities (Brussels; Copenhagen; Paris; Thessaloniki, Greece; Milan; Amsterdam; The Hague, the Netherlands; and London). These findings were consistent with those of our study which also found Brussels, Copenhagen, Paris, Milan, Amsterdam, and London to have a rate ratio of greater than two (Thessaloniki and The Hague did not meet our criteria for big city). In addition to the disparities that exist between levels within countries and their big cities, there is also variation within big cities themselves within different districts of a city.

Our study used a narrow definition of TB in big cities to refer to cases residing within the administrative boundaries of a municipality, although for two big cities (Hannover, Germany; and Milan) information was not available. TB case ascertainment is a dynamic process both in EU/EEA countries and in their big cities, so the actual number of cases and notification rate may change over time. Since we collected the data on TB in big cities at approximately the same time as EU/EEA countries uploaded the revised 2009 data to ECDC, presented in the 2012 report [1], we optimised comparison of data. Our study did not collect data on risk factors of urban and national TB cases, which may further explain the urban-rural difference found in this study. We also did not gather information on TB control strategies and resources, which may differ in urban and rural areas, and effect case detection and notification levels.

Factors contributing to the high notification rates in western EU/EEA big cities are likely to be related to the relatively high proportion of immigrants from high-incidence countries, outbreaks among homeless people, drug users and alcoholics, and on-going transmission to other urban populations [5,10,19,20]. Factors such as the high population density in big cities, the high prevalence of congregate settings, population pockets in big cities with lower socio-economic status [21], and at times inadequate public health responses [22–24], are also likely to contribute to higher TB notification rates in big cities.

Our study shows that with TB notification rates declining to less than 20 per 100,000 population, in most EU/EEA countries, TB rates in big cities remain higher than the national notification rate. Our data also illustrate the TB epidemiology transition: a situation whereby TB
Figure 2
Average tuberculosis notification rates per 100,000 population and by borough or postal code area in London and Rotterdam, 2007-2011
disease concentrates in big cities as national incidence falls, most likely as a result of the risk groups found there. We expect that countries going down from high and intermediate incidence to low-incidence are likely to experience the same phenomenon and should consider this changing epidemiological situation in their TB control programmes in a timely manner. To tackle this problem we recommend that big city TB data, including risk profiles of patients, are collected and analysed systematically and that interventions to control TB successfully in big cities are shared. The accompanying consensus statement on TB goes some way to ensuring consistency in approaches that are required [16].

Members of Tuberculosis in European Union Big Cities Working Group


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Authors’ contributions

GdV wrote the first draft of the manuscript. All authors contributed to the editing of the paper and have seen and agreed the final version.

Conflict of interest

None declared.

References


