

Differential decline in tuberculosis incidence among US- and non-US-born persons in New York City

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SUMMARY

SETTING: A large urban tuberculosis control program.
OBJECTIVES: To examine changes in tuberculosis incidence and characteristics of cases in New York City (NYC), and assess the epidemiology of tuberculosis among non-US-born persons.
DESIGN: Tuberculosis surveillance data (1995–1999) for NYC were analyzed.
RESULTS: Tuberculosis incidence decreased by 56.6% in US-born and 19.6% in non-US-born persons (age-adjusted) over the study period. The decline in tuberculosis incidence among US-born persons was more substantial in the first half of the study period (23–24%) than in the second half (13–15%). The greatest decline in incidence was among US-born Hispanic or Black males aged 25–64. However, although there was an

overall decline in incidence among non-US-born persons, there was no significant change in any sex or racial/ethnic subgroup. The percent of multidrug-resistant (MDR) cases among non-US-born patients remained stable, but recent arrivals accounted for 79% of non-US-born MDR-TB patients in 1999, a significant increase from 16% in 1997.

CONCLUSIONS: Continuing current tuberculosis control efforts and treatment of immigrants with latent tuberculosis infection are of highest priority for reducing incident cases in NYC. Global collaboration towards earlier detection and treatment of active tuberculosis cases in high incidence countries is also essential.

KEY WORDS: tuberculosis; incidence case rate; epidemiology; immigrants.

IN 1992, at the peak of the recent tuberculosis epidemic in the United States, New York City (NYC) comprised 3% of the US population but 14.3% of the nation's tuberculosis cases.¹ The tuberculosis case rate was nearly five times the national rate of 10.5 per 100 000 population.² Through increased funding, staff, and intensified control efforts focusing on interrupting recent transmission and completion of treatment,^{3–5} the number of cases in US-born persons declined in NYC from 1993, as in the rest of the country, and declined significantly thereafter.⁶ However, the disproportionately slower decline in the number of tuberculosis cases among non-US-born persons brought the number in the non-US-born above that in the US-born for the first time in 1997, and has remained thus since.⁷ The present study was conducted to examine changes in tuberculosis incidence rates and clinical characteristics of cases in NYC, and to assess the impact of immigration on the epidemiology of tuberculosis among non-US-born persons.

METHODS

This was a population-based descriptive study using tuberculosis surveillance data maintained by the Tuberculosis Control Program of the NYC Department of Health. Patients with bacteriologic or clinical confirmation of tuberculosis verified between 1 January 1995 and 31 December 1999 in NYC were included. Using the Centers for Disease Control and Prevention (CDC) case definition,^{8,9} patients could have been counted as a case more than once during the study period if they had another disease episode documented in NYC.

Multidrug-resistant (MDR) tuberculosis was defined as disease with organisms resistant to at least isoniazid and rifampin. Isoniazid resistance referred to isolates resistant to isoniazid only or in combination with anti-tuberculosis drugs other than rifampin. Similarly, rifampin resistance referred to isolates resistant to rifampin only or in combination with anti-tuberculosis drugs other than isoniazid. Resistance was defined as

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the growth of >1% of colonies on drug-containing media, as compared with growth on drug-free medium. Time in the US was defined as the time from the date of entry into the US until the date of diagnosis. Persons in the US for 5 years or less were defined as recent arrivals. Country of birth and date of entry into the US were based on patient's self-report. To be comparable with other studies, country of birth was grouped according to world region based on World Bank definitions.¹⁰ Non-US-born persons were individuals born outside the US and its territories.

Patient data were obtained from the NYC Tuberculosis Case Registry. Population denominators used for calculating incidence rates were based on 1990 census data for NYC. Census data stratified by age, sex, race/ethnicity and countries of birth were obtained from the NYC Department of City Planning.

All data analyses were performed with PC SAS (SAS Institute, Cary, NC, version 8). Pearson's χ^2 test was used for comparison of categorical data; the Wilcoxon Rank-Sum test was used for comparing medians of continuous variables. The tuberculosis incidence rate (morbidity rate) was calculated by dividing the number of newly reported cases in 1 year by the total NYC population, which included legal and undocumented immigrants. Case rates were calculated for age, sex, race and country of birth. Age-adjusted incidence rates for non-US-born persons were computed by the direct method using the 10-year interval age distribution of the 1990 US-born population in NYC as the standard. All incidence rates were expressed as the number of cases per 100 000 population per year. As a result of using 1990 census data as denominators, case rates may have been overestimated.

RESULTS

Between 1 January 1995 and 31 December 1999, 9241 newly diagnosed tuberculosis cases were reported in

NYC. Seventy (0.76%) patients with unknown country of birth were excluded, leaving 9171 patients who met the study criteria; 4630 (50.5%) were US-born, and 4541 (49.5%) were non-US-born. Date of entry into the US was known for 91.4% (4150/4541) of the non-US-born patients. Of 246 patients who had had prior tuberculosis disease episodes, 30 (19 US-born and 11 non-US-born) had a second tuberculosis episode during the study period.

Change in tuberculosis incidence

The overall tuberculosis incidence rate in NYC decreased by 40% over the study period, from 33.4 in 1995 to 19.9/100 000 in 1999. The case rate declined by 56.6% in US-born and by 19.6% in non-US-born persons ($P < 0.001$). The age-adjusted tuberculosis rate was 2.3 times higher in non-US-born than in US-born persons during the study period (40.0 vs. 17.7/100 000; $P < 0.001$). The significant decline in tuberculosis incidence among US-born persons was more substantial in the first half of the study period (1995–1997, 23–24%), than in the second half (13–15%) (Table 1). Decline in incidence was greatest among US-born Hispanic or non-Hispanic Black males aged between 25 and 64 years. However, although the overall incidence rate among non-US-born persons declined, there was no significant change in any specific sex or racial/ethnic subgroup. Throughout the study period, the highest incidence rate among non-US-born persons was in Asian/Pacific Islanders, which was nearly two times higher than in Hispanics and non-Hispanic Blacks, and nearly seven times higher than in non-Hispanic Whites.

The median age at diagnosis was 42 years in US-born patients, significantly older than in non-US-born patients (38 years). The tuberculosis case rate by age group, year of diagnosis and country of birth is shown in Figure 1. Highly significant decreases among US-born persons were observed in the 25–44 and 45–64

Table 1 Tuberculosis case rates for US- and non-US-born persons by selected demographic characteristics, NYC, 1995–1999*

	Strata-specific annual rate/100 000 population									
	US-born (n = 4630)					Non-US-born (n = 4541)				
	1995	1996	1997	1998	1999	1995	1996	1997	1998	1999
Total TB cases, n	1409	1082	826	702	611	1016	944	891	852	838
Total rate†	27.0	20.8	15.8	13.5	11.7	45.0	42.9	38.4	38.1	36.2
% decrease compared to previous year	—	23.0	24.0	14.6	13.3	—	4.7	10.5	0.8	5.0
Sex										
Male	37.8	27.0	20.7	17.9	15.6	63.7	60.3	55.7	55.0	52.8
Female	17.6	15.3	11.6	9.6	8.4	36.3	32.7	31.9	29.0	29.5
Race/ethnicity										
Asian/Pacific Islander	10.0	10.0	8.4	10.0	7.5	85.0	78.6	80.5	77.1	84.0
Hispanic	29.8	23.8	17.6	14.1	12.3	58.9	53.4	46.4	44.4	39.7
NH-Black	60.9	46.9	35.7	30.8	26.1	51.1	50.4	47.9	45.6	40.6
NH-White	7.7	5.3	4.3	3.7	3.6	14.1	12.6	11.4	10.9	12.2

* Denominators for strata-specific rates were based on 1990 census in NYC.

† Rates for non-US-born persons were age-adjusted.

NH = non-Hispanic.

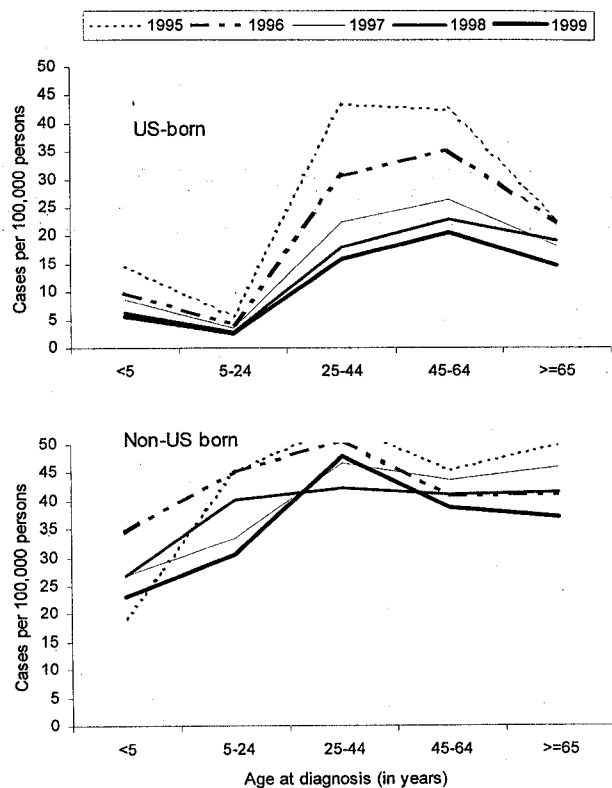


Figure 1 Tuberculosis case rate by age group, year of diagnosis and country of origin, New York City, 1995-1999.

year age groups. However, the decline in case rates in these two age groups also slowed down in the second half of the study period.

Change in clinical characteristics

A total of 7471 (81.5%) cases were confirmed by culture and 1700 (18.5%) culture-negative cases were confirmed based on clinical criteria. The proportion confirmed by culture was significantly higher in US-born patients than in non-US-born patients in 1995 (84.2% vs. 79.6%, χ^2 , $P = 0.003$), but was not significantly different in subsequent years (81.7% vs. 80.6%, $P = 0.273$). Among non-US-born patients with a known date of entry to the US, patients who had been in the US for ≤ 5 years were less likely to have culture-confirmed disease than those who had been in US for > 5 years (75.8% vs. 84.2%, $P < 0.001$). This difference persisted even after excluding those aged under 6 years, of whom 89% were confirmed based on clinical criteria ($P < 0.001$). The likelihood of having a sputum smear positive for acid-fast bacilli during the first month after diagnosis or of having cavitory lesions did not vary significantly by year of diagnosis, country of birth or length of residence in the US.

Of the US-born patients, 41.9% were human immunodeficiency virus (HIV) positive, 32.4% were HIV-negative and 25.7% had unknown HIV status. The number of HIV-infected patients declined by

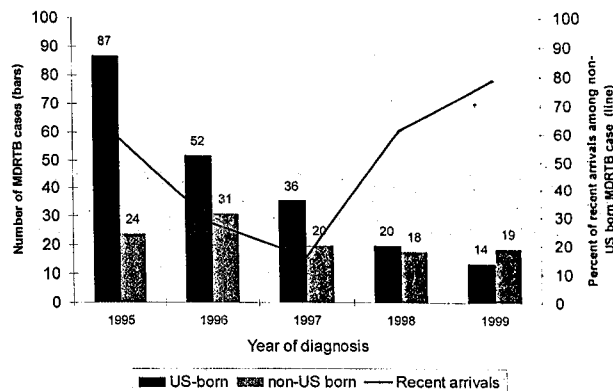


Figure 2 Distribution of multidrug-resistant tuberculosis (MDR-TB) cases by year of diagnosis, country of origin and years in the United States, New York City, 1995-1999.

67.1% in US-born patients, whereas the percentage of HIV-infected cases decreased by only 24%, from 46.8% in 1995 to 35.5% in 1999. Among non-US-born patients, 12.9% were HIV-positive, 52.3% were HIV-negative and 34.8% were unknown; there was a 25.9% decrease in the number of HIV-infected patients in non-US-born patients over the 5-year period. Although the proportion of HIV-infected patients remained low in non-US-born patients overall, the proportion of HIV infection was much higher among patients from the African (26.3%) and Latin America/Caribbean regions (20.2%) than from other regions (1.4-13.5%).

Among the 96.5% of culture-confirmed patients who had isolates tested for susceptibility to first-line anti-tuberculosis drugs, US-born persons were twice as likely as non-US-born persons to have MDR-TB (5.7% vs. 3.1%). However, US-born patients had 84% fewer MDR cases in 1999 compared to 1995, and for the first time there were fewer MDR cases in US-born than in non-US-born patients (Figure 2).

Recent arrivals accounted for 79% of non-US-born MDR cases in 1999, nearly a five-fold increase from 16% in 1997. In 1999, 52.6% (10/19) of non-US-born patients with MDR-TB had been in the US for ≤ 2 years, 26.3% (5/19) for 2-5 years, and 21.1% (4/19) for > 5 years. Non-US-born patients in the US for ≤ 5 years were 3.5 times more likely to have MDR-TB than those who had been in the US for > 5 years.

While rifampin mono-resistance was uncommon among non-US-born patients (0.6%), isoniazid resistance other than MDR was nearly twice as common in non-US-born than in US-born patients (7.1% vs. 3.8%). The number of isoniazid-resistant tuberculosis patients from Bangladesh, Nepal, Thailand, Cambodia, Afghanistan, Russia, Georgia, Uzbekistan, Sierra Leone and Portugal increased significantly in 1999. In 1995, no cases from any of these countries had isoniazid-resistant strains, except for Bangladesh and

Russia. In addition, 65.9% of patients with isoniazid-resistant strains from these countries were diagnosed within 5 years of entry to the US compared to 37% of patients from other countries.

Top countries of origin

Patients from the Latin American and Caribbean region accounted for 2234 (49%) of all non-US-born patients, followed by Asia, including China and India (32%), Africa (6%), the Middle East (5%), former socialist economies of Europe (5%), and the region of established market economies (2%).

A total of 135 countries were reported as places of birth for non-US-born patients—an average of 90 countries each year. Of the 838 cases in non-US-born persons in 1999, 63% were from 12 countries. These 12 countries, with 20 or more cases per country, are ranked by number of cases in Table 2. Bangladesh, Nepal and Peru ranked respectively 12th, 39th, and 15th in 1995, and moved to 8th, 9th and 10th place, respectively, in 1999 (an increase of 30–500%). The ranking for the other nine countries remained similar over the study period. The number of cases from the Dominican Republic and Haiti decreased most, by respectively 45.6% and 37.5%. In 1999, 15 tuberculosis patients were from Russia and 11 were from Vietnam.

Years in the US among the non-US-born

Of 4151 (91.4%) non-US-born patients with known date of entry into the US, the median number of years in the US was 6.6 (range 1 day–88 years), and the mean was 10.7 years (standard deviation [SD] 11.8). On average 23.7% of cases were diagnosed within the first 2 years of arrival, 18.2% between the third and fifth years, and 58.1% after the fifth year in the US. The median age at arrival in the US was 27 years.

Recent arrivals accounted for 42.1% of all non-US-born cases in 1999, a 10% increase from 38.2% in 1995 (Table 2). However, for those born in Nepal, Bangladesh, Mexico, India, Ecuador, and Peru, over 50% of cases in 1999 were diagnosed within the first 5 years after arrival. The mean age at immigration was 34 years (SD 15 years). By contrast, the majority of patients born in China, the Dominican Republic, Haiti, the Philippines, Republic of Korea or Pakistan were diagnosed after the fifth year in the US, and were older at the time of entry into the US (mean age 44 years; SD 19; $P < 0.001$).

DISCUSSION

The differential decline in tuberculosis incidence in US- and non-US-born persons in NYC over the study period is consistent with the experience in other parts of the country.¹¹ The significant decrease in tuberculosis incidence among US-born persons not only elucidates that tuberculosis transmission was occurring primarily in this group in the 1980s and early 1990s, but also attests to successful interruption of ongoing tuberculosis transmission as a result of effective tuberculosis control efforts in NYC after 1992.^{3–5} The dramatic decline in MDR-TB among US-born patients is further evidence that effective control quickly reversed the epidemic in this group.

A number of studies have shown that receiving highly active antiretroviral therapy (HAART) can reduce the incidence and risk of HIV-associated tuberculosis by more than 80%.^{12,13} Even though HAART was introduced in NYC in 1996, the earliest data on HAART collected from four large hospital-based clinics in NYC in 1997 showed that about 40% were prescribed HAART in the first half of 1997 and 60%

Table 2 Change in tuberculosis rates in non-US countries of origin that contributed at least 20 TB cases in NYC in 1999

World region/country	1999 (n = 838)			Recent arrivals		Change in cases (1999 vs. 1995) %
	Cases n	Percent of total	Rate/100 000*	in 1999 %	in 1995 %	
China	98	11.7	86	30.4	42.4	-18.3
Latin America/Caribbean						
Dominican Republic	68	8.1	30	22.7	50.0	-45.6
Haiti	65	7.8	93	30.7	37.7	-37.5
Ecuador	61	7.3	103	67.8	75.5	0.0
Mexico	38	4.5	112	58.3	56.1	-28.3
Peru	22	2.6	109	50.0	43.8	+37.5
India	45	5.4	106	57.1	50.0	+12.5
Other Asian countries						
Philippines	33	3.9	91	22.6	57.7	-5.7
Bangladesh	26	3.1	299	76.0	64.7	+30.0
Nepal	24	2.9	9195	87.0	75.0	+500.0
Republic of Korea	24	2.9	48	41.7	33.3	-4.0
Middle Eastern region						
Pakistan	24	2.9	167	40.9	65.2	-14.3
All countries of non-US-born immigrants	838	100	40.6	42.1	38.2	-17.5

* Country-specific rate per 100 000 population. Population was based on 1990 census in NYC.

in the second half (unpublished data, NYC Department of Health and Mental Hygiene). A study of the use of protease inhibitors (PI) in HIV-infected TB patients in NYC in 1997 also showed that while 68% of 446 study subjects were aware of their HIV positivity, only 18% of the 446 received a PI prior to tuberculosis treatment (unpublished data, NYC Department of Health and Mental Hygiene). This suggests that the use of HAART may not have contributed significantly to the substantial decline in tuberculosis incidence among US-born persons in NYC, especially in the first half of the study period (1995–1997). However, it would be likely to influence later trends.

While case rates among non-US-born persons in NYC also declined during the study period, the relatively slower decline in this group supports the notion that tuberculosis incidence in the non-US-born is not driven by recent transmission, but by a continuing influx of persons with high prevalence of latent infection, and by reactivation of latent tuberculosis infection.^{14–17} Of the 12 countries listed in Table 2, except for Nepal and Mexico 10 were from the top 20 sources of immigrants to NYC during the 1990s.^{18,19} The Bangladeshi population in NYC grew the most during the 1990s; tuberculosis cases from this country increased significantly, by 30%, over the study period. Moreover, more than 50% of cases from Bangladesh diagnosed in 1999 were recent arrivals. This high incidence is consistent with the tuberculosis situation in Bangladesh, which has the fourth highest tuberculosis burden worldwide, with 300 000 new cases in 1997.²⁰

The number of tuberculosis cases did not always parallel the increase in immigration, however. The former Soviet Union, including Russia, had the largest number of legal immigrants to NYC in 1995–1996, and increased by 53%, from 13 260 new immigrants in 1990–1994 to 20 327 in 1995–1996.^{18,19} In NYC, however, the number of tuberculosis cases in Russians actually decreased by 6% during the study period. The epidemic spread of tuberculosis in Russia during the 1990s has been reported elsewhere: the case rate rose from a low of 34/100 000 in 1991 to 57.9/100 000 in 1995 and 85/100 000 in 1999.^{21,22} This dramatic increase in TB incidence in Russia was not reflected in the Russian population in NYC.

Recent arrivals who develop active tuberculosis disease after their arrival in NYC have undoubtedly had a great impact on local tuberculosis dynamic and control strategies. However, the lack of information on recent arrivals precludes direct assessment of the dimensions of such immigration to NYC, where the concentration of immigrants from around the world, especially countries with high tuberculosis incidence, is quite large. The proportion of active tuberculosis disease among recent arrivals varied by country in NYC (Table 2). This variation is indirect evidence of the differences in 1) the tuberculosis burden and risk of

infection in those countries (six of the 12 countries are among the 22 highest-burden countries, as estimated by the World Health Organization),²⁰ 2) the different age distribution in immigrants from those countries, and 3) the length of time in the US and in NYC of different immigrant populations. Global efforts to control tuberculosis in developing countries with high tuberculosis incidence are therefore essential.

The percentage of MDR cases among non-US-born patients remained relatively stable over the study period, but is still more than twice the national average of 1.1%.²³ Moreover, in 1999, nearly 80% of MDR cases in the non-US-born were among recent arrivals, as was observed also in 2000 and 2001.⁶ Non-MDR isoniazid resistance was also common. These trends are worrisome on two levels. First, it suggests that MDR strains in non-US-born patients are acquired prior to entering the US, and reflects inadequate tuberculosis control in those countries.^{24,25} Second, isoniazid treatment of latent tuberculosis infection may be unsuccessful in a significant proportion of people originating from those countries.

These findings should be interpreted with the following considerations. Given the absence of annual population estimates for NYC after 1990, the population denominator used for calculating incidence rates throughout the study period (1995–1999) was that of the 1990 census. According to the Immigration and Naturalization Services (INS), the number of legal immigrants in NYC increased by 11% from 1990 to 1996,¹⁶ not including visitors and students. Thus, the incidence rates in non-US-born persons in NYC may be overestimated. If we applied the national estimates of the annual per cent increase in the non-US-born population to the NYC non-US-born,²⁶ the annual incidence rates for non-US-born persons would have been 4.5 to 10.7/100 000 lower than the incidence rates observed in this study.

In summary, the differential decline in tuberculosis incidence among US- and non-US-born persons in NYC not only portends changes for tuberculosis control efforts in the US, but also mirrors the global tuberculosis epidemic in developing countries. The findings of this study corroborate the effectiveness of the current tuberculosis control efforts in NYC, and support the recent CDC guidelines for increasing tuberculin testing and treatment of latent tuberculosis infection among recent immigrants from high tuberculosis incidence countries to further reduce incident cases among non-US-born persons in the US.²⁷ Nevertheless, to accelerate the decline in tuberculosis incidence in non-US-born persons, improved global control efforts are required.

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RÉSUMÉ

CONTEXTE : Un grand programme urbain de lutte anti-tuberculeuse.

OBJECTIFS : Examiner les modifications des taux d'incidence de la tuberculose et les caractéristiques des cas à New York (NYC), et évaluer l'épidémiologie de la tuberculose chez les sujets nés en dehors des Etats-Unis.

SCHEMA : Analyse des données de surveillance de la tuberculose pour NYC (1995–1999).

RÉSULTATS : L'incidence de la tuberculose a décliné de 56,6% chez les sujets nés aux Etats-Unis et de 19,6% chez ceux nés en dehors des Etats-Unis (après ajustement pour l'âge) au cours de la période d'étude. La décroissance de l'incidence de la tuberculose chez ceux nés aux Etats-Unis a été plus substantielle dans la première moitié de la période d'étude (23–24%) que dans la seconde moitié (13–15%). La décroissance de l'incidence a été plus marquée parmi les sujets hispaniques et noirs de sexe masculin, nés aux Etats-Unis et âgés de 25 à 64 ans.

Toutefois, bien qu'il y ait eu une décroissance globale du taux d'incidence parmi ceux nés en dehors des Etats-Unis, on n'a pas noté de modification significative dans aucun sous-groupe pour le sexe, la race ou l'ethnie. Le pourcentage de cas de multirésistance (MR) parmi les patients nés en dehors des Etats-Unis est resté stable, mais des arrivées récentes rendent compte en 1999 de 79% des patients TB-MR nés en dehors des Etats-Unis, une augmentation significative par rapport aux 16% de 1997.

CONCLUSIONS : La poursuite des efforts actuels de lutte contre la tuberculose et le traitement des immigrants atteints d'infection tuberculeuse latente sont les priorités les plus fortes pour réduire l'incidence des cas à NYC. Une collaboration mondiale en vue d'une détection plus précoce et d'un traitement des cas de tuberculose active dans les régions à haute incidence est également essentielle.

RESUMEN

MARCO DE REFERENCIA: Amplio programa urbano de control de la tuberculosis.

OBJETIVO: Estudiar los cambios en las tasas de incidencia de la tuberculosis y las características de los casos en la ciudad de Nueva York y evaluar la epidemiología de la tuberculosis en las personas nacidas fuera de los EEUU.

DISEÑO: Análisis de los datos de vigilancia de la tuberculosis entre 1995 y 1999.

RESULTADOS: Durante el período de estudio, la tasa de incidencia de la tuberculosis disminuyó de 56,6% en los nacidos en los EEUU y en un 19,6% en los nacidos fuera de los EEUU. La disminución de la incidencia de la tuberculosis en las personas nacidas en los EEUU fue más substancial en la primera mitad del período de estudio (23-24%) que en la segunda (13-15%). La disminución de la incidencia fue mayor en los sujetos hispanicos o negros de sexo masculino nacidos en los EEUU de

25 a 64 años de edad. Sin embargo, aunque se constató una disminución global de la tasa de incidencia en los sujetos nacidos fuera de los EEUU, no hubo cambio significativo en ningún subgrupo por sexo o por raza/etnia. El porcentaje de casos de multirresistencia (MR) en los sujetos nacidos fuera de los EEUU permaneció estable, pero la llegada reciente de nuevas personas tuvo como resultado una proporción de 79% de casos de TB-MR nacidos fuera de los EEUU, aumento significativo en comparación con un 16% en 1997.

CONCLUSIÓN: La prosecución de los esfuerzos actuales de control de la tuberculosis y el tratamiento de los inmigrantes con infección tuberculosa latente son de la más alta prioridad para reducir la incidencia de los casos en la ciudad de Nueva York. También es esencial una colaboración mundial para la detección y tratamiento precoces de los casos de tuberculosis activa en los países de alta incidencia.