

Tuberculosis among the homeless, United States, 1994–2010

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SUMMARY

OBJECTIVES: 1) To describe homeless persons diagnosed with tuberculosis (TB) during the period 1994–2010, and 2) to estimate a TB incidence rate among homeless persons in the United States.

METHODS: TB cases reported to the National Tuberculosis Surveillance System were analyzed by origin of birth. Incidence rates were calculated using the US Department of Housing and Urban Development homeless population estimates. Analysis of genotyping results identified clustering as a marker for transmission among homeless TB patients.

RESULTS: Of 270 948 reported TB cases, 16 527 (6%) were homeless. The TB incidence rate among homeless persons ranged from 36 to 47 cases per 100 000 population

in 2006–2010. Homeless TB patients had over twice the odds of not completing treatment and of belonging to a genotype cluster. US- and foreign-born homeless TB patients had respectively 8 and 12 times the odds of substance abuse.

CONCLUSIONS: Compared to the general population, homeless persons had an approximately 10-fold increase in TB incidence, were less likely to complete treatment and more likely to abuse substances. Public health outreach should target homeless populations to reduce the excess burden of TB in this population.

KEY WORDS: genotyping; housing; latent tuberculous infection

IN THE UNITED STATES, an estimated 1% of people experience homelessness in a given year,¹ and concerns have been expressed about a potential increase in homelessness during the recent economic downturn.² Substance abuse, incarceration and human immunodeficiency virus (HIV) infection—conditions that more frequently affect homeless persons—are also risk factors for tuberculosis (TB).^{3–6} Persons without stable housing and employment often lack access to medical care,^{7,8} which delays the diagnosis of TB,⁹ resulting in prolonged infectious periods.¹⁰ TB genotyping data suggest that homelessness is associated with greater transmission,^{11,12} and homeless-associated outbreaks can be substantial, involving large numbers of patients and multiple sites of transmission.^{3,13–18}

TB was recognized as a disease associated with homelessness as early as 1914.¹⁹ Since 1993, when national TB surveillance began to include patients' housing status, the proportion of persons with incident TB who were homeless during the year before diagnosis has remained stable, at close to 6%.²⁰ However, as the US Census does not enumerate persons who are unstably housed, calculation of an incident TB rate in this population was difficult before 2005, when the US Department of Housing and Urban Development (HUD) began producing the Annual Homeless Assessment Report.²¹

In this article, we estimate the 2006–2010 TB

incidence rate among homeless persons and describe the characteristics of homeless TB patients during 1994–2010.

METHODS

Patient population

As part of the National TB Surveillance System, the 50 US states and the District of Columbia report all verified TB cases to the Centers for Disease Control and Prevention (CDC).²⁰ A person with TB is reported as homeless if, during the 12 months before the initial diagnostic evaluation for TB, the person lacked a fixed, regular and adequate night-time residence; had a primary night-time residence that was a supervised publicly or privately operated shelter, an institution that provides temporary residence, or a public or private building not designated for, or ordinarily used as, a regular sleeping accommodation for human beings; or had no home or was alternating between multiple residences.²² We analyzed all reported TB cases during 1994–2010 to determine the number and proportion among persons reported as homeless.

TB incidence among homeless persons

Population denominators for calculating national TB incidence rates were based on HUD's Annual Homeless Assessment Reports.^{21,23} We estimated a TB

incidence among homeless persons for the four US fiscal years from 1 October 2006 to 30 September 2010. The number of reported TB cases among persons who had been homeless during the previous 12 months was divided by the estimated total number of sheltered and unsheltered homeless persons for each of the four corresponding 1-year periods. As HUD's estimated denominators had wide confidence intervals that overlapped each year, we presented these results as a range rather than individual annual estimates.

Descriptive analyses

We examined the demographic information, clinical characteristics, and treatment outcomes among homeless persons with TB during 1994–2010. Univariate analyses were conducted to compare TB characteristics among homeless and non-homeless persons. All analyses were stratified by origin of birth (US or foreign-born). Prevalence odds ratios (ORs) and the corresponding 95% confidence intervals (CIs) were calculated to measure the strength of association for each characteristic under consideration.

Tuberculosis genotype clustering as a marker for transmission

Surveillance case records with corresponding TB genotype results from the National TB Genotyping Service were examined.²⁴ We defined a TB genotype cluster as ≥ 2 TB cases in the same county during 2004–2010 with matching spoligotype and 12-locus mycobacterial interspersed repetitive unit–variable number tandem repeats. We determined the proportion of homeless persons who were in county-based genotype

clusters and examined associations between patient characteristics and cluster status. Finally, we reviewed all county-based genotype clusters during two consecutive time periods (i.e., 2005–2007 and 2008–2010) with a log likelihood ratio (LLR) ≥ 10 , and determined the proportion of patients in these clusters that were homeless. The LLR is a statistical test employed by the CDC to compare the geographic concentration of cases with matching genotype patterns in a county to the concentration in the rest of the country during the preceding 3 years. Higher LLRs (e.g., >5) are considered suggestive of ongoing transmission, as seen in outbreaks.^{24,25}

Ethical review

Approval by an institutional review board was not required; as the data were collected and analyzed for this project as part of routine TB surveillance, the project was not considered research involving human subjects. Investigators did not have access to identifying data.

RESULTS

Patient population

The National TB Surveillance System included 270 948 reported and verified TB cases during 1994–2010. Except for HIV results, which some states did not consistently report during this period, completeness of reporting was $>90\%$ for all variables examined. Overall, 16 527 (6%) TB cases were diagnosed among persons who had experienced homelessness during the previous 12 months. The annual number of TB cases among US-born homeless persons declined from

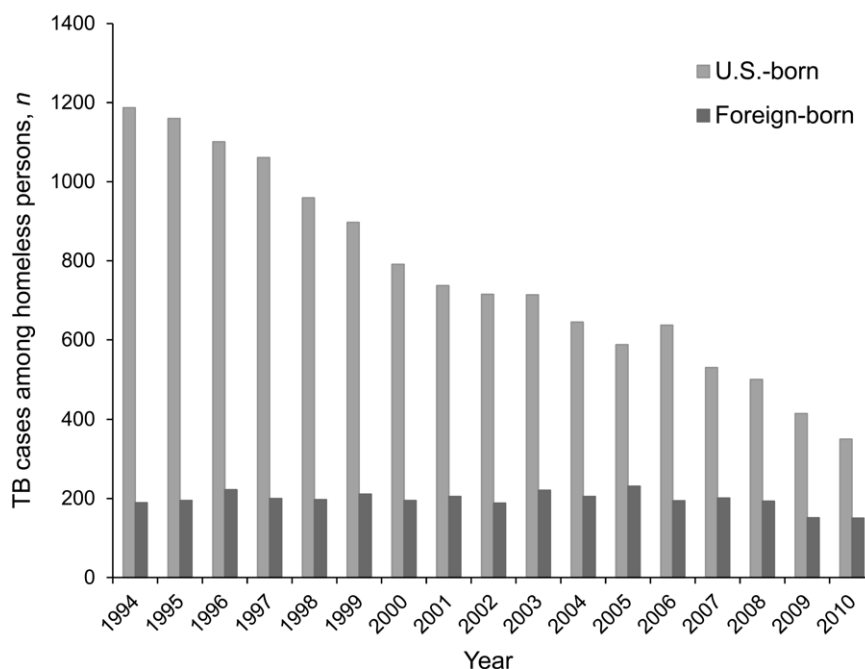


Figure Homeless persons with tuberculosis (TB) by origin of birth, United States, 1994–2010.

1187 in 1994 to 590 in 2010, and the number among foreign-born homeless persons fluctuated between 189 in 1994 and 150 in 2010 (Figure).

Tuberculosis incidence among homeless persons

Based on an estimated 1.6 million sheltered and unsheltered individuals per year in the United States during 2006–2010,^{21,23} the annual TB incidence rate among homeless persons ranged from 36 to 47 cases per 100 000 population.

Descriptive results

Table 1 shows the demographic, risk factors and clinical characteristics of homeless persons diagnosed with TB, stratified by US or foreign birth, with non-homeless persons as the referent group. Most homeless TB patients were males between the ages of 25 and 64 years. The majority of the US-born homeless persons with TB were Black (52%) or White (34%) non-Hispanic; the majority of the foreign-born were of Hispanic ethnicity (67%). The prevalence of reported HIV coinfection was higher among both US- and foreign-born homeless persons with TB than in the non-homeless (22% vs. 9% and 15% vs. 5%, re-

spectively). The proportion of homeless TB patients who were deceased at diagnosis or who died during treatment was the same as among non-homeless patients (8%) (data not shown).

Of all the characteristics analyzed, substance abuse yielded the strongest association with homeless compared to non-homeless TB patients. The odds of substance abuse was 8.3 (95%CI 8.0–8.7) among US-born homeless TB patients and 12.3 (95%CI 11.5–13.2) among foreign-born homeless TB patients.

Overall, homeless TB patients had a greater likelihood of not completing treatment due to being lost to follow-up, having moved or refusing treatment. When stratifying by origin of birth, US-born homeless TB patients had 2.3 times (95%CI 2.2–2.5) and foreign-born homeless TB patients 2.6 times (95%CI 2.3–2.9) the odds of not completing treatment. Among homeless persons, the additional risk factor of incarceration (but not substance abuse or HIV infection) increased the risk of not completing treatment, particularly among the foreign-born homeless; only 60% of foreign-born persons who were residents of correctional facilities at the time of TB diagnosis after having been homeless during the previous 12 months were

Table 1 Demographic, risk factor and clinical characteristics of homeless and non-homeless persons with tuberculosis by origin of birth, United States, 1994–2010

Characteristic	US-born			Foreign-born		
	Homeless (n = 13 073) n (%)	Non-homeless (n = 129 160) n (%)	Prevalence OR (95%CI)	Homeless (n = 3375) n (%)	Non-homeless (n = 124 372) n (%)	Prevalence OR (95%CI)
Male	11 209 (86)	80 857 (63)	3.6 (3.4–3.8)	2961 (88)	72 484 (58)	5.1 (4.6–5.7)
Age group, years						
<15	135 (1)	12 561 (10)	0.1 (0.1–0.1)	66 (2)	4 183 (3)	0.6 (0.4–0.7)
15–24	255 (2)	7 839 (6)	0.3 (0.3–0.4)	349 (10)	17 543 (14)	0.7 (0.6–0.8)
25–44	5 647 (43)	35 305 (27)	2.0 (1.9–2.1)	1709 (51)	50 296 (40)	1.5 (1.4–1.6)
45–64	6 463 (49)	37 926 (29)	2.4 (2.3–2.4)	1091 (32)	30 231 (24)	1.5 (1.4–1.6)
≥65	572 (4)	35 510 (27)	0.1 (0.1–0.1)	160 (5)	22 104 (18)	0.2 (0.2–0.3)
Race/ethnicity*						
Black	6 790 (52)	57 585 (45)	1.3 (1.3–1.4)	448 (13)	15 481 (12)	1.1 (1.0–1.2)
White	4 504 (34)	46 014 (36)	0.9 (0.9–1.0)	206 (6)	7 563 (6)	1.0 (0.9–1.2)
Asian	28 (0)	2 176 (2)	0.1 (0.1–0.2)	439 (13)	54 974 (44)	0.2 (0.2–0.2)
Hispanic	1 159 (9)	18 035 (14)	0.6 (0.6–0.6)	2 252 (67)	45 225 (36)	3.5 (3.3–3.8)
Any substance use†	9 041 (69)	27 415 (21)	8.3 (8.0–8.7)	1 601 (47)	8 494 (7)	12.3 (11.5–13.2)
Excessive alcohol use	7 356 (61)	21 671 (18)	7.1 (6.8–7.4)	1 361 (44)	7 013 (6)	12.7 (11.8–13.7)
Non-injection drug use	4 505 (34)	11 163 (9)	6.1 (5.9–6.4)	607 (18)	2 467 (2)	11.9 (10.8–13.1)
Injection drug use	1 904 (15)	3 930 (3)	5.7 (5.4–6.1)	191 (6)	582 (0.5)	13.8 (11.7–16.3)
Incarcerated at diagnosis	1 105 (9)	5 520 (4)	2.1 (1.9–2.2)	367 (11)	2 527 (2)	5.9 (5.3–6.6)
Local jail‡	899 (83)	2 696 (50)	4.6 (3.9–5.4)	265 (75)	1 164 (47)	3.0 (2.6–3.3)
Clinical characteristics						
AFB smear-positive§	6 975 (60)	46 249 (54)	1.3 (1.3–1.4)	1 753 (60)	42 330 (48)	1.6 (1.5–1.7)
Cavitary disease¶	3 736 (33)	28 274 (29)	1.2 (1.2–1.3)	879 (30)	24 023 (27)	1.2 (1.2–1.3)
HIV-positive result	3 076 (30)	14 689 (15)	2.5 (2.4–2.6)	516 (25)	6 804 (9)	3.6 (3.2–4.0)
Completion of treatment¶¶						
Completed	9 412 (89)	94 908 (94)	0.4 (0.4–0.5)	2 227 (81)	94 222 (92)	0.4 (0.4–0.4)
Moved/lost/refused treatment	494 (17)	7 787 (7)	2.6 (2.4–2.9)	1 050 (9)	3 998 (4)	2.7 (2.5–3.0)

*Persons of Hispanic ethnicity may be of any race. Race reported for persons not of Hispanic ethnicity. Table does not include persons who reported other or multiple race or ethnicity.

†Defined as self-reported excessive alcohol use or injection/non-injection drug use during the year before diagnosis.

‡Facility type percentages based on subset of those incarcerated at diagnosis.

§Among cases with pulmonary tuberculosis.

¶For the years 1994–2008, most recent year for which data are available. Among persons who were alive at diagnosis and began anti-tuberculosis treatment; excludes cases with unknown or missing information for reason treatment was stopped.

OR = odds ratio; CI = confidence interval; AFB = acid-fast bacilli; HIV = human immunodeficiency virus.

Table 2 Characteristics of homeless persons with tuberculosis by genotype cluster status, United States, 2004–2010*

Characteristic	Homeless TB patients in clusters (n = 2101) n (%)	Homeless TB patients not in clusters (n = 1255) n (%)	Total	Prevalence OR (95%CI)
US-born	1710 (81)	771 (61)	2481	2.7 (2.3–3.2)
Any substance abuse [†]	1447 (69)	720 (57)	2167	1.6 (1.4–1.9)
Excessive alcohol use	1149 (55)	608 (48)	1757	1.3 (1.1–1.5)
Non-injection drug use	799 (38)	353 (28)	1152	1.5 (1.3–1.8)
Injection drug use	233 (11)	119 (9)	352	1.2 (0.9–1.5)
Incarcerated at diagnosis	162 (8)	116 (9)	278	0.8 (0.6–1.1)
Clinical characteristics				
AFB smear-positive	1317 (63)	781 (62)	2098	0.9 (0.8–1.1)
Cavitary disease	732 (35)	399 (35)	1131	1.1 (0.9–1.3)
HIV-positive result	383 (18)	192 (15)	575	1.3 (1.1–1.6)
Previous TB	149 (7)	57 (5)	206	1.6 (1.2–2.2)
INH resistance	130 (6)	87 (7)	217	1.1 (0.9–1.5)
MDR-TB	24 (1)	13 (1)	37	1.1 (0.6–2.2)
Treatment completion within a year [‡]	1436 (68)	822 (65)	2258	0.8 (0.7–1.0)

*TB genotype results were available for 3356 of the 3942 homeless TB patients diagnosed with TB in 2004–2010. Cluster was defined as ≥ 2 TB cases in the same county with indistinguishable genotype patterns (i.e., matching spoligotype and 12-locus mycobacterial interspersed repetitive unit–variable number tandem repeats).

[†]Any substance abuse was defined as self-reported excessive alcohol use or injection/non-injection drug use during the year before diagnosis.

[‡]For the years 1994–2008, most recent year for which data are available. Among persons who were alive at diagnosis and began anti-tuberculosis treatment; excludes cases with unknown or missing information for reason treatment was stopped.

TB = tuberculosis; OR = odds ratio; CI = confidence interval; AFB = acid-fast bacilli; HIV = human immunodeficiency virus; INH = isoniazid; MDR-TB = multidrug-resistant TB.

documented as having completed anti-tuberculosis treatment.

Tuberculosis genotype clustering as a marker for transmission

Of 52 225 TB cases with genotype results from 2004 to 2010, 3356 (6%) were in homeless persons. Among homeless TB patients, the odds of being in a county-based genotype cluster was 2.5 times greater (95%CI 2.3–2.7) than the corresponding odds among non-homeless TB patients (63% vs. 40%). Compared with homeless persons who were not in TB genotype clusters, a greater proportion of homeless persons in TB genotype clusters were US-born or HIV-infected, substance abusers or had a previous history of TB (Table 2). In the 114 county-based clusters during 2005–2007 and 111 clusters during 2008–2010 with a LLR ≥ 10 , the average proportion of homeless cases was 19% and 20%, respectively.

DISCUSSION

Although the number of TB cases among persons experiencing homelessness decreased between 1994 and 2010, the proportion of total TB cases that occurred among homeless persons remained stable, at 6%, and they were disproportionately represented in genotype clusters that suggested local transmission. Furthermore, the annual TB incidence associated with homelessness was approximately 10-fold the rate in the general population (i.e., an estimated 36–47/100 000 homeless

persons for 2006–2010, in contrast to the overall TB incidence rate of 3.6/100 000²⁰), which empirically supports the perception that homeless individuals had a higher TB burden.

Mirroring the trend in the overall epidemiology of TB in the United States, foreign-born persons constitute an important and growing proportion of homeless persons with TB (Figure).^{26,27} However, with the exception of race, ethnicity and age group, foreign-born homeless TB patients were often more similar to their US-born homeless counterparts than to other foreign-born TB patients, particularly with regard to treatment completion and substance use (Table 1). A recent study among homeless persons in Boston highlights drug overdose as a growing cause of death in this population.²⁸

Addressing TB among homeless persons represents both one of our greatest challenges and opportunities in achieving our national goal of TB elimination.²⁹ The areas where the demographic characteristics of homeless TB patients do not align with those of the general population of homeless in the United States^{21,23} suggest that additional risk factors, such as recent incarceration, are particularly conducive to TB, but also that certain other factors might be protective. These differences can assist TB control programs in developing interventions for those individuals at highest risk for TB. For example, one notable finding is the very small number of homeless children diagnosed with TB despite the fact that 20% of the homeless population is reported to be aged <18 years.²¹

Children experiencing homelessness may be protected from TB exposure through a different experience with the shelter system, such as separate sleeping areas for youth and families with children, thus reducing potential TB exposure associated with overcrowding.

Our TB genotyping findings are consistent with recent analyses that have shown that TB genotype clusters with fewer patients are more likely to grow into large outbreaks when one of the initial patients in the cluster is homeless.¹¹ The risk factors of US birth, male sex, racial/ethnic minority and substance abuse have been found to be associated with greater TB transmission among homeless persons.³⁰ We found that homeless TB patients had over twice the odds of living in a county with at least one other TB case with a matching genotype, suggesting more local transmission than was seen among non-homeless counterparts. Homeless persons were also overrepresented in the country's statistically most worrying genotype clusters: they comprised 19–20% of those clusters despite comprising only 6% of the overall TB cases reported for 2005–2010.

There are a number of limitations to this study. We were unable to calculate a separate TB incidence rate for foreign-born persons because HUD's Annual Homeless Assessment Reports,^{21,23} which we used to estimate homeless population denominators, do not collect information on country of origin. While the definition of homelessness is standardized for national TB surveillance purposes, the definition might still be applied differently across TB reporting jurisdictions. Our surveillance system does not capture history of incarceration among all homeless TB patients. We may therefore be underestimating TB transmission among this highly mobile population. In addition, HUD's national population estimates of sheltered homeless persons exclude those who do not seek any shelter-based services during the year (e.g., persons exclusively living in places not meant for human habitation or who are staying with family or friends), thus potentially underestimating the true number of unhoused or unstably housed persons. The proportion of homeless persons that fall into this latter category is unknown, but to the extent that they are missed, our estimated TB rates are inflated. However, it is unlikely that the 10-fold increase that we found is solely due to such methodological factors. The ability to detect genotype clusters is dependent upon adequate genotype surveillance coverage. Although 89% of culture-positive TB cases had corresponding genotype results in 2010, coverage was as low as 51% in 2004, when the United States began to offer universal TB genotyping services.²⁴

As the overall number of TB cases continues to decline nationally,²⁰ the case rate in homeless individuals remains unacceptably high. Available data did not allow us to ascertain the timeliness of TB diagnosis

among persons experiencing homelessness. However, the odds of having acid-fast bacilli smear-positive or cavitary TB disease were higher among homeless persons, suggesting more infectious disease, possibly due to delayed diagnosis and treatment. Homeless shelters, which are conducive to crowding and house populations with increased risk of advanced TB disease, are prime settings for TB transmission.¹⁸ TB screening before admission to shelters may reduce the risk of TB transmission in homeless shelters and facilitate treatment for homeless TB patients. Furthermore, identification and treatment of homeless persons with latent tuberculous infection (LTBI) provides an opportunity to prevent future cases in this population and potential cost savings for health jurisdictions.³¹ Ultimately, addressing LTBI may have the greatest impact on reducing TB disease burden within this high-risk group. A new LTBI treatment regimen that reduces the treatment time from 9 to 3 months might increase LTBI treatment success among the often transient homeless population.³²

Acknowledgement

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Conflict of interest: none declared.

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R É S U M É

OBJECTIFS : Décrire les personnes sans abri où le diagnostic de tuberculose (TB) a été porté pendant la période 1994 à 2010 et estimer un taux d'incidence de la TB parmi des sujets sans abri aux États-Unis.

MÉTHODES : On a analysé les cas de TB signalés au système national de surveillance de la TB en fonction de leur lieu de naissance. Les taux d'incidence ont été calculés au moyen des estimations de population sans abri du Department of Housing and Urban Development des États Unis. L'analyse des résultats génotypiques a permis d'identifier le regroupement en grappes comme marqueur de transmission parmi les patients sans abri atteints de TB.

RÉSULTATS : Sur 270948 cas de TB déclarés, 16527 (6% des patients) étaient sans abri. Le taux d'incidence

de la TB chez les sujets sans abri varie entre 36 et 47 cas pour 100 000 habitants en 2006–2010. Chez les patients TB sans abri, le risque de non-achèvement du traitement et celui d'appartenir à une grappe génotypique sont plus que doublés. Les patients sans abri nés aux États-Unis ou à l'étranger connaissent un risque d'être drogués accru respectivement de 8 et 12 fois.

CONCLUSIONS : Par comparaison avec la population générale, les sujets sans abri connaissent une augmentation d'environ 10 fois de l'incidence de la TB, sont moins susceptibles d'achever le traitement et plus susceptibles d'utiliser des drogues. La communauté de santé publique devrait cibler la population sans abri afin de réduire l'excès de fardeau de la TB dans cette population.

R E S U M E N

OBJETIVOS: Describir los casos de tuberculosis (TB) que se notificaron en personas sin domicilio fijo entre 1994 y el 2010 y calcular la tasa de incidencia de TB en las personas sin vivienda en los Estados Unidos.

MÉTODOS: Los casos de TB notificados al Sistema Nacional de Vigilancia de la Tuberculosis se analizaron en función del lugar de nacimiento. Se calcularon las tasas de incidencia a partir de las estimaciones de poblaciones sin vivienda del Department of Housing and Urban Development de los Estados Unidos. Los análisis de los resultados de la genotipificación revelaron conglomerados que constituyen un marcador de transmisión en la población de pacientes tuberculosos sin vivienda.

RESULTADOS: De los 270948 casos de TB notificados, 16527 eran personas sin vivienda (6%). La tasa de incidencia en las personas sin domicilio osciló entre 36 y

47 casos por 100000 personas entre el 2006 y el 2010. Los pacientes tuberculosos sin vivienda exhibían una posibilidad dos veces mayor de no completar el tratamiento y de formar parte de un conglomerado genotípico. Los pacientes tuberculosos y sin vivienda nacidos en los Estados Unidos y nacidos en el extranjero presentaban probabilidades de 8 a 12 veces superiores de abuso de sustancias ilícitas.

CONCLUSIÓN: En comparación con la población general, las personas sin domicilio fijo exhibieron una incidencia de TB cerca de 10 veces superior, presentaban menos probabilidad de completar el tratamiento y con mayor frecuencia consumían sustancias ilícitas. Las iniciativas de extensión de salud pública se deben dirigir a las poblaciones sin vivienda, a fin de disminuir el exceso de la carga de morbilidad por TB que las aqueja.