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Trends, seasonality and forecasts of pulmonary tuberculosis in Portugal

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SUMMARY

SETTING: Tuberculosis (TB) is a global public health concern. Surveillance programmes present invaluable epidemiological information regarding its temporal evolution, particularly for pulmonary tuberculosis (PTB), the most common form of TB and the one that presents the greatest challenge in public health.

OBJECTIVES: To characterise, model and predict monthly incidence rates for PTB in Portugal disaggregated by high/low-incidence areas, sex and age groups.

DESIGN: PTB monthly incidence rates were estimated based on PTB cases diagnosed in 2000–2010, disaggregated by population and geographic characteristics. Seasonal-trend LOESS (STL) decomposition was employed to model trend and seasonality. Seasonal autoregressive integrated moving average (SARIMA) models were fit to characterise series behaviour and forecast PTB monthly incidence rates.

RESULTS: Overall, the time series showed a downward trend in and seasonality of PTB diagnosis, with a peak in March and a trough in December. The mean seasonal amplitude was consistently higher in high-incidence areas, in males and in adults aged 25–54 years. SARIMA models were found to adequately fit and forecast the time series, thus predicting trend and seasonal persistence.

CONCLUSIONS: STL and SARIMA findings concurred and were accurate. Endemic PTB seems to be slowly declining and case diagnosis is likely seasonal, which can be expected to persist if past conditions continue.

KEY WORDS: pulmonary tuberculosis; Portugal; time series analysis; STL; forecast

TUBERCULOSIS (TB) is the second cause of mortality due to an infectious disease worldwide. Caused by the *Mycobacterium tuberculosis* bacillus, TB is transmitted through the air when a person with pulmonary tuberculosis (PTB) coughs, sneezes or speaks.[1,2] National TB control programmes enable the collection of high quality surveillance data, providing epidemiological information about population, space and time of the utmost importance.[3,4]

Time series analysis is widely employed in public health research to better describe data and/or make inferences that take into consideration correlations between time-adjacent observations.[5] TB research is no exception, with several studies describing trends and seasonality around the world.[3,6–14] Knowledge about seasonality and factors affecting trends in TB incidence can be invaluable to evaluate programmes, assess health needs and manage the disease.[9,15] Moreover, taking into account the correlation between nearby observations in time series allows the prediction of short-term future incidence rates and the suitable planning of control strategies.[4,5,16,17]

No published studies with these methodologies were found concerning PTB trend and seasonality or forecasts in Portugal. The present study aims to supply a descriptive overview of trend and seasonality of PTB monthly incidence rates in Portugal from 2000 to 2010, disaggregated by high/low-incidence areas and population subgroups (sex and age groups). It also aims to estimate short-term PTB incidence rate forecasts for geographic subsets.

MATERIALS AND METHODS

Data source

Data were provided by Portugal's National Tuberculosis Control Programme (NTP), taking into account only PTB cases diagnosed from January 2000 to December 2010 in the mainland. Previous spatiotemporal studies have identified critical areas of high/low

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PTB incidence in Portugal.[18] Clusters of municipalities with high incidence PTB (Oporto and Lisbon Metropolitan Areas) and low PTB incidence areas (the remaining municipalities) were analysed over the period under study. Constant detection rates among municipalities and in time were assumed. Data were also disaggregated by sex and age group (0–14, 15–24, 25–34, 35–44, 45–54, 55–64 and $\geqslant$65 years). Statistics Portugal provided estimates of the annual population at risk by geographic and population subsets.

Ethical approval was not required for the study.

Statistical analysis

Monthly PTB incidence rates (per 100 000 population) were computed taking into consideration the date of diagnosis. Seasonal-trend decomposition based on the LOESS (STL) filtering method developed by Cleveland et al.,[19] was used to decompose each time series into trend, seasonal and residual components of variation by employing locally weighted regression. Assuming an addictive decomposition form, the PTB incidence rate at month t (Y_t) can be written as:

$$Y_t = S_t + T_t + E_t$$

where S_t is the seasonal component, T_t the trend component and E_t the residual component.[16] This decomposition method involves selecting a set of parameters that determines the degree of smoothing of the trend and seasonality. The STL function in the *R* software (R Computing, Vienna, Austria) was initially applied with default parameters for the degree of smoothing of seasonal and trend components. However, to explore potential inter-annual variation of the seasonal component, the seasonal LOESS smoothing parameter was set to estimate the seasonal effect based on 7 months.[19] The mean seasonal amplitude was computed from the seasonal component as the mean difference between the months with the highest and lowest incidence rates for each year.[9] The average monthly percentage change (AMPC) was calculated as a summary measure of the trend component over time,[3,4,10] where n was the total number of months at study, thus:

$$AMPC = \frac{\sum_{i=2}^{n}\left(\frac{Rate_{Month\ i}}{Rate_{Month\ i-1}} - 1\right)}{n-1} \times 100$$

Seasonal autoregressive integrated moving average (SARIMA) models were fitted to mainland and geographic subsets time series via the ARIMA function in the R package 'Forecast'. When time series were found to be non-stationary, a Box-Cox transformation, with power λ, was applied to stabilise the variance.[20] For each series, the autocorrelation function (ACF) and partial autocorrelation function (PACF) were analysed to suggest the parameters of the model SARIMA$(p,d,q)(P,D,Q)_S$. The lowercase symbols represent non-seasonal parameters, with p representing the parameter of the autoregressive part, d the degree of simple differencing and q the parameter of the moving average part of the model. The uppercase symbols represent seasonal parameters, where D is the degree of the seasonal differencing and S indicates the seasonal period length.[16] Parameters were estimated through the maximum likelihood estimation method (MLE) and the best-fit model was the one with the lowest values of the corrected Akaike's Information Criterion (AICc). Diagnostic checks were performed in the best-fitted models through residual analysis, determining if they were consistent with the assumptions of a SARIMA model, i.e., they behave at least like white noise (based on ACF and partial ACF plots, the Ljung-Box test, the turning point test and the Kwiatkowski-Phillips-Schmidt-Shin [KPSS] test), normally distributed (K-S test) and zero mean (t-test).[16,21]

A set with the last 12 months of data was used to evaluate the model forecasts. The model was fitted with data from January 2000 to December 2009, and forecasts were made from January to December 2010. The accuracy of the predictions was assessed using root mean square error (RMSE), mean absolute error (MAE) and mean absolute percentage error (MAPE).[16,22] A significance level of 5% was used for all tests. The statistical analysis in the present study was carried out using the open source R software 2.15.1.

RESULTS

Trend and seasonality of PTB incidence rates

A total of 28 615 PTB cases were reported in mainland Portugal over the 132 months of the study. Annual PTB incidence rates showed a steady decline, dropping from 32.4 per 100 000 cases in 2000 to 18.3/100 000 in 2010. Likewise, monthly incidence rates of PTB showed a downward trend component (Figure 1A), with a mean monthly decline of 0.41% (Table 1). Figure 2A shows the monthly seasonal component pattern for the mainland, with an average peak in March, which has one more case per 100 000 population than the trough month in December. The inter-annual variation shows a shift in peak month from March to January in the last 4 years, while December was the trough month for all study years.

Table 1 summarises long-term time trends and seasonal characteristics for mainland Portugal by sex and age group. Monthly PTB incidence rates and mean seasonal amplitude were overall higher for males. Of the total number of PTB cases reported during the study period, 0.5% ($n = 134$) had no date of birth, and were thus excluded from the age group analysis. Figure 3 shows that the 25–34 years age

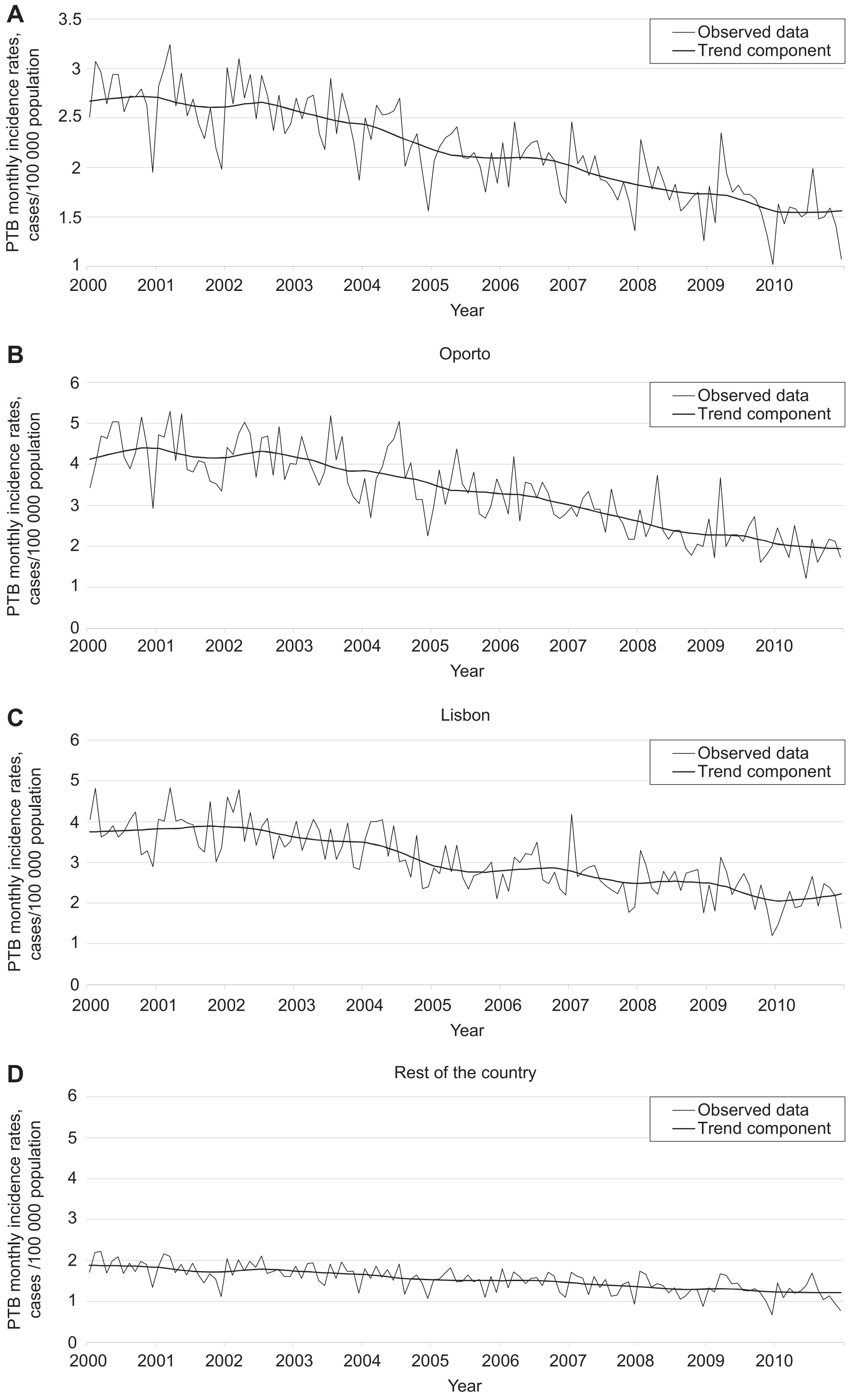

Figure 1 PTB monthly incidence rates in Portugal (thin line), 2000–2010, and trend component (bold line) from the STL decomposition: **A)** mainland; **B)** Oporto metropolitan area; **C)** Lisbon metropolitan area; **D)** remaining country. PTB = pulmonary tuberculosis; STL = seasonal and trend decomposition procedure based on loess.

group had the highest incidence rates for the first 2 years; however, it also had the fastest drop in trend among adults (0.66% monthly decline). In 2010, the 35–44 and 45–54 years age groups had the highest monthly incidence rates. Children (aged <15 years) had the lowest PTB incidence rates throughout the entire period.

Table 2 presents results from high/low-risk areas by

Table 1 Pulmonary tuberculosis cases, mean monthly incidence rate, average monthly percentage change in trend component and mean seasonal amplitude in mainland Portugal, 2000–2010

	Cases *n* (%)	Mean monthly incidence rate /100 000	Average monthly percentage change in trend component %	Seasonal peak/trough month	Mean seasonal amplitude /100 000
Global	28 615	2.17	−0.41	March/December	0.75
Sex					
Male	20 373 (71.2)	3.21	−0.42	March/December	1.09
Female	8 242 (28.8)	1.21	−0.36	March/December	0.46
Age group, years					
0–14	479 (1.7)	0.23	−0.44	March/October	0.20
15–24	2 862 (10.1)	1.76	−0.36	March/December	0.73
25–34	6 494 (22.8)	3.28	−0.66	March/December	1.20
35–44	6 961 (24.4)	3.59	−0.34	March/December	1.51
45–54	4 759 (16.7)	2.68	−0.25	May/December	1.22
55–64	2 648 (9.3)	1.76	−0.44	January/December	0.79
⩾65	4 278 (15.0)	1.86	−0.40	March/December	0.77

sex and age group. Overall, the Oporto metropolitan area had higher incidence rates than the Lisbon metropolitan area, and both showed a substantial reduction in trend (Figures 1B and 1C). However, the decrease over time was quicker in Oporto (0.57%) than in Lisbon (0.40%), reducing the disparity between the incidence rates until 2009, after which Lisbon showed higher incidence rates. The inter-annual seasonal variation can be seen in Figures 2B, C and D, presenting a magnitude of one case per 100 000 population between March (peak month) and December (trough month) for both high-incidence urban areas.

Modelling and forecasts of PTB incidence rates

Mainland Portugal PTB time series showed large autocorrelation values at lags 12, 24 and 36, indicating the need for seasonal differencing with a 12-month period. Furthermore, as a slow decrease in autocorrelation values indicates a long-term trend, a first differencing was performed. The model that best fit the data was SARIMA$(0,1,1)(0,1,1)_{12}$, defined as:

$$(1-B)(1-B^{12})Y_t = (1+0.91B)(1+B^{12})e_t$$

The residual diagnostic analysis was performed and was consistent with the model assumptions. By comparing forecasts for the test set year and the monthly PTB incidence rates reported in 2010 (Table 3), it can be seen that all incidence rates for 2010 fell inside the forecast intervals, with RMSE = 0.16, MAE = 0.13 and MAPE = 8.10%. Estimated future projections indicate persistence of the decreasing trend in the next 2 years, with a seasonal peak in March and a trough in December (Figure 4A).

The model that best fit the Oporto series was SARIMA$(2,1,0)(0,1,1)_{12}$ (Figure 4B), with all observed incidence rates for the test set year falling inside the forecast limits (RMSE = 0.48, MAE = 0.4, MAPE = 23.04%). Forecasts followed the declining trend of the series, but it should be noted that the prediction limits show a substantial and rapid increase as the prediction horizon increases, while the seasonal pattern is expected to remain unchanged. The model that best fit both Lisbon and the remainder of the country was SARIMA$(0,1,1)(0,1,1)_{12}$ (Figure 4C and D, respectively), with the test set showing only one observed value slightly outside the forecast limits for each model (RMSE = 0.45 and 0.17, MAE = 0.37 and 0.14, MAPE = 19.1% and 11.01%, respectively, for Lisbon and the remaining municipalities). Future projections show a falling trend and confirm the presence of seasonality. The model's residuals for the geographic subset were consistent with the assumptions.

DISCUSSION

Overall, monthly PTB incidence rates in Portugal from 2000 to 2010 revealed a consistent downward trend, with a seasonal peak in early spring and a trough in winter. The present results are highly dependent on the quality and accuracy of the data. Although, according to the World Health Organization, Portugal has one of the world's highest TB case detection rates (87% in 2000 and 2008),[23] there are still factors affecting the NTP's case notification process, such as health-seeking behaviour, access to health services and, primarily, health care efficiency.[24,25] This is of particular concern when analysing geographic subsets, where health services may have varying case detection rates.

Trend and seasonality

STL decomposition is a simple, flexible and effective method for decomposing time series, allowing a straightforward descriptive analysis.[16,19] Three addictive components were identified: a long-term trend representing the overall pattern of change over time, an annual seasonality allowed to be flexible over the years, and the residual component assumed to be stationary.[5,16] The trend was summarised as an

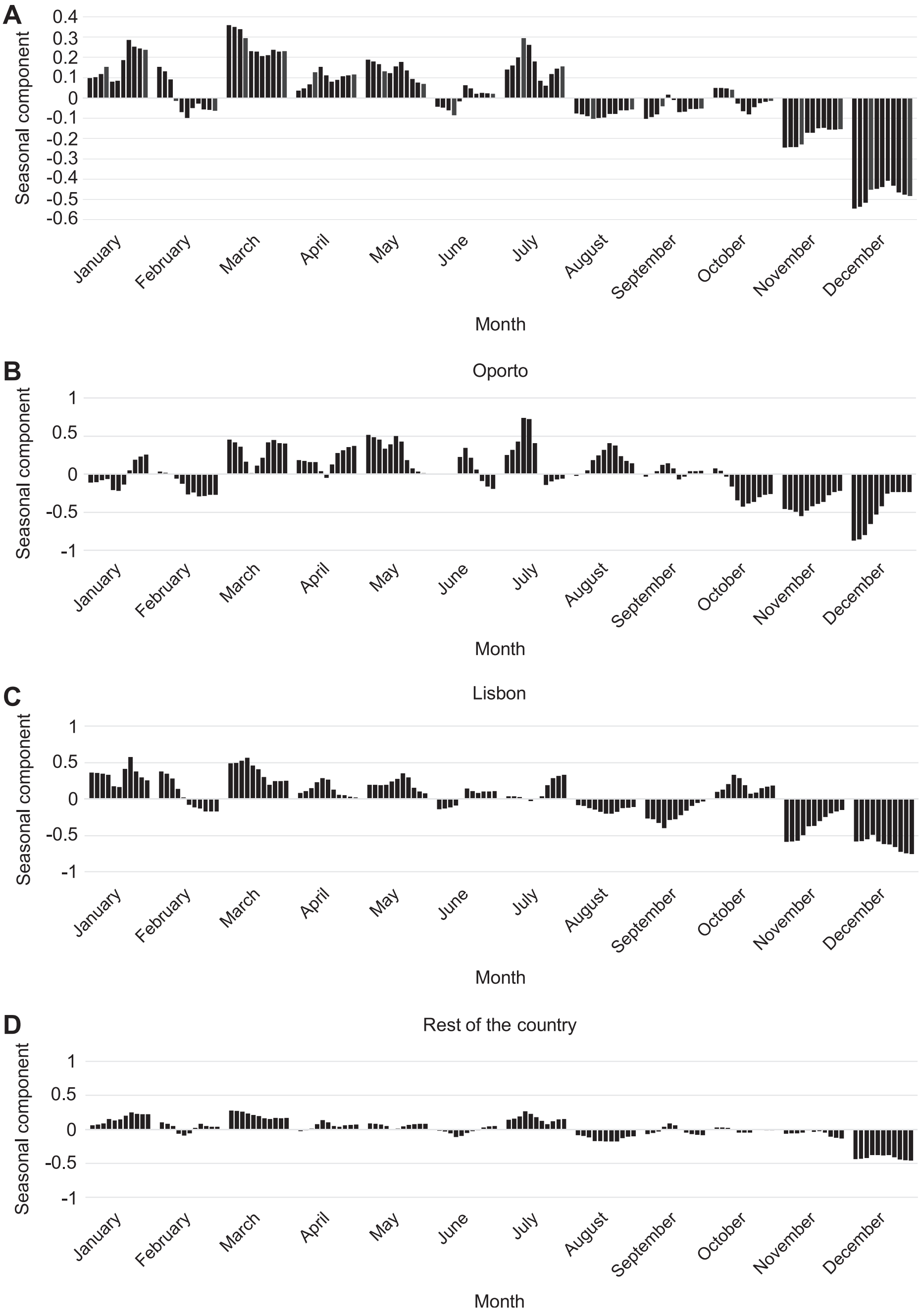

Figure 2 Seasonal subseries plot of the seasonal component estimated by STL decomposition of PTB monthly incidence rates in Portugal, 2000–2010: **A)** mainland; **B)** Oporto metropolitan area; **C)** Lisbon metropolitan area; **D)** the rest of the country. Each month is graphed separately against time (2000–2010), where the annual fitted values for each month are presented by the vertical lines. The units on the vertical axis are cases per 100 000 population. PTB = pulmonary tuberculosis; STL = Seasonal and Trend decomposition procedure based on LOESS.

AMPC, which uses a single value to describe the average pattern and speed of change in monthly PTB incidence rates.[3,10] This measure is easily comparable across subgroups; however, if trend changes exhibit a varying pattern over time, the AMPC may not be an accurate measure of the trend.[4,26]

Overall, monthly PTB incidence rates showed a long-term trend, with a constant mean monthly decrease of 0.41%. This is consistent with national and international official reports, which suggest an endemic steady decrease in TB disease in the population.[1,3,27] Overall, seasonality was detected, with a peak in March and a trough in December, similar to previous literature from the Northern hemisphere.[6–9,11,13] The peak-to-trough month difference was one more case diagnosed per

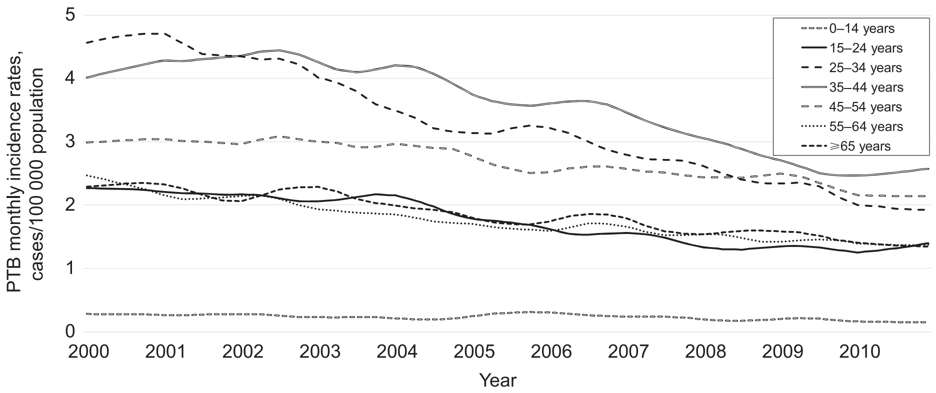

Figure 3 Monthly PTB incidence rates by age group from mainland Portugal, 2000–2010. PTB = pulmonary tuberculosis.

100 000 population, to which high-incidence urban areas (Oporto and Lisbon) seemed to be the greatest contributors. Moreover, males and individuals aged 25–54 years had the highest seasonal amplitude in mainland Portugal and geographic subsets.

In general, PTB incidence rates for males were twice as high as among females, as reported in other

Table 2 Pulmonary tuberculosis cases, mean monthly incidence rate, average monthly percentage change in trend component and mean seasonal amplitude in high/low-incidence areas* of Portugal, 2000–2010

Cluster	Cases *n* (%)	Mean monthly incidence rate /100 000	Average monthly percentage change in trend component %	Seasonal peak/ trough month	Mean seasonal amplitude /100 000
Oporto	7 788	3.32	−0.57	March/December	1.02
Sex					
Male	5 650 (72.6)	5.00	−0.57	May/November	1.74
Female	2 138 (27.4)	1.76	−0.54	August/December	0.93
Age group, years					
0–14	155 (2.0)	0.39	−0.86	August/October	0.51
15–24	781 (10.2)	2.53	−0.61	August/February	1.75
25–34	1 815 (23.6)	4.83	−0.79	March/July	1.96
35–44	2 019 (26.3)	5.38	−0.41	April/October	2.55
45–54	1 352 (17.6)	4.11	−0.39	March/December	2.36
55–64	649 (8.4)	2.59	−0.83	July/November	1.85
⩾65	911 (11.9)	2.90	−0.54	July/February	2.56
Lisbon	8 522	3.04	−0.40	March/December	1.08
Sex					
Male	5 850 (68.7)	4.40	−0.44	March/December	1.79
Female	2 672 (31.3)	1.81	−0.28	October/December	0.67
Age group, years					
0–14	135 (1.6)	0.32	−0.45	March/August	0.71
15–24	855 (10.1)	2.60	−0.31	October/September	1.71
25–34	2 187 (25.7)	5.10	−0.68	February/December	2.10
35–44	2 108 (24.8)	5.45	−0.29	January/December	2.36
45–54	1 369 (16.1)	3.58	−0.26	May/November	2.03
55–64	801 (9.4)	2.20	−0.46	January/December	1.83
⩾65	1 051 (12.4)	2.10	−0.17	March/February	1.24
Remaining country	12 305	1.53	−0.33	March/December	0.65
Sex					
Male	8 873 (72.1)	2.29	−0.33	July/December	0.99
Female	3 432 (27.9)	0.83	−0.32	March/December	0.39
Age group, years					
0–14	189 (1.5)	0.15	−0.04	June/August	0.22
15–24	1 226 (10.0)	1.24	−0.23	July/December	0.65
25–34	2 492 (20.3)	2.12	−0.56	January/December	1.20
35–44	2 834 (23.1)	2.41	−0.34	July/December	1.31
45–54	2 038 (16.6)	1.92	−0.12	January/December	1.00
55–64	1 198 (9.7)	1.35	−0.24	July/December	0.76
⩾65	2 316 (18.8)	1.55	−0.46	March/December	0.75

* High-incidence areas: Oporto and Lisbon metropolitan areas; low-incidence areas: rest of the country.

Table 3 Predicted and reported pulmonary tuberculosis monthly incidence rates in mainland Portugal, 2000–2010

Months	Predicted incidence rate	Predicted lower limit 95%PI	Predicted higher limit 95%PI	Reported incidence rates
SARIMA $(0,1,1)(0,1,1)_{12}$				
January 2010	1.75	1.36	2.15	1.63
February 2010	1.61	1.21	2.01	1.43
March 2010	1.88	1.48	2.28	1.60
April 2010	1.66	1.26	2.07	1.58
May 2010	1.72	1.31	2.12	1.50
June 2010	1.56	1.15	1.96	1.54
July 2010	1.67	1.26	2.08	1.99
August 2010	1.46	1.05	1.87	1.48
September 2010	1.46	1.05	1.87	1.50
October 2010	1.50	1.09	1.92	1.59
November 2010	1.31	0.90	1.73	1.41
December 2010	1.01	0.59	1.42	1.07

SARIMA = seasonal autoregressive integrated moving average; PI = prediction interval.

countries.[3,9,25] However, the decrease in mainland Portugal rates differed between males and females over time, due to a slower decline in female PTB rates, also observed in the Lisbon urban area. More information is needed to understand the causes of this disparity in decline in Lisbon.

The age group analysis confirms a slow endemic decrease, with declining PTB rates in all age groups and a shift in case ages from young adults (25–34 years) to older ages (35–44 years). Children (aged <15 years) represented a very small proportion of PTB cases diagnosed (1.7%), displaying the lowest rates with a slight downward trend. Such behaviour is characteristic of high-incidence European Union countries such as Portugal.[10] However, contrary to other studies conducted in the United States,[7,9] childhood PTB did not contribute significantly to overall seasonality. Given that children tend to develop active PTB disease rapidly and are regarded as sentinels of ongoing transmission,[10] these findings further suggest a reduction/stabilisation in recent PTB transmission in Portugal.

Modelling and forecasts

Of all the forecasting methods available for time series analysis, ARIMA models have been shown to outperform other techniques when applied to TB data.[17] The selected SARIMA models presented the best fit to PTB time series; they explained most of the data variance and provided an effective model for the seasonality and correlation structure of the time series. Furthermore, SARIMA models confirmed the presence of seasonality and a downward trend detected using STL decomposition. The models provided accurate predictions for the test subgroup in mainland Portugal and geographic subsets. It should be noted that predictions for Oporto presented a higher uncertainty when compared with predictions for Lisbon in terms of errors analysis (MAPE, MAE and RMSE) and the magnitude of the prediction intervals.

Assuming that the past pattern modelled herein will continue into the future, seasonality and trend can be predicted to persist in the near future. However, the aforementioned assumption may not be valid for the prediction period (2011–2012), given that Portugal entered into an economic crisis in 2008.[28] Economic recession has already been shown to swiftly affect TB rates, and its full impact may only be seen years later.[29,30] This is an appropriate method for modelling PTB time series, although methods that incorporate external covariates potentially affecting PTB incidence should also be explored.

Seasonality hypothesis

Seasonal interpretations should take into account the nature of the data, namely the fact that monthly incidence rates represent the date when PTB cases were diagnosed. A possible explanation for the seasonal effect in PTB case diagnosis is the occurrence of flu in winter, which may lead health carers to suspect other respiratory infections with similar symptoms (e.g., cough, fever, night sweats).[1,7,9] Furthermore, reports have drawn attention to the disruption of TB services in urban areas, particularly Lisbon, due to the reorganisation of public health services to deal with flu.[24] The correct diagnosis of PTB may therefore be hindered in winter, leading to a peak in diagnosis later on in the year.

Previous studies have shown that delays in PTB diagnosis vary widely in Portugal, making inferences regarding the seasonality of PTB disease a challenge.[31] Nevertheless, low levels of vitamin D and impaired immunity due to respiratory infections that are frequent in winter are believed to enhance development of the disease.[8,9,11,12] Lastly, it is difficult to link case seasonality in diagnosis with time of transmission, as an infected person has an incubation period of from 8 weeks to a lifetime.[8,32]

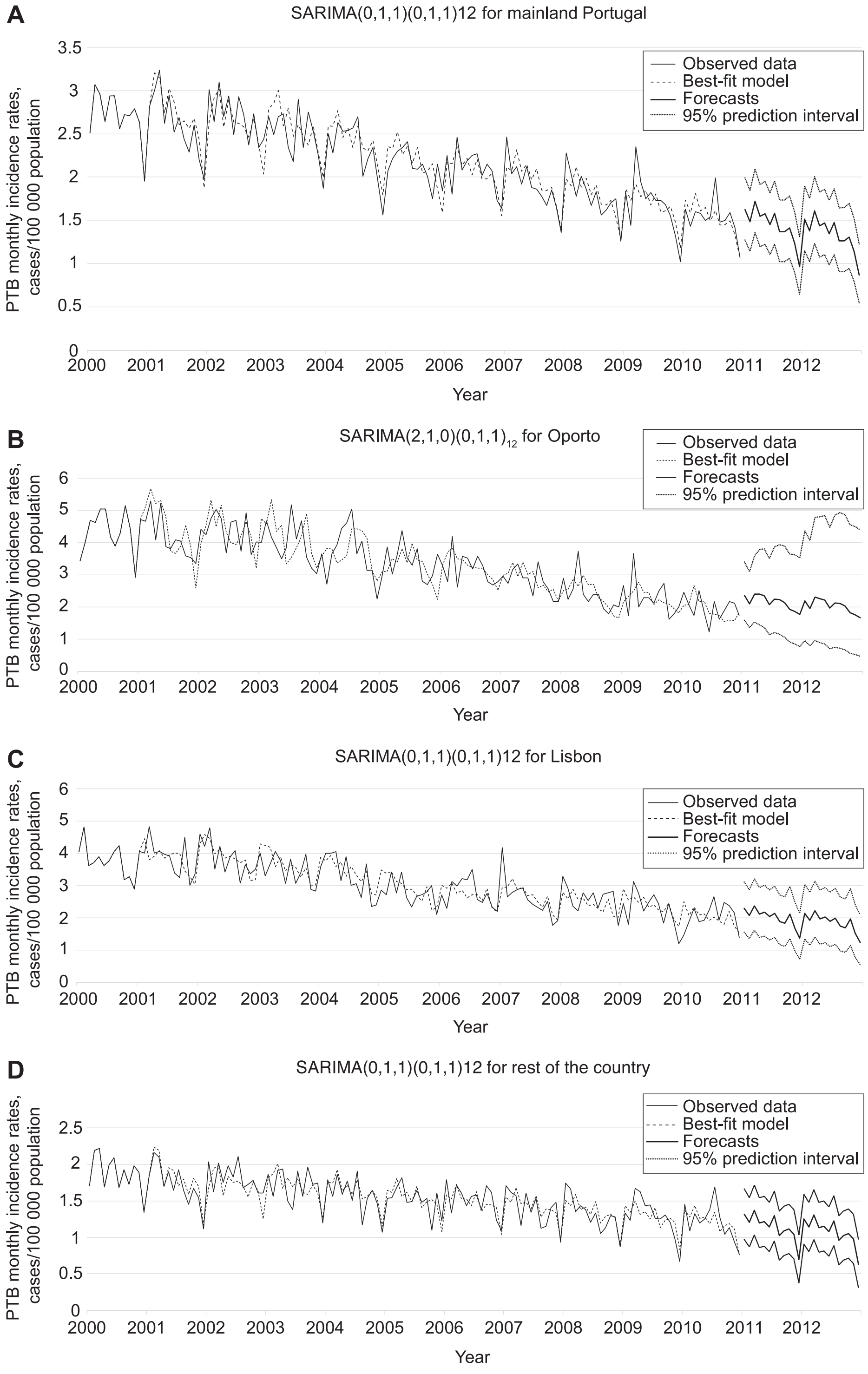

Figure 4 Fitting and forecasts from SARIMA models applied to PTB monthly incidence rates, 2000–2010, with prediction intervals of 95%. **A)** SARIMA $(0,1,1)(0,1,1)_{12}$ for mainland Portugal; **B)** SARIMA $(2,1,0)(0,1,1)_{12}$ for Oporto; **C)** SARIMA $(0,1,1)(0,1,1)_{12}$ for Lisbon; **D)** SARIMA $(0,1,1)(0,1,1)_{12}$ for the rest of the country. PTB = pulmonary tuberculosis; SARIMA = seasonal autoregressive integrated moving average.

CONCLUSIONS

Endemic PTB decreased slowly and steadily in Portugal from 2000 to 2010. Both STL decomposition and best-fit SARIMA models show that PTB case diagnosis is seasonal, with a peak in early spring and a trough in winter. Short-term forecasts indicate a continuation of the seasonal pattern and a downward trend if past conditions remain unchanged. However, factors influencing this seasonal pattern are uncertain.

This study uses SARIMA models to incorporate the time dependence of PTB incidence, resulting in more realistic trends and seasonal estimates than obtained by classical regression models that assume independence of observations. This is a valuable tool when planning public health interventions, as temporal PTB behaviour at national level and high/low-incidence areas allow target-specific interventions. Moreover, forecasts can be used to evaluate the effectiveness of the NTP by comparing actual with expected PTB incidence.

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Conflict of interest: none declared.

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RESUME

CONTEXTE : La tuberculose (TB) est un problème de santé publique mondial. Les programmes de surveillance offrent de précieuses informations épidémiologiques relatives à son évolution dans le temps, particulièrement en ce qui concerne la tuberculose pulmonaire (TBP), la forme la plus fréquente de TB et celle qui pose les plus grands défis en santé publique.

OBJECTIFS : Caractériser, modéliser et prédire l'incidence mensuelle de la TBP, désagrégée par zones d'incidence élevée/faible, sexe et tranche d'âge, au Portugal.

SCHÉMA : Les taux d'incidence ont été estimés en fonction des cas diagnostiqués en 2000–2010, désagrégés par caractéristiques démographiques et géographiques. Une décomposition de LOESS (STL) des variations saisonnières a été employée pour modéliser les tendances et la saisonnalité. Les modèles autorégressives saisonnières intégrées des moyennes mobiles (SARIMA) ont été adaptés de façon à caractériser le comportement des séries et prévoir le taux d'incidence mensuel de TBP.

RÉSULTATS : Au total, les séries chronologiques ont mis en évidence une tendance à la baisse et une saisonalité du diagnostic de TBP, avec un pic diagnostique en mars et un creux en décembre. L'amplitude saisonnière moyenne était régulièrement plus élevée dans les zones d'incidence élevée, chez les hommes et chez les adultes (25–54 ans). Les modèles SARIMA se sont avérés convenir parfaitement aux séries chronologiques et ont permis de prévoir les tendances et la persistance saisonnières.

CONCLUSIONS : Les résultats de STL et de SARIMA ont été concordants et précis. La TBP endémique semble décliner lentement et le diagnostic des cas est volontiers saisonnier. On peut s'attendre à ce que cette situation persiste si les conditions prévalant dans le passé restent identiques à l'avenir.

RESUMEN

MARCO DE REFERENCIA: La tuberculosis (TB) representa una preocupación mundial de salud pública. Los programas de vigilancia ofrecen una información epidemiológica valiosa con respecto a su evolución temporal, sobre todo de los casos de tuberculosis pulmonar (TBP), que constituyen la localización más frecuente de la enfermedad y el mayor peligro de salud pública.

OBJETIVO: Caracterizar, modelizar y pronosticar las tasas mensuales de incidencia de TBP en Portugal y desagregar los datos en función de las regiones de alta o baja incidencia y el sexo y los grupos de edad de los pacientes.

MÉTODO: Se calcularon las tasas mensuales de incidencia a partir de los casos de TBP diagnosticados del 2000 al 2010 y se desagregaron según las características poblacionales y geográficas. Se aplicó un método de descomposición de las tendencias estacionales basado en la regresión local LOESS (STL), con el fin de modelizar la tendencia y la estacionalidad. Se adaptaron modelos autorregresivos estacional integrado de medias móvil (SARIMA) con el fin de caracterizar el comportamiento de las series y pronosticar las tasas de incidencia mensual de TBP.

RESULTADOS: En general, las series temporales exhibieron una tendencia decreciente y una variación estacional del diagnóstico de TBP, con un valor máximo en marzo y un valor mínimo en diciembre. La amplitud estacional promedio fue constantemente mayor en las regiones de alta incidencia, en los hombres y en los adultos (entre 25 años y 54 años). Se observó que los modelos SARIMA presentaban un ajuste adecuado y pronosticaban las series temporales, anticipando así la persistencia de las tendencias y la estacionalidad.

CONCLUSIÓN: Los resultados obtenidos con el método STL y los modelos SARIMA son concordantes y precisos. La TBP endémica parece presentar una lenta disminución y el diagnóstico de los casos es con frecuencia estacional; se prevé la persistencia de esta situación, si las condiciones pasadas se mantienen en el futuro.