Epidemiology of TB: A Local and National Overview

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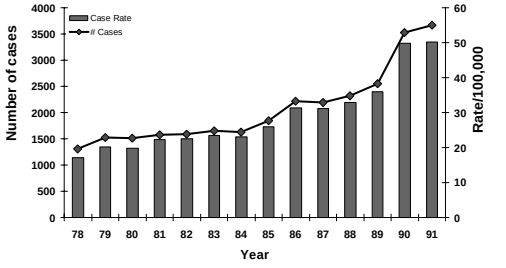
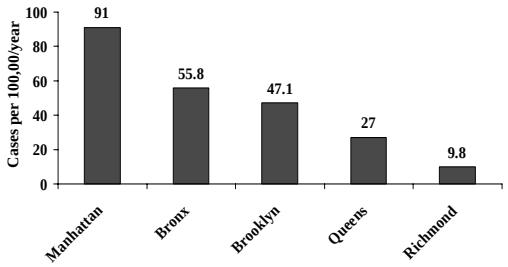
Tuberculosis in New York City:

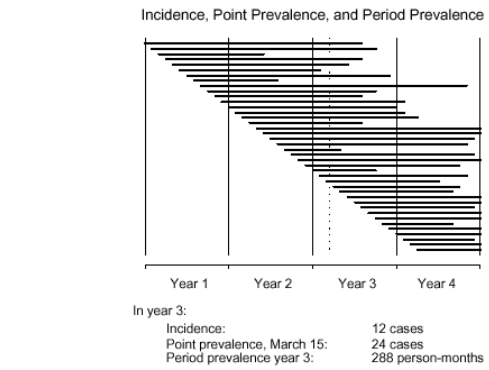
The Last Decade

Tuberculosis Cases and Rates New York City, 1978 - 1991



Tuberculosis rates by borough New York City, 1991



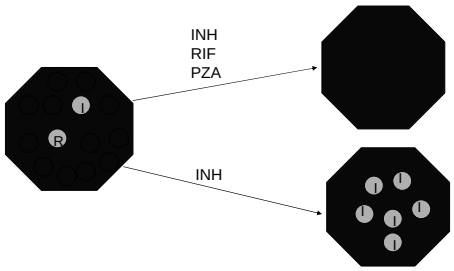


Rates of natural resistance in *M. tuberculosis*

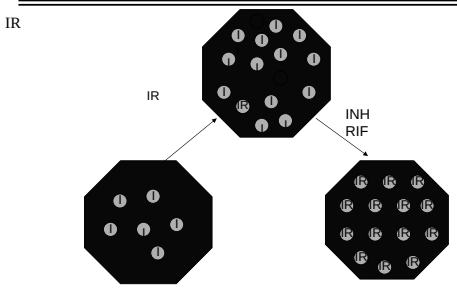
- Isoniazid 1 in 10^6
- Rifampin 1 in 10^8
- Ethambutol 1 in 10^6
- Streptomycin 1 in 10^5
- INH & RIF 1 in 10^{14}

Number of organisms in a TB cavity = 10^9-10^{11}

Pathogenesis of Drug Resistance I



Pathogenesis of Drug Resistance II



How to get MDRTB

- Acquired resistance
  - Non adherence to therapy
  - inappropriate therapy
- Primary resistance
  - nosocomial transmission
  - community transmission

Emergence of Resistance

(Inappropriate Therapy)

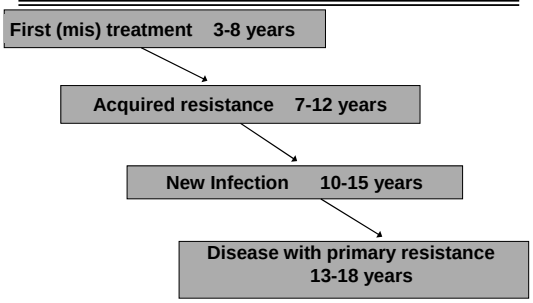
Treatment	6/90	9/90	2/91
Isoniazid	→	→	→
Rifampin	→	→	→
Ethambutol		→	→
Smear	+	+	+
Culture	+	+	+
Susceptibility			
Isoniazid	R	R	R
Rifampin	S	R	R
Ethambutol	S	S	R

Emergence of Resistance

(Nonadherence and Inappropriate Therapy)

Treatment	6/90	9/90	12/90	3/91	6/91
Isoniazid	→	→	→	→	→
Rifampin	→	?	→	→	→
Ethambutol		→	DOT	→	→
Smear	+	+	+	-	+
Culture	+	+	+	+	+
Susceptibility					
Isoniazid	S	R	R	R	
Rifampin	S	S	S	R	
Ethambutol	S	S	R	R	

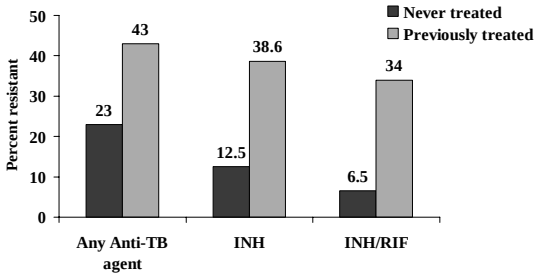
Evolution of Drug Resistance in a Community



Causes of resurgent tuberculosis in New York City

- Poverty, homelessness, crowding, substance abuse
- TB abroad on the rise; immigration from high prevalence countries
- HIV/AIDS epidemic
- Decline of public health infrastructure; lack of accessible health care
- Marked reduction in TB control program staff and clinic facilities
- By 1989, less than half of patients who began treatment were cured

Patients with resistant isolates New York City, 1991(N=466)



Nosocomial, HIV related outbreaks of multidrug resistant TB as of October, 1992

Facility	*Location*	*Time Period*	*Total*
Hospital A	Miami	1988-91	65
Hospital B	NYC	1989-91	51
Hospital C	NYC	1989-92	70
Hospital D	NYC	1990-91	29
Hospital E	NYS	1990-91	7
Hospital F	NYC	1990-91	16
Hospital I	NJ	1990-92	13
Hospital J	NYC	1991-92	28
Prisons*	NYS	1990-92	42
Total Cases			297

* 24 prison cases are also counted with Hospital C

Prevalence of HIV and mortality of patients with multidrug-resistant TB as of Oct., 1992

Facility	*HIV+*	*Mortality*	*Median Interval*
Hospital A	93%	72%	7 weeks
Hospital B*	100%	89%	16 weeks
Hospital C	95%	77%	4 weeks
Hospital D	91%	83%	4 weeks
Hospital E	14%	43%	4 weeks
Hospital F	82%	82%	4 weeks
Hospital I	100%	85%	4 weeks
Hospital J	96%	93%	4 weeks
Prison System **	98%	79%	4 weeks

* HIV infection was part of case definition
** Includes 24 cases also counted with Hospital C

Nosocomial Tuberculosis
Common Characteristics

- Diagnosis was not considered or late diagnosis
- CXR often “atypical” for TB
- Ineffective or inadequate isolation
- Most cases in HIV seropositive patients
- Multidrug-resistant strains
  - standard treatment not effective
  - Appropriate treatment also often ineffective for prolonged periods
  - Laboratory results delayed

A Multi-institutional Outbreak of Highly Drug-Resistant Tuberculosis

Frieden et al. JAMA 1996;276:1229-1235

Characteristics of strain W outbreak
Patient Selection

- Patients were selected from those cared for at public and nonpublic institutions from January 1, 1990 to August 1, 1993
- Patients had to have isolates resistant to at least I/R/E/S and RBT, if testing included it
- For those suspected of having strain W TB, results of isolate testing by RFLP had to have an identical or closely related pattern to strain W

Characteristics of strain W outbreak
Results

- 357 patients met case definition, 267 had isolates for RFLP
- 78% were sputum AFB smear positive
- Of 249 with known serostatus, 230 (92%) were HIV+
- Median survival for the 230 HIV+ patients was 66 days
- 221 HIV+ patients had positive cultures from a pulmonary source
- Patients with strain W had more documented HIV infection than other CX+ TB patients (86% vs. 37% ; P<.001)

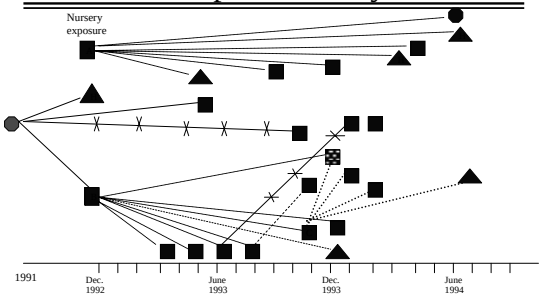
Characteristics of strain W outbreak
Epidemiological links-1

- 267 (75%) had isolates available for RFLP testing
- 237 isolates had an identical RFLP pattern (strain W)
- 30 isolates had RFLP patterns that were very similar to strain W
- Patients resided in all boroughs and most zip codes in NYC
- Cared for at 41 hospitals and hospitalized for 19,740 days

Characteristics of strain W outbreak
Epidemiological links-2

- 186 (70%) of 267 were epidemiologically linked
- 178 (96%) occurred in 11 different hospitals (range 1-76 case/hospital)
- 3 (2%) were linked in the correctional system
- 5 (3%) were linked in the community
- Outbreaks lasted up to 38 months and most took place in 4 hospitals
- Median time from exposure to disease was 17 weeks

MDRTB Transmission in a Hospital Nursery



Nivin et al. CID 1998;26:303-7

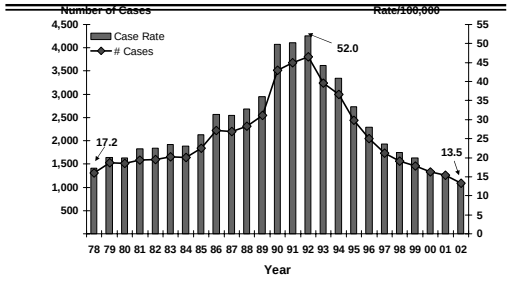
TB Control: The 5 components of DOTS

- **Political commitment**
- **Diagnosis by microscopy**
- **Adequate supply of the right drugs**
- **Directly observed treatment**
- **Accountability**

Programmatic measures used to control TB in NYC

- DOT as standard of care
- Intensive case management
- Detention until cure for least adherent
- Improved Infection Control
  - Hospitals
  - Correctional facilities
- Changes in empiric treatment regimens
- Mandatory susceptibility testing and reporting

Tuberculosis Cases and Rates New York City, 1978 – 2002*



* Rates since 2000 are based on 2000 Census data.

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Trends in Tuberculosis - 1 New York City, 1992-2002

- 71.6% fewer cases since 1992
- 93.9% fewer MDRTB cases
- 88.4% fewer US-born cases
- 76.9% fewer cases in 25-44 year age group

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Trends in Tuberculosis - 2 New York City, 1992-2002

- HIV-infected cases decreased from 34% in 1992 to 15% in 2001, increasing to 18% in 2002
- Females increased from 28% in 1986 to 39% in 2002
- Non-US-born cases increased from 18% in 1992 to 66% in 2001, decreasing to 65% in 2002

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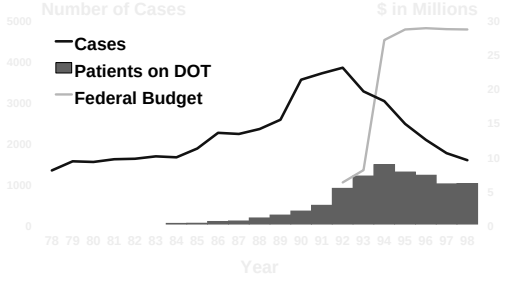
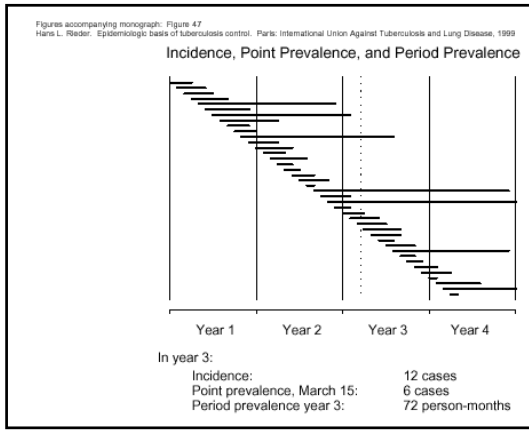
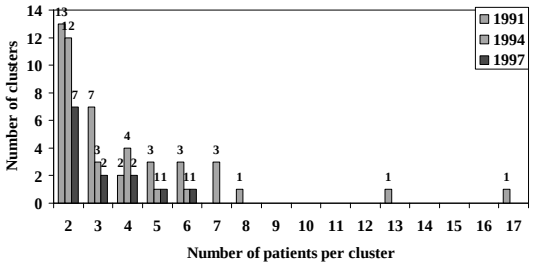
Tuberculosis Cases New York City, 1978-1998

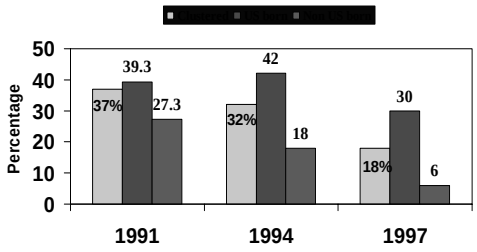




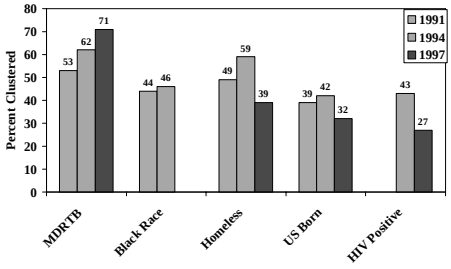
Cluster size among NYC TB patients during three surveys



Clustering among NYC TB patients during three surveys



Risk factors associated with clustering of TB in NYC

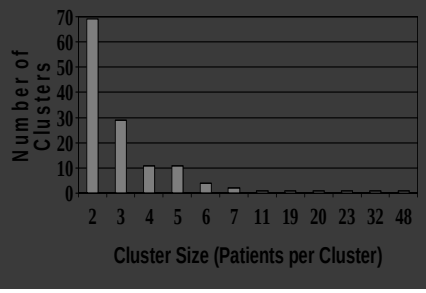


DNA Clustering by country of origin, NYC 1991-2002

	US-Born Patients			Non US-Born Patients			
	Total Culture Positive	Clustered Cases No.	(%)	Total Culture Positive	Clustered Cases No.	(%)	Overall % Clustering
Cross-Sectional Surveys (NYC April Studies)							
1991*	267	105	**39%**	77	21	**27%**	37%
1994**	147	62	**42%**	103	18	**17%**	32%
1997**	96	31	**32%**	117	7	**6%**	18%
NYC 2001- 2002 Incident ME Project cases (2 years)							
RFLP alone for cases >3 bands	393	191	**49%**	973	201	**21%**	29%
RFLP and Spoligo for ALL Cases	496	260	**52%**	1088	255	**23%**	33%

* Frieden, et al, 1995: includes only cases with strains of >3 RFLP bands.
**Unpublished study includes only cases with strains of >3 RFLP bands.

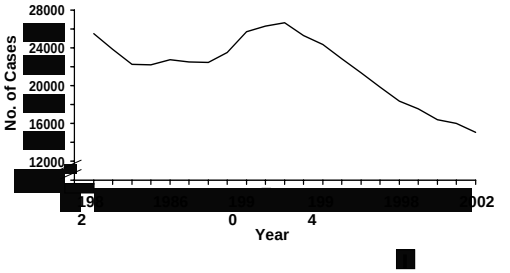
Number and Size of DNA Clusters (N=132 clusters)



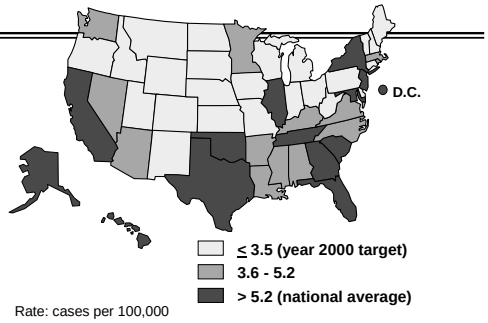
Multivariate Analysis Clustering

Variable	OR Adjusted	(95% CI)
Age <60	1.79	1.28 – 2.51
US-Born	2.46	1.83 – 3.29
Asian	0.41	0.29 – 0.59
History of TB or LTBI	2.00	1.09 – 3.66
Low band RFLP	9.33	6.47 – 13.46

Reported TB Cases
United States, 1982-2002

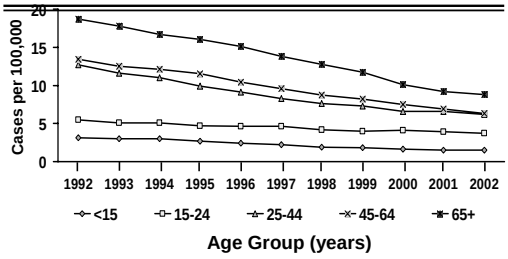


TB Case Rates, United States, 2002

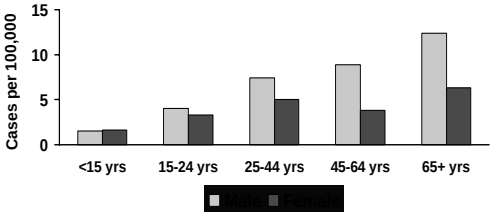


Rate: cases per 100,000

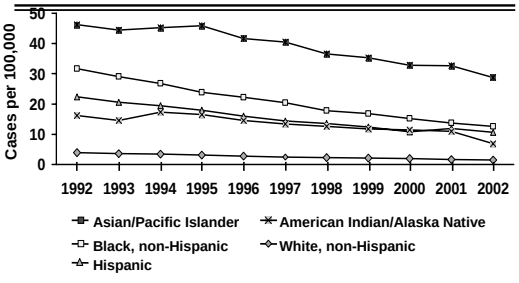
TB Case Rates by Age Group
United States, 1992-2002



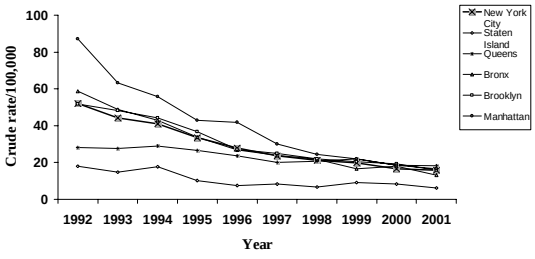
TB Case Rates by Age Group and Sex, United States, 2002



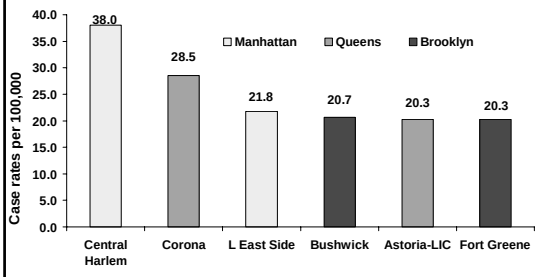
TB Case Rates by Race/Ethnicity
United States, 1992-2002



Crude Case Rates by Borough
New York City, 1992 - 2001



Health Districts with Case Rate* $20
New York City, 2002



* Rates per 100,000 based on 2000 Census data.

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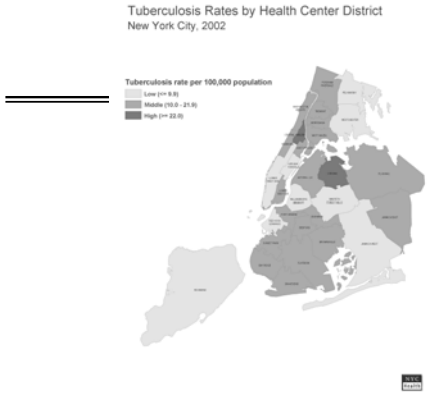
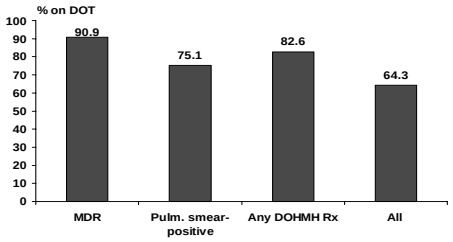


Percent of Eligible* Tuberculosis Patients on Directly Observed Therapy** New York City, 2001



* Eligible patients were those diagnosed while alive and who received some treatment on an outpatient basis.
** Ever on DOT as of March of the year after being confirmed as a case of tuberculosis.

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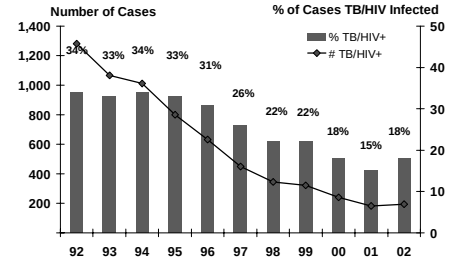
Trend in HIV-Infection and TB New York City, 1992-2002



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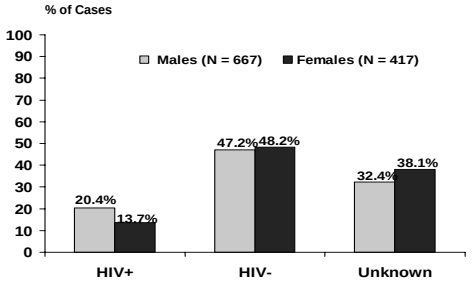
HIV Infection and Tuberculosis New York City, 2002



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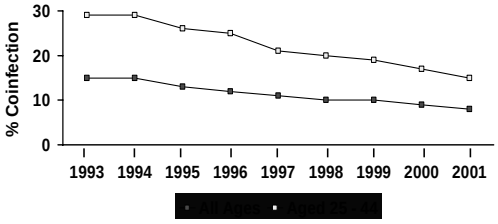
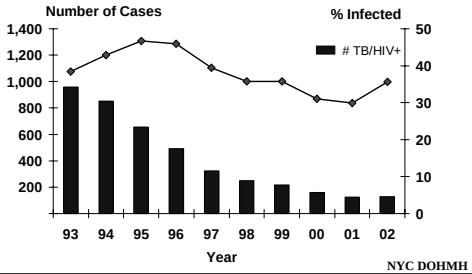
Estimated HIV Coinfection in Persons Reported with TB United States, 1993-2001



Note: Minimum estimates based on reported HIV-positive status
among all TB cases in the age group. All 2001 cases from California have an unknown HIV status.

HIV-Infected US-Born TB Cases New York City, 1993-2002



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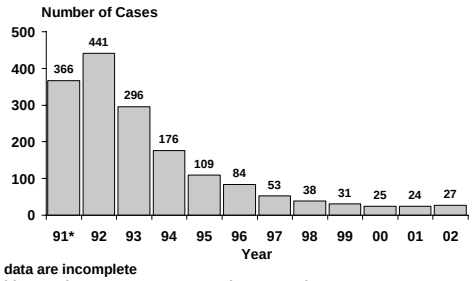
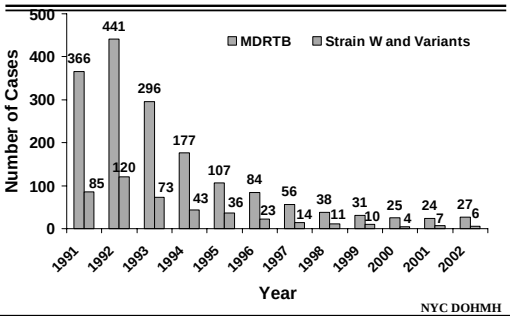
Multidrug-Resistant TB* New York City, 1991 - 2002



*1991 data are incomplete
**multidrug-resistant TB or MDRTB: resistant to at last INH & RIF NYC DOHMH

W and related strain epidemic curve in NYC, 1991-2001



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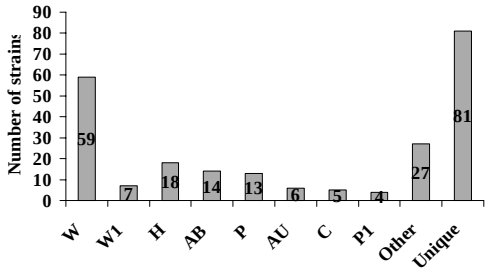
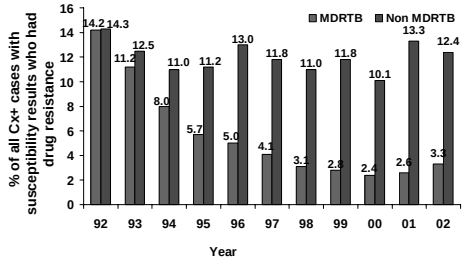
Major multidrug-resistant strains in New York City, 1995-1997



Drug Resistance in New York City, 1992-2002



MDR-TB: resistant to at least INH & RIF
ODR-TB: resistance to other first-line drugs

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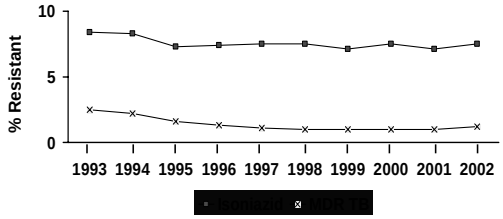
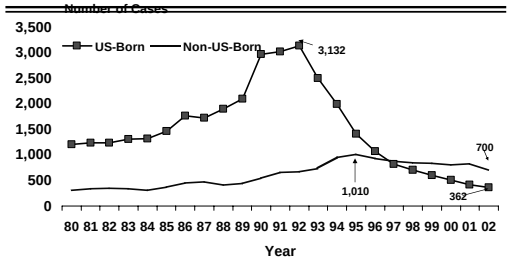
Primary Anti-TB Drug Resistance United States, 1993-2002



Note: Based on initial isolates from persons with no prior history of TB.
MDR TB defined as resistance to at least isoniazid and rifampin.

US* and Non-US Born TB Cases New York City, 1980 – 2002



•Puerto Rico and U.S. Virgin Islands are included as U.S.-born
•There were 22 cases with unknown country of birth

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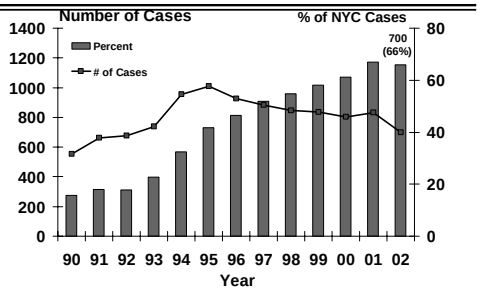
Non-US Born Tuberculosis Cases New York City, 1990 - 2002



*NYC cases with known country of birth

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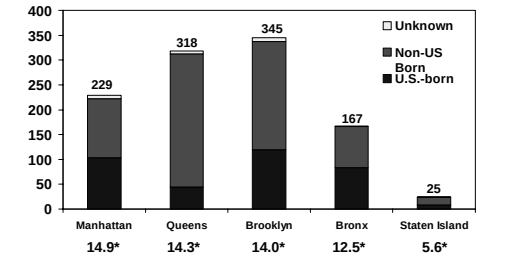
Tuberculosis Cases by Area of Birth and Borough, New York City, 2002



*Rate per 100,000 based on 2000 Census

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22 High-Burden TB Countries*

1. India	12. Kenya
2. China	13. Vietnam
3. Indonesia	14. Tanzania
4. Nigeria	15. Brazil
5. Bangladesh	16. Thailand
6. Ethiopia	17. Uganda
7. Philippines	18. Myanmar
8. Pakistan	19. Mozambique
9. South Africa	20. Cambodia
10. Russian Federation	21. Zimbabwe
11. DR Congo	22. Afghanistan

*As per the World Health Organization

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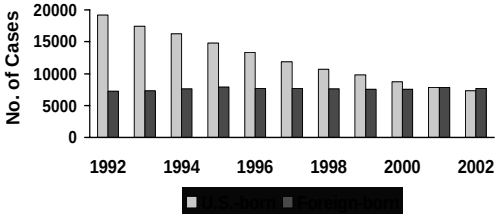
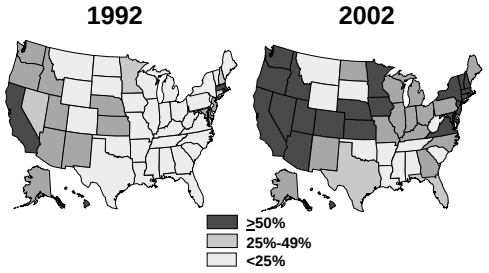
Top 10 Countries of Birth NYC TB Cases 2002

China	106
Ecuador	74
Dominican Republic	55
India	44
Haiti	44
Mexico	34
Republic of Korea	21
Bangladesh	17
Pakistan	18
Russia	17

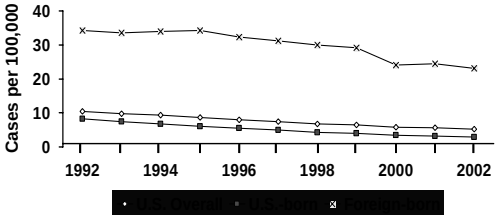
Number of TB Cases in U.S.-born vs. Foreign-born Persons United States, 1992-2002



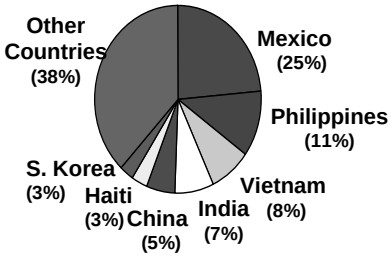
Percentage of TB Cases Among Foreign-born Persons, US



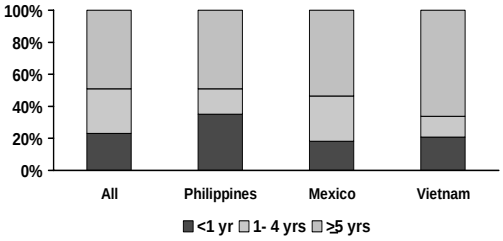
TB Case Rates in U.S.-born vs. Foreign-born Persons, United States, 1992-2002



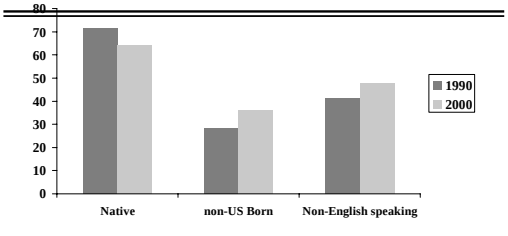
Countries of Birth for Foreign-born Persons Reported with TB United States, 2002



Length of U.S. Residence Prior to TB Diagnosis, United States, 2002

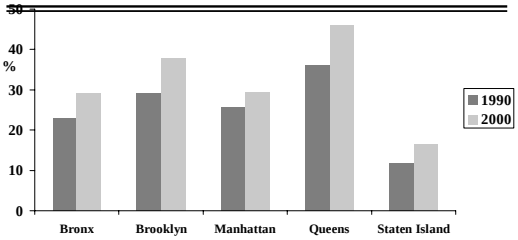


New York City Population, 1990 and 2000



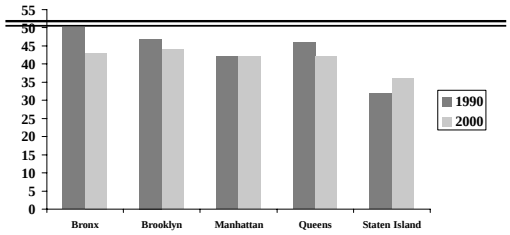
Source: 1990 and 2000 Census Profiles Population Division, NYC Department of City Planning

NYC non-US Born Population by Borough



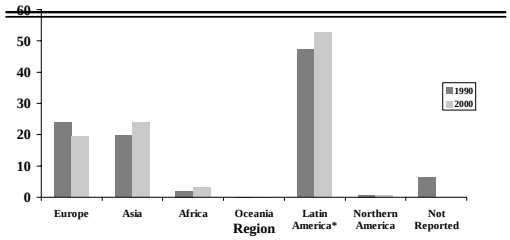
Source: 1990 and 2000 Census Profiles, Population Division, NYC Department of City Planning

Percent NYC non-US born Population Entering US in Past Ten Years



Source: 1990 and 2000 Census Profiles Population Division, NYC Department of City Planning

NYC non-US born Population by Region



*Includes Mexico and Caribbean

Source: 1990 and 2000 Census Profiles, Population Division, NYC Department of City Planning

NYC Population and TB Case Rates:
Top 12 Countries of Origin for TB cases

NYC 2000 population	1,222,737
In US <10 years*	384,226
Expected TB cases using:	
Total population	1,839
In US <10 years	617
Actual 2001 Cases in NYC	560

*Estimate applying regional % in US <10 yrs to country-specific population

Sources: US Census 2000 and WHO estimated TB case rates

Limitations of Census Data

- 1990 Census denominators - overestimate incidence rate
- Time spent outside US for US-born, and re-entry for non-US born unavailable
- Immigration status of non-US born TB cases not available

Current Prevention Strategies

- Improving LTBI treatment completion for high risk individuals
- Targeted testing in high risk communities
- Screening of immigrants
- Identifying missed opportunities for TB prevention

LTBI Treatment

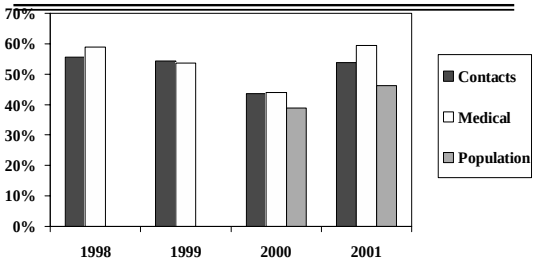
Treatment for LTBI is resource intensive and has limited success

- Isoniazid treatment for 9-12 months is 75% effective
- Cost per case prevented $14,558
- Cost per TB case $16,391

– But if completion rate is 50%, it is not cost effective

Source: Institute of Medicine, Ending Neglect, 2000

LTBI Treatment Completion Rates DOHMH Chest Centers



*2001 data are preliminary

Yield of targeted tuberculin testing is low

Results of targeted testing in Haitian and Ecuadorian communities, NYC 2000 (n=308)

TST positive (n=116)	**38%**
Completed medical evaluation	**59%**
Started treatment for LTBI	**33%**
Completed treatment	**13%**

Screening of Immigrants/Refugees

- **Immigrants/refugees (>15 years of age) are screened by chest x-ray and sputa before entry**
- **Non-infectious disease - required to report to health department at destination**
- **Account for small proportion of foreign-born cases**
  - **In NYC, on average 20/year**
  - **2% of FB cases in 2001**
- **Excludes majority of foreign-born (tourists, students, temporary workers, undocumented)**

Will there always be 1000 TB cases per year in NYC?

- **Non-US born population increasing in NYC**
- **Prevention strategies are resource intensive and have limited success**
- **Immigrant screening abroad covers small proportion of cases in non-US born**
- **Case rates in country of origin and recent arrival in US strongest predictors of disease**
- **Imported TB likely to continue to contribute significantly to NYC cases in near future**

Challenges in the Future

- HIV infection and congregate settings
- Continued high immigration from high incidence countries
- Potential for decreased vigilance in hospitals
- Decreased funding
- International TB efforts not moving at the pace needed to fulfill WHO goals