



Original Article

## Migration Flow and Its Impact on Tuberculosis Notification in Portugal



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### ABSTRACT

**Introduction:** Tuberculosis notification in Portugal has decreased in the last few years. As a consequence of the economic crisis, emigration has increased and immigration has decreased. Immigrants are a risk group for tuberculosis. Most emigrants are 20–44 years old and belong to the age group most affected by tuberculosis.

**Objective:** To describe the decrease in tuberculosis notification in Portugal over the last years from a demographical point of view.

**Methods:** Mathematical analysis was performed to quantify the effect of the migration movements (separately and simultaneously) on tuberculosis notification in Portugal from 2008 to 2014. We calculated the estimated tuberculosis notification for each year during the period of study: 1) fixing immigration rate and tuberculosis rate in immigrants at 2008 values; 2) fixing emigration rate and tuberculosis rate in emigrants at 2008 values; 3) fixing both phenomena at 2008 values.

**Results:** The differences between the observed and the estimated numbers were small ( $\leq 0.5$  cases/100 000 inhabitants).

**Discussion:** Impact of the migration movements on tuberculosis notification rate does not seem to be significant when analyzed for each phenomenon individually and simultaneously, by our model. This might mean that we have to concentrate our efforts in other risk factors for tuberculosis.

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## El flujo de migratorio y su impacto en la notificación de tuberculosis en Portugal

### RESUMEN

**Introducción:** La notificación de casos de tuberculosis en Portugal ha disminuido en los últimos años. Como consecuencia de la crisis económica, la emigración ha aumentado y la inmigración ha disminuido. Los inmigrantes son un grupo de riesgo para la tuberculosis. La mayoría de los emigrantes tienen entre 20 y 44 años y pertenecen al grupo de edad más afectado por la tuberculosis.

**Objetivo:** Describir la disminución de la notificación de casos tuberculosis en Portugal en los últimos años, desde un punto de vista demográfico.

**Métodos:** Se realizó un análisis matemático para cuantificar el efecto de los movimientos migratorios (por separado y simultáneamente) en la notificación de casos de tuberculosis en Portugal de 2008 a 2014. Se calculó la notificación de casos de tuberculosis estimada para cada año durante el período de estudio. La notificación estimada de tuberculosis para cada año del periodo de estudio se calculó: 1) fijando las tasas de inmigración y de tuberculosis en inmigrantes con datos del año 2008; 2) fijando las tasas de emigración y de tuberculosis en emigrantes con datos del año 2008, y 3) fijando ambos fenómenos con datos del año 2008.

*Palabras clave:*

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**Resultados:** Las diferencias entre los valores observados y los valores estimados fueron pequeñas ( $\leq 0,5$  casos/100.000 habitantes).

**Discusión:** Según el modelo matemático propuesto en este trabajo, el impacto de los movimientos migratorios en la tasa de notificación de casos de tuberculosis en Portugal no parece ser significativo cuando se analiza cada fenómeno tanto individual como simultáneamente. Estos datos indicarían que deberíamos concentrar los esfuerzos en identificar otros factores de riesgo para la tuberculosis.

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## Introduction

Since WHO declared tuberculosis (TB) a global emergency, many efforts have been made worldwide to decrease TB incidence.<sup>1</sup> In Portugal, a TB National Programme was implemented in 1995 and in 2006 the “STOP TB strategy” was launched to delineate specific goals and strengthen the struggle towards the end of TB.<sup>2,3</sup>

Eight years later, in 2014, Portugal reached the threshold of low incidence, registering 20 new cases per 100 000 inhabitants.<sup>4</sup> Despite this, it remains the highest incidence country in the Western Europe and some areas still have an intermediate incidence. Lisbon and Oporto are the districts with the highest incidence.<sup>4,5</sup>

Homeless people, drug users, prisoners and migrants are at increased risk of developing TB. These groups concentrate in urban settings and their numbers tend to have an impact on TB.<sup>6–10</sup> This work concentrates solely on the migrant movements' effect on TB. In fact, in many European countries, most cases of tuberculosis occur within the immigrant population. About 26.8% of TB cases reported in the European Union (EU) and European Economic Area countries are of foreign origin.<sup>5</sup> Therefore, migrants from high incidence countries have a considerable impact on the tuberculosis burden in low incidence countries.<sup>5,10</sup> Increased risk of TB in this group might be related to higher exposure in the country of origin and/or worse socioeconomic conditions, comparing to the resident population.<sup>11</sup>

As opposed to other European countries, like Iceland, Cyprus, Norway or Sweden, where more than 70% of tuberculosis cases occur in foreign born individuals, in Portugal, this group represents only about 16% of cases.<sup>6,10,12</sup> Nevertheless, TB incidence among immigrants in Portugal is much higher than in non-immigrants and it has been increasing.<sup>13</sup>

As a consequence of the economic crisis, in the last few years, an increasing number of individuals have left the country to live abroad. Portugal is the EU country with the largest number of emigrants per capita.<sup>14</sup> In 2014, the number of emigrants had risen to the double, compared to 2008. The majority are young adults, aged 20–44 years old, that left Portugal seeking for better working and living conditions abroad.<sup>15,16</sup> This age group overlaps with the one most affected by TB, between 25 and 54 years old.<sup>4</sup>

The main aim of this study is to describe the decrease in TB in Portugal over the last years purely from a demographical point of view. As such, the authors quantify the effect of the migration movements (immigration and emigration) on the TB notification in Portugal (from 2008 to 2014).

## Methods

### Data and Sources

Data on tuberculosis notification were collected from the Portuguese Tuberculosis Surveillance System (SVIG-TB) coordinated by the Directorate General of Health (DGH) during the seven year period ranging from 2008 to 2014. Data on migration movements for the period of study (2008–2014) were collected from

Immigration and Borders Service Statistics and Statistics Portugal, the public Portuguese entity responsible for the official statistical information and included: 1) the absolute number of resident immigrants in each year; 2) the absolute number of immigrants entering the country per year; 3) the absolute number of emigrants per year; 4) the migration balance, which refers to the difference between the number of individuals entering and leaving the country, per year.

For the purpose of this paper, TB cases with no information on the country of origin were excluded from the analysis.

As this was a retrospective study and used routinely collected surveillance data, neither ethical approval nor informed consent were required.

### Mathematical Analysis

The impact of the migration movements on the TB burden was initially addressed separately for immigration and emigration, and simultaneously afterwards. The separate analysis allowed for the study of the influence of each migration phenomenon in isolation.

Firstly, the expected number of TB cases per 100 000 inhabitants for year  $t$  (2008, 2009, . . . , 2014) under a steady situation of immigration (*i.e.*, keeping both the number of immigrants and the number of TB-cases among immigrants at their 2008 values) was computed by:

$$\text{Expected TB cases}(t) = \frac{TB_{NI}(t) + TB_I(t_0)}{P(t) - E(t) + I(t_0)} \times 100\,000.$$

Here,  $TB_{NI}(t)$  denotes the number of TB-cases within the non-immigrant resident population in year  $t$ ,  $TB_I(t_0)$  denotes the number of TB-cases within the immigrant population in  $t_0 = 2008$ , and  $P(t)$  (*resp.*  $E(t)$ ,  $I(t_0)$ ) represents the number of Portuguese individuals (*resp.* emigrants, immigrants) in year  $t$  (*resp.*  $t$ ,  $t_0$ ). Clearly,  $P(t) - E(t) + I(t_0)$  corresponds to the total number of individuals resident in Portugal in year  $t$ .

Then, for each year, the expected number was compared with the observed number of TB-cases (including different annual counts for the number of immigrants and TB-cases among immigrants). The magnitude of the differences allowed for the evaluation of the impact of the immigration process on the TB incidence.

The model evaluating the impact of the emigration on TB in Portugal followed a similar reasoning; keeping both the number of emigrants and the number of TB-cases among emigrants at its 2008 value, the expected number of TB cases for year  $t$  per 100 000 inhabitants was calculated by

$$\text{Expected TB cases}(t) = \frac{TB_{NI}(t) + (TB_E(t) - TB_E(t_0)) + TB_I(t)}{P(t) - E(t_0) + I(t)} \times 100\,000$$

where the number of TB-cases among emigrants in year  $t$ ,  $TB_E(t)$ , assumed the same per-capita rate as  $TB_{NI}(t)$ , namely

$$TB_E(t) = E(t) \times \frac{TB_{NI}(t)}{P(t) - E(t)}.$$

**Table 1**  
Migration Movements.

Year	Total resident population N	Resident immigrants N	Emigrants N	Immigrants <sup>a</sup> N	Migration balance <sup>b</sup>	Portuguese individuals <sup>c</sup> N
2008	10 563 014	440 277	20 357	29 718	9361	10 553 653
2009	10 573 479	454 191	16 899	32 307	15 408	10 558 071
2010	10 572 721	445 262	23 760	27 575	3815	10 568 906
2011	10 542 398	436 822	43 998	19 667	–24 331	10 566 729
2012	10 487 289	417 042	51 958	14 606	–37 352	10 524 641
2013	10 427 301	401 320	53 786	17 554	–36 232	10 463 533
2014	10 374 822	395 195	49 572	19 516	–30 056	10 404 878

M: male; F: female.

<sup>a</sup> Immigrants entering the country each year.<sup>b</sup> Migration balance: immigrants – emigrants.<sup>c</sup> Portuguese individuals = total resident population + emigrants – immigrants.**Table 2**  
Tuberculosis Numbers.

Year	TB cases <sup>a</sup> N	TB rate <sup>b</sup>	TBPI <sup>c</sup> N	TBPI rate <sup>d</sup>	TBI <sup>e</sup> N	% TBI	TBI rate <sup>f</sup>	TB cases missing origin N (%)
2008	2967	27.8	2523	23.9	410	13.8	93.1	34 (1.2)
2009	2869	27.1	2432	23.0	437	15.2	96.2	0 (0)
2010	2714	25.6	2273	21.5	438	16.1	98.4	3 (0.1)
2011	2609	24.7	2203	20.9	404	15.5	92.5	2 (0.1)
2012	2606	24.6	2176	20.7	408	15.7	97.8	22 (0.8)
2013	2399	22.8	1989	19.0	393	16.4	97.9	17 (0.7)
2014	2264	21.8	1904	18.3	357	15.8	90.3	3 (0.1)

M: male; F: female; TB: tuberculosis.

<sup>a</sup> As documented in SVIG-TB; includes the cases for which the country of origin is missing.<sup>b</sup> TB rate: TB cases (excluding TB cases with missing origin) per 100 000 inhabitants.<sup>c</sup> TBPI: TB cases in Portuguese individuals = TB cases – TB cases in immigrants – TB cases with missing origin.<sup>d</sup> TBPI rate: TBPI cases per 100 000 inhabitants.<sup>e</sup> TBI: TB cases in immigrants.<sup>f</sup> TBI rate: TBI cases per 100 000 resident immigrants.

Indeed, had the TB-emigrants in year  $t$  stayed in the country and the difference  $TB_E(t) - TB_E(t_0)$  would have been accounted for in the total number of cases within national territory. The magnitude of the differences between observed and expected counts allowed for the evaluation of the impact of the emigration process on the TB incidence.

The study of the simultaneous effect of immigration and emigration combined the previous two equations. Under a steady scenario of immigration and emigration, the expected number of TB cases for year  $t$  per 100 000 inhabitants would be

$$\text{Expected TB cases}(t) = \frac{TB_{NI}(t) + (TB_E(t) - TB_E(t_0)) + TB_I(t_0)}{P(t) - E(t_0) + I(t_0)} \times 100\,000.$$

Finally, the relative annual fluctuations observed within the total number of Portuguese residents were compared with the relative annual decreases in the number of TB-cases. For each variable, the relative annual fluctuation between year  $t + 1$  and year  $t$  was computed as

$$\frac{\text{Number}(t + 1) - \text{Number}(t)}{\text{Number}(t)}.$$

## Results

From 2009 to 2013 there was a steady annual increase in the number of emigrants and essentially a decrease in the number of immigrants. The years 2008 and 2014 have slightly contradicted this trend.

Until 2010, the number of immigrants per year was higher than the number of emigrants. From 2011 to 2014, there was an inversion in the migration flow, and the number of emigrants exceeded the number of immigrants, thus turning the migration balance negative (Table 1).

The number of TB cases has been consistently decreasing since 2008. Cases occurring in immigrants represented 13.8% of all cases in 2008, 15.2% in 2009 and remained stable at about 16% since 2010. Immigrants have a much higher notification rate of TB than the Portuguese individuals (Table 2).

Similar to the TB notification rate, the total resident population in Portugal, has essentially decreased over 2008–2014 (with the exception of a slight increase from 2008 to 2009). However, the relative annual decrease on the number of residents was lower than the decrease on the TB numbers (Table 3).

As shown in Table 1, from 2008 to 2014 there were relatively few immigrants entering Portugal. Fixing both the immigration rate and the TB rate among immigrants at their 2008 values, and

**Table 3**  
Variation of the Total Number of Residents and TB Notification Rate.

Period	Resident population decrease	Tuberculosis cases decrease
2008–2009	0.00	–0.03
2009–2010	0.00	–0.05
2010–2011	0.00	–0.04
2011–2012	–0.01	0.00
2012–2013	–0.01	–0.08
2013–2014	–0.01	–0.06

**Table 4**  
Differences Between Observed and Estimated Numbers of TB Cases When Evaluating the Impact of the Immigration on the TB Notification Rate.

Year	Observed number of TB cases per 100 000 in inhabitants (O)	Expected TB cases per 100 000 inhabitants (E)	O – E
2008	27.77	NA	NA
2009	27.13	26.89	0.24
2010	25.64	25.37	0.27
2011	24.73	24.76	–0.03
2012	24.64	24.62	0.02
2013	22.84	22.98	–0.14
2014	21.79	22.28	–0.49

O: observed; E: expected.

**Table 5**  
Differences Between Observed and Estimated Numbers of TB Cases When Evaluating the Impact of the Emigration on the TB Notification Rate.

Year	Observed number of TB cases per 100 000 in inhabitants (O)	Estimated TB cases per 100 000 inhabitants (E)	O – E
2008	27.77	NA	NA
2009	27.13	27.13	0.00
2010	25.64	25.64	0.00
2011	24.73	24.71	0.02
2012	24.64	24.62	0.02
2013	22.84	22.82	0.02
2014	21.79	21.77	0.02

O: observed; E: estimated.

considering the variation on emigration that has actually occurred, we've estimated the number of TB cases per 100 000 inhabitants for each studied year (Table 4). The differences between the observed and the estimated numbers were residual, ranging from more 0.27 cases/100 000 inhabitants in 2010 to less 0.49 cases/100 000 inhabitants in 2014.

On the other hand, emigration rose significantly during the period of study (Table 1), which could have influenced the TB rate in the country to go lower.

The official number of TB cases in emigrants leaving the country in 2008 was 4.87/100 000 inhabitants. Assuming that this rate remained constant along 2008–2014 and that the total number of emigrants did not change either along that period, we estimated annual numbers for TB in Portugal. The observed numbers were only slightly higher than their estimates. The differences were even smaller than those found for the immigration impact (<0.1 cases/100 000 inhabitants) (Table 5).

When looking at both migration movements at the same time, the observed TB rate was again identical to the estimated TB rate (differences between less 0.43 cases/100 000 inhabitants in 2014 and more 0.28 cases/100 000 inhabitants in 2010) (Table 6).

## Discussion

The number of TB cases has been decreasing in Portugal (notification rate was 27.8/100 000 inhabitants in 2008 vs

**Table 6**  
Differences Between Observed and Estimated Numbers of TB Cases When Evaluating Simultaneously the Impact of Immigration and Emigration on the TB Notification Rate.

Year	Observed number of TB cases per 100 000 in inhabitants (O)	Estimated TB cases per 100 000 inhabitants (E)	O – E
2008	27.77	NA	NA
2009	27.13	26.89	0.24
2010	25.64	25.36	0.28
2011	24.73	24.71	0.02
2012	24.63	24.55	0.08
2013	22.84	22.91	–0.07
2014	21.79	22.22	–0.43

O: observed; E: estimated.

21.8 cases/100 000 inhabitants in 2014). Since 2009, the resident population has also been decreasing, but at a slower pace, as shown in Table 3. As for that, the decreasing number of TB cases cannot only be due to the reduction in the resident population.

Between 2008 and 2010, the number of immigrants exceeded the number of emigrants (positive migration balance). Since 2011 until 2014, migration balance turned negative. Moreover, TB rate has been consistently higher among immigrants compared to the native population (>90 cases/100 000 inhabitants vs 18.3–23.9 cases/100 000 inhabitants). The percentage of TB cases in this group has risen from 13.2% in 2008 to 15.2% in 2009 and remained at about 16% since 2010. This model allowed us to evaluate the impact of the immigration on the TB rate. It showed that, since 2011, as immigration is decreasing, there is a tendency to a lower number of TB cases. However, the differences are very small, representing less than 1 case per 100 000 inhabitants, so the impact does not seem to be significant.

A decrease in TB incidence has been the trend in the whole WHO European Region over the last years, where it has fallen by 5.2% each year, since 2005.<sup>5</sup>

Efforts have been made to achieve lower TB rates in Europe, even in low incidence countries. Out of 31 low incidence countries evaluated, more than half (54.8%) reported to have a dedicated national TB programme.<sup>17</sup>

Despite this global trend and even though we failed to demonstrate a significant impact of the immigration global decrease on TB rate, immigrants are still a risk group as in many of their origin countries, infectious diseases, such as TB, are still an important cause of death and morbidity.<sup>18</sup>

In low incidence countries, the impact of immigration on the burden of TB has been largely studied.<sup>10,19–21</sup> Addressing risk groups is one of the key strategies against TB.<sup>8,22</sup>

In the recently published action framework of the WHO towards TB elimination in low incidence countries<sup>23</sup> strategies involving migrants are mentioned in three of the eight priority action areas: 1) to address the most vulnerable and hard-to-reach groups; 2) to address special needs of migrants and crossborder issues and 3) to undertake screening for active TB and latent tuberculosis infection (LTBI) in TB contacts and selected high-risk groups, and provide appropriate treatment.

Many efforts have been made to detect TB and LTBI among migrants.<sup>12</sup> Some EU countries have implemented screening of migrants before, or at entry.<sup>24</sup> Underwood et al. compared contact tracing with new entrant screening in London and found the former to be more effective, as it identifies families and communities at high risk.<sup>21</sup> With the recent increase in the number of immigrants coming to Europe as refugees (rising from about 219 000 in 2014 to more than one million in 2015), TB control in this group is also a concern.<sup>25,26</sup> Regarding this matter, the ERS/WHO European Region has performed a study in order to document the policies and practices of low and intermediate TB incidence European countries with

regards to detection and management of TB and latent TB infection among this vulnerable group.<sup>26</sup>

In countries where most cases of TB occur in foreign born individuals or where incidence in this group is increasing, despite a decreasing TB rate, as it occurs in Portugal, policies on this subject are of great importance.

As for the emigration increase over the period of study, our model showed very little differences between the number of observed and expected cases (<0.1 cases/100 000 inhabitants each year). The fact that the differences between observed and expected cases were smaller than those found for the immigration impact can mean that the increase in emigration that we observed over 2008–2014 has not significantly impact the national TB rate.

We assumed the TB rate in emigrants to be similar to the TB rate in the Portuguese individuals that stayed in the country. However, we do not know if these individuals had other risk factors for TB or if they became more vulnerable for TB when they moved abroad.

Torres Redondo et al.<sup>27</sup> retrospectively analyzed the Portuguese emigrants diagnosed with TB when returning to the country, in the Northern Region in 2014. Most cases (76.3%) had moved to low TB incidence countries and had lived there for more than 2 years (median time of 42.0 months), which could suggest that exposure to TB could have already occurred in the foreign country. About 67% shared housing with work colleagues. These data suggest that risk for TB might increase when emigrants leave the country as they might experience harder living conditions and economic adversity. Nevertheless, had they stayed in the country they might have been unemployed which also accounts as a risk factor for TB.<sup>28</sup>

Despite the lack of knowledge about this group, our model failed to demonstrate an impact of emigration on TB notification rate.

Individually, the migration movements did not influence TB rate when analyzed by our model, so we tried to look at the impact of both movement altogether. Differences were again very small (<0.5 cases/100 000 inhabitants each year), so, even when combined, migration movements do not seem to largely influence TB notification rate.

This might mean that we have to concentrate our efforts in other risk factors. Sousa et al.<sup>28</sup> recently found HIV to be the factor with this highest impact: an increase of 10 HIV notifications per 100 000 inhabitants was associated with a rise of 2 new TB cases per 100 000 inhabitants. Also, an increase of 1000 unemployed subjects per 100 000 inhabitants was associated with one new case of TB per 100 000 inhabitants.

Apart from HIV infection, poor living and working conditions, which can facilitate TB transmission and risk factors that impair host's defense, like malnutrition, smoking, diabetes, alcohol abuse and indoor air pollution have been pointed out as major determinants.<sup>29–32</sup>

Silicosis also increases the risk of TB by 2.8–39 times.<sup>33,34</sup> Silicosis can be a challenging diagnosis and treatment must be longer.<sup>35</sup>

Preventive strategies that target these factors might have an important impact on TB burden.

These risk factors also add to the risk for TB in the migrant population. Paulino et al.<sup>13</sup> found that foreign born patients were more likely to be HIV positive, to be employed, homeless or live in shelters. Reducing HIV infection and providing better living conditions might have an even greater impact on TB among migrants. A study performed in Italy by Ingrosso et al. also showed that HIV infection is three times more frequent in foreign born people affected by TB than among Italians.<sup>36</sup>

Altogether, these factors represent areas of intervention towards TB elimination and should all be addressed in national and international TB programmes.<sup>23</sup>

In this work, the authors tried to understand the impact of two demographic factors – the migration movements and the decrease in the total number of residents – on the burden of TB in

Portugal over the 7-year period 2008–2014. As such, other risk factors such as HIV infection, homelessness or overcrowded housing were assumed to remain constant over that period.

In conclusion, the changing pattern of migration in Portugal over the period of study (2008–2014) does not seem to have had a significant impact on the TB notification rate.

## Authorship

All authors contributed to drafting and review of the manuscript.

## Conflict of Interest

The authors declare to have no conflict of interest directly or indirectly related to the manuscript contents.

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## References

- World Health Organization. WHO declares tuberculosis a global emergency. *Sozial- und Präventivmedizin*. 1993;38:251–2.
- Direcção Geral da Saúde. Programa Nacional de Luta contra a Tuberculose. Ministério da Saúde, Comissão Nacional de Luta contra a Tuberculose; 1995.
- Organização Mundial de Saúde. A estratégia stop TB; 2006. [http://www.who.int/tb/publications/2006/stoptb.strategy\\_por.pdf](http://www.who.int/tb/publications/2006/stoptb.strategy_por.pdf) [last accessed 25.09.16].
- Diniz A, Duarte R, Bettencourt J, Melo T, Gomes M, Oliveira O. Direcção Geral da Saúde. Portugal – Infecção VIH, SIDA e Tuberculose em números – 2015; 2015. [www.dgs.pt](http://www.dgs.pt) [last accessed 25.09.16].
- European Centre for Disease Prevention and Control/WHO Regional Office for Europe. Tuberculosis surveillance and monitoring in Europe 2016. Stockholm: European Centre for Disease Prevention and Control; 2016.
- Odono A, Tillmann T, Sandgren A, Williams G, Rechel B, Ingleby D. Tuberculosis among migrant populations in the European Union and the European Economic Area. *Eur J Public Health*. 2014;25:506–12.
- van Hest NA, Aldridge RW, de Vries G, Sandgren A, Hauer B, Hayward A, et al. Tuberculosis control in big cities and urban risk groups in the European Union: a consensus statement. *Euro Surveill*. 2014;19, pii=20728.
- European Centre for Disease Prevention and Control. Guidance on tuberculosis control in vulnerable and hard-to-reach populations. Stockholm: European Centre for Disease Prevention and Control; 2016.
- Franco I, Sousa P, Gomes M, Oliveira A, Gaio AR, Duarte R. Social profile of the highest tuberculosis incidence areas in Portugal. *Rev Port Pneumol*. 2016;22:50–6.
- Ködmön C, Zucs P, van der Werf MJ. Migration-related tuberculosis: epidemiology and characteristics of tuberculosis cases originating outside the European Union and European Economic Area, 2007 to 2013. *Euro Surveill*. 2016;21.
- Hargreaves JR, Boccia D, Evans CA, Adato M, Petticrew M, Porter JDH. The social determinants of tuberculosis: from evidence to action. *Am J Public Health*. 2011;101:654–62.
- Mulder C, Klinkenberg E, Manissero D. Effectiveness of tuberculosis contact tracing among migrants and the foreign born population. *Euro Surveill*. 2009;14, pii=19153.
- Paulino J, Martins A, Machado M, Gomes M, Gaio AR, Duarte R. Tuberculosis in native- and foreign-born populations in Portugal. *Int J Tuberc Lung Dis*. 2016;20:357–62.
- Pires RP, Pereira C, Azevedo J, Ribeiro AC. Observatório da Emigração. Emigração Portuguesa-Relatório Estatístico 2014, Lisboa. Observatório da Emigração e Rede Migra, CIES-IUL, ISCTE-IUL; 2014.
- Instituto Nacional de Estatística. <https://www.ine.pt/xportal/xmain?xpgid=ine-main&xpid=INE> [last accessed 25.09.16].
- Filipe Correia MI. Análise dos efeitos da crise das dívidas soberanas na migração do sul para o norte da Europa: o caso Português. Trabalho final de Mestrado em Economia Internacional e Estudos Europeus. Outubro de 2015.
- D'Ambrosio L, Masoud D, Tadolini M, Centis R, Sotgiu G, van der Werf MJ, et al. Tuberculosis elimination: theory and practice in Europe. *Eur Respir J*. 2014;43:1410–20.

18. Brian D, Gushulak BD, MacPherson DW. Globalization of infectious diseases: the impact of migration. *Clin Infect Dis*. 2004;38:1742–8.
19. Buonora N, Chiavarini M, Salmasi L, Giaimo M, Minelli L. Impact of immigration on burden of tuberculosis in Umbria: a low-incidence Italian region with high immigrants rates. *J Prev Med Hyg*. 2013;54:29–34.
20. Pareek M, Greenaway C, Noori T, Munoz J, Zenner D. The impact of migration on tuberculosis epidemiology and control in high-income countries: a review. *BMC Med*. 2016;14:48.
21. Underwood BR, White VLC, Baker T, Law M, Moore-Gillon JC. Contact tracing and population screening for tuberculosis – who should be assessed? *J Public Health Med*. 2003;25:59–61.
22. The end TB strategy global strategy and targets for tuberculosis prevention, care and control after 2015; November 2015, [http://www.who.int/tb/post2015\\_TBstrategy.pdf](http://www.who.int/tb/post2015_TBstrategy.pdf) [last accessed 25.09.16].
23. Lönnroth K, Battista Migliori T, Abubakar I, D'Ambrosio L, de Vries G, Diel R, et al. Towards tuberculosis elimination: an action framework for low-incidence countries. *Eur Respir J*. 2015;45:928–52.
24. Pareek M, Baussano I, Abubakar I, Dye C, Lalvani A. Evaluation of immigrant tuberculosis screening in industrialized countries. *Emerg Infect Dis*. 2012;18:1422–9.
25. Solovic I, Abubakar I, Sotgiu G, Dara M, Goletti D, Duarte R, et al. Standard operating procedures for tuberculosis care. *Eur Respir J*. 2017;49.
26. Dara M, Solovic I, Sotgiu G, D'Ambrosio L, Centis R, Tran R, et al. TB care among refugees arriving in Europe: a ERS/WHO Europe Region Survey of Current Practices. *Eur Respir J*. 2016;48:808–17.
27. Torres Redondo M, Carvalho C, Correia AM, Duarte R. Tuberculosis en los portugueses residentes en el extranjero. *Arch Bronconeumol*. 2016, <http://dx.doi.org/10.1016/j.arbres.2016.09.015>
28. Sousa P, Oliveira A, Gomes M, Gaio AR, Duarte R. Longitudinal clustering of tuberculosis incidence and predictors for the time profiles: the impact of HIV. *Int J Tuberc Lung Dis*. 2016;20:1027–32.
29. Lönnroth K, Jaramillo E, Williams BG, Dye C, Raviglione M. Drivers of tuberculosis epidemics: the role of risk factors and social determinants. *Soc Sci Med*. 2009;68:2240–6.
30. Harling G, Ehrlich R, Myer L. The social epidemiology of tuberculosis in South Africa: a multilevel analysis. *Soc Sci Med*. 2008;66:492–505.
31. Francisco J, Oliveira O, Felgueiras Ó, Gaio AR, Duarte R. How much is too much alcohol in tuberculosis? *Eur Respir J*. 2017;49.
32. Cordeiro da Costa J, Oliveira O, Baía L, Gaio R, Correia-Neves M, Duarte R. Prevalence and factors associated with diabetes mellitus among tuberculosis patients: a nationwide cohort. *Eur Respir J*. 2016;48:264–8.
33. Calvert GM, Rice FL, Boiano JM, Sheehy JW, Sanderson WT. Occupational silica exposure and risk of various diseases: an analysis using death certificates from 27 states of the United States. *Occup Environ Med*. 2003;60:122–9.
34. Hnizdo E, Murray J. Risk of pulmonary tuberculosis relative to silicosis and exposure to silica dust in South African gold miners [published erratum appears in *Occup Environ Med* 1999 Mar;56(3):215–6]. *Occup Environ Med*. 1998;55:496–502.
35. Melo V, Baía L, Rita Gaio A, Duarte R. Silicosis, tuberculosis time bomb? *Rev Port Pneumol*. 2016;22:355–7.
36. Ingrosso L, Vescio F, Giuliani M, Migliori GB, Fattorini L, Severoni S, et al. Risk factors for tuberculosis in foreign-born people (FBP) in Italy: a systematic review and meta-analysis. *PLoS ONE*. 2014;9:e94728.