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Prevalence of tuberculosis and risk of pulmonary tuberculosis in close contacts of patients in a penitentiary center in the municipality of Palmira, Colombia

Prevalencia de tuberculosis y riesgo de tuberculosis pulmonar en contactos estrechos de pacientes en un centro penitenciario del municipio de Palmira, Colombia

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Abstract

Introduction: Latent tuberculosis in penitentiary institutions is more frequent. Factors such as overcrowding, malnutrition and limited access to health services increased the risk of reactivation, transmission and poor prognosis.

Objective: To determine the prevalence of latent tuberculosis infection and describe risk factors associated to inmates of a prison.

Methods: Multi-method Operational Research. Cross-sectional study. Prospective follow-up was carried out through the epidemiological surveillance records of the TB control program to determine the prevalence of Pulmonary tuberculosis in the following two years, and risk factors for developing pulmonary tuberculosis in the population of inmates.

Results: Of 2,837 inmates incarcerated (2015-2016), 10.0% were close contact of patients with pulmonary tuberculosis. Overall prevalence of TST positivity was 90.7%, and 92.5% in the population with BCG scar. When were compared to population of inmates + vs population of inmates - groups, those inmates allocated in yard #1 were more likely to be TST+ (p = 0.008). When comparing the groups latent vs active TB, statistical significance was found with having a BMI less than or equal to 18.5 (p = 0.027), OR 5.385 (CI 1.016-28.53). The indirect follow-up through surveillance records showed nine inmates tuberculosis 2 years after the initial diagnosis.

Conclusion: The prison permit concentrate and magnifies determinants that favor the tuberculosis transmission and development to active tuberculosis, which demands strategies for tuberculosis prevention, humanization of the conditions of the population of inmates, and improvement of the health condition.

Resumen

Introducción: La tuberculosis latente en instituciones penitenciarias es más frecuente. Factores como hacinamiento, desnutrición y acceso limitado servicios de salud elevan el riesgo de reactivación, transmisión y mal pronóstico.

Objetivo: Determinar la prevalencia y los determinantes de infección latente y desarrollo de tuberculosis pulmonar en un centro carcelario de Palmira, Colombia.

Métodos: Investigación Operativa multimétodo. Estudio de corte transversal. Se realizó un seguimiento prospectivo a través de los registros de vigilancia epidemiológica del programa de control de tuberculosis para determinar la prevalencia de tuberculosis Pulmonar en los siguientes dos años, y factores de riesgo de desarrollar tuberculosis pulmonar en población privada de la libertad.

Resultados: De 2,837 internos recluidos (2015-2016), 10.0% fueron contacto estrecho de pacientes con tuberculosis pulmonar, la prevalencia de positividad general de PPD 90.7% y en población con cicatriz de BCG fue 92.5 %. Al comparar los grupos PPD+ vs PPD- las variables significativas fueron reclusión en patio uno (p= 0.008). Al comparar tuberculosis latente vs tuberculosis activa el IMC ≤18.5 fue significante (OR 5.385; IC: 1.016-28.53; p= 0.027); el seguimiento epidemiológico en los siguientes dos años identificó que nueve internos desarrollaron tuberculosis pulmonar activa.

Conclusión: La cárcel concentra y magnifica los determinantes que favorecen la presencia de la trasmisión de tuberculosis, el desarrollo a tuberculosis activa, lo que demanda estrategias de prevención de la tuberculosis, humanización de las condiciones de la población privada de la libertad, y mejoramiento de la oferta en salud de manera prioritaria, oportunas y constante.

Key study facts

Objective	To determine the prevalence and determinants of latent infection and the development of pulmonary tuberculosis in a prison in Palmira, Colombia.
Study design	Multi-method Operations Research
Source of information	Registry of the tuberculosis program of Palmira. Reports from sanitation personnel and yard leaders. Medical records
Population/sample	2,837 individuals were evaluated and 293 records were analyzed.
Statistical analysis	Descriptive statistics were applied using the Shapiro-Wilk, Chi-square and Mann-Whitney statistical tests. The frequency of overall PPD positivity was calculated as a ratio. Association measures OR (95% CI) were calculated. ARTI = 1 - (1-p)1/a, where P is the prevalence of positive PPDs per yard and a is the mean age of the tested cohort per yard.
Main findings	Overcrowding, barriers to health care services, biological and social vulnerability and the high burden of disease present in prison settings increase the risk of TB transmission and the generation of epidemics, converting these scenarios into a focal point of infection that enhances and perpetuates the risk of disease transmission..

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Introduction

In 2017, the WHO reported 10.4 million cases of tuberculosis and 1.6 million deaths from this cause (1). The disease is transmitted mainly by the aerogenous route and the pulmonary presentation is the most frequent with three main phases: primary infection, latent infection and active infection (2). The main risk factors are associated with clinical comorbidities related to immunocompromise, adverse social conditions associated with poverty, and limitations in access to health services (3,4).

The conditions of overcrowding, malnutrition, drug dependency and deficiencies in the supply of health services make the population deprived of liberty a highly vulnerable group. Prisoners become infected and sick with tuberculosis more often than the general population with the incidences reported being greater than 2,000 cases/100,000 inmates, exceeding those of the general population up to 52 times (5-8).

Given the complexity of the transmission of tuberculosis in prisons, the control of the transmission of the disease requires timely evaluation of respiratory symptoms, comprehensive access to health services, efficient treatment and follow-up of positive cases and the timely identification of cases of latent tuberculosis among contacts who should receive prophylactic treatment (5,9,10).

The prison situation in Colombia is precarious. With high rates of overcrowding that exceed 50%, barriers to access to health services, high consumption of psychoactive substances, comorbidities such as HIV/AIDS and malnutrition. These are all conditions that lead to the development and perpetuation of tuberculosis (11-15). Imprisoned patients become potential sources of infection for the population deprived of liberty and the general population(3-4). In 2017, 987 cases of tuberculosis of all forms were reported in the country in the population deprived of liberty, which represented an incidence of 800 cases/100,000 prisoners (16).

During 2015 and 2016, the prison in the municipality of Palmira reported a 50% increase in the number of tuberculosis cases with respect to 2014. Given this alarming situation, it was necessary to evaluate the dynamics of tuberculosis transmission, the frequency of latent tuberculosis and to identify the factors related to the development of latent lung disease, including disease prevention and control strategies in the second prison center of the Valle del Cauca department.

The objective of this study was to determine the prevalence of latent tuberculosis and to identify the risk of developing active pulmonary tuberculosis in the population deprived of liberty (as close contacts of a case of confirmed pulmonary tuberculosis), in a prison center in Palmira, Colombia.

Methods

Study area and population

The study was carried out in the penitentiary and prison establishment of the high- and medium-security prison in Palmira, Colombia. There were 2,837 inmates reported during the study period: of these, 293 inmates were confined in patios one, two and three and were all classified as close contacts of patients with active pulmonary tuberculosis. Close contact was defined as any subject sharing a closed space for prolonged periods of at least six hours for at least three months (17).

Inclusion criteria

Adult men without respiratory symptoms, deprived of liberty in the Palmira Penitentiary classified as close contacts with a case of active pulmonary tuberculosis, and who voluntarily accepted the application of the PPD and attended the medical consultation.

Exclusion criteria

Inmates with a history of tuberculosis or who had received immunosuppressive treatment or the administration of live (measles, mumps, influenza) or attenuated (rubella, chickenpox) vaccines in the four weeks prior to the application of PPD.

Design

An operational investigation was carried out to identify and intervene in the population deprived of liberty at risk of tuberculosis transmission, framed within the collective intervention plan of the 2017 tuberculosis control program of the Municipality of Palmira, Colombia.

To identify the prevalence of latent tuberculosis in the population deprived of liberty who were identified as close contacts of cases of pulmonary tuberculosis, a cross-sectional descriptive observational study was carried out. To assess risk factors for latent tuberculosis, a case-control analysis was performed comparing demographic, clinical and social characteristics of those with positive PPD and negative PPD. To determine the risk of developing pulmonary tuberculosis in close contacts evaluated with PPD, a prospective follow-up was carried out during the following two years, through the epidemiological surveillance records of the Palmira tuberculosis control program.

Procedures

The population deprived of liberty of the penitentiary and prison establishment of high- and medium-security prison of Palmira that had a confirmed diagnosis of pulmonary tuberculosis during 2015 was identified from the registry of the tuberculosis program of Palmira. Through the health personnel and the leaders of each yard, the population of inmates who were close contacts of a case of pulmonary tuberculosis during 2015 were identified.

Once the close contacts were identified for each yard, they were invited to participate. The volunteer participants underwent medical consultation to assess the presence of respiratory symptoms and identify their medical history. The application of the PPD was carried out by two nurses, two nursing assistants and two doctors trained in the application and reading of the PPD.

For the test, 0.1 ml of PPD TUBERCULIN MAMMALIAN, manufacturer: BB-NCIPD LTDA Sofia, Bulgaria, lot n° P3511, was used, according to the guidelines of the CDC protocol (18). The

reading was made at 48 and 72 hours after administration and the induration was measured in mm by two evaluators independently. When there was a difference of greater than 5 mm between evaluators, a third evaluator resolved the discrepancy. A diameter greater than 10 mm in people not infected with the human immunodeficiency virus (HIV) and 5 mm in people infected with HIV was taken as the cut-off point for PPD positivity.

All participants with positive PPD results were referred to a medical consultation to define the start of chemoprophylaxis according to the guidelines set forth in the external circular 007/2015 of the Colombian Ministry of Health and Social Protection. To identify which of the participants evaluated with PPD developed pulmonary tuberculosis, records from the municipality's tuberculosis program were consulted every six months for the next two years.

Data management

All participant information was entered into an electronic database. To determine the distribution of the numerical variables, the Shapiro-Wilk test was applied, with values of $p \leq 0.05$ being taken as significant. When the variables presented normal distribution, they were summarized through their average and standard deviation, otherwise, the median values and the interquartile ranges were used. Categorical variables were presented as proportions.

To evaluate the dependence between the exposure variables and the outcome variables, the Chi-square and Mann-Whitney tests were used. The frequency of overall PPD positivity was calculated as a ratio, taking the number of positive PPDs (>5 mm) as the numerator and the number of participants tested with PPD as the denominator.

To determine the annual risk of pulmonary tuberculosis infection in PPL, an exposure from birth to the time of evaluation was assumed and calculated through the formula: ARTI = 1 - (1-p) 1 / a, where P is the prevalence of positive PPDs per yard and a is the mean age of the cohort tested per yard.

The risk of developing pulmonary tuberculosis in the participants with positive PPD was calculated as an incidence and the possible determinants were estimated through the calculation of the OR with its respective confidence interval.

All analyzes were performed with the Stata® statistical package (Stata Corp., 2011, Stata 12 Base Reference manual, College Station, TX, USA).

Ethical considerations

This study was approved by the Ethics Committee of the Universidad Libre (Free University) and the National Penitentiary and Prison Institute, as a minimal risk investigation. We highlight the nature of Operational Research, within which this research resides, due to the prevention and control actions carried out by the Palmira Colombia tuberculosis control program. All the people voluntarily consented to the application of the PPD, the respiratory symptoms were evaluated by doctors trained in tuberculosis and those who were diagnosed with tuberculosis received anti-tuberculosis treatment.

Results

During 2015, the Penitentiary and Prison Establishment of the high- and medium-security prison of Palmira reported a population of 2,837 individuals deprived of liberty, which exceeds by more than double the official capacity for inmates, giving an overcrowding index of 212%. These inmates were either in the condition of having been accused of a crime or has been convicted with a median of 15 months in prison (IQR 8-38).

During this same year, 45 cases of active pulmonary tuberculosis were reported to the Palmira municipal tuberculosis control program, which indicates an incidence of 1,586 cases of tuberculosis per 100,000 PPL. These 45 cases of tuberculosis were identified, through contact tracing, giving 293 close contacts for an index of 7 contacts for each case of pulmonary tuberculosis. All were evaluated by the medical service and PPD was applied.

The median age of the patients evaluated with PPD was 31 years (IQR 24-35). Those under the age of 29 were the most frequent age group, 74% of those evaluated reported not having health insurance and 22.2% came from other departments. Regarding schooling, 88% reported having some degree of schooling, with 85.6% completing primary school, and only one reported having completed higher education.

The prevalence of overall PPD positivity in close contacts was 90.7% and in the BCG scar population, it was 92.5%. There were no PPD results between 5 to 10 mm in the five HIV patients. When evaluating the prevalence of positivity for each of the three patios, it was found that it ranged between 86% and 100%. In Patio One, 107 close contacts were identified, corresponding to 14% of the inmates (107/767): of these, 86% had a positive result for PPD, contributing 34.4% of the global prevalence. In Patio Two, 121 close contacts were identified, corresponding to 17% of the inmates (121/697): of these, 90.9% had a positive result, contributing 41.5% of the global prevalence. Patio Three presented a prevalence of 100% with 64 close contacts, representing 23.9% of the global prevalence. In the PPD reading measurement, a median of 14.4 mm was presented for the reading at 48 hours and 13 mm at 72 hours.

The median age with positive PPD was 29 years (IQR 24-65) with no statistically significant differences with respect to negative PPD ($p= 0.493$). The median time of imprisonment for positive PPD was 24 months and for positive PPD negative was 14 months: there were, however, no statistical differences ($p= 0.116$). There was no evidence of dependence between behavioral factors such as consumption of liquor, cigarettes or psychoactive substances and having a positive PPD. The only significant variable was having been confined to Patio One ($p= 0.008$) (Table 1).

Regarding the annual risk of tuberculosis infection for the three evaluated patios it was 2.99%, in Patio One it was 0.99% and for patios Two and Three it was 1.00% (Table 2).

Of the 293 participants evaluated with PPD, via the epidemiological surveillance records of the Palmira tuberculosis control program,

Table 1. Clinical and demographic characteristics of the study population with latent tuberculosis by comparison group

Caracteristic	Description	Positive PPD	%	Negative PPD	%	P - value
		n= 267	91.1	n= 26	8.9	
Age (Median (IR))		29	24-65	29	24-65	0.523*
Originating from a department of High Load	YES	248	92.5	23	88.4	0.212
	NO	19	7.1	3	11.5	
Assurance	YES	72	95.7	2	4.3	0.011
	NO	195	94.7	24	5.3	
Time of detention (months)	≥12	147	55.0	18	69.2	0.085
	< 12	120	44.0	8	30.7	
Patio	1	92	86.1	15	13.9	0.008
	2	111	90.9	11	9.1	
	3	64	100.0	0	0.0	
BMI	< 8.5	11	4.1	2	7.7	0.721
	≥18.5	256	95.9	24	92.3	
HIV	YES	5	1.9	0	0.0	0.928
	NO	262	98.1	26	100.0	
Diabetes	YES	16	6.0	2	7.7	0.933
	NO	251	94.0	24	92.3	
Asthma	YES	22	8.2	4	15.3	0.3888
	NO	245	92.0	22	84.6	
Chronic Kidney Disease	YES	15	5.6	0	0.0	0.4385
	NO	252	94.3	26	100.0	
Cancer of any type	YES	12	4.5	0	0.0	0.5582
	NO	255	95.5	26	100.0	
Alcoholism	YES	125	46.8	13	50.0	0.916
	NO	142	53.1	13	50	
Cigarette (smoking)	YES	97	36.3	5	19.2	0.126
	NO	170	63.6	21	81.0	
Consumption of psychoactive substances	YES	186	69.6	15	57.6	0.302
	NO	81	30.3	11	42.3	

* Mann-Whitney.
RI: interquartile ranges
PPD: purified protein derivative

Table 2. Annual risk of tuberculosis infection in the Villa de las Palmas penitentiary in Palmira, Valle del Cauca 2015-1018.

Patio	Age Median	P	(1-P)	1/ age	ARTI1-(1-p)1/age
Patio 1	31	55.6%	0.141	0.0322	0.9954
Patio 2	32	92.8%	0.091	0.0310	0.9971
Patio 3	29.7	100.0%	0.000	0.0336	1
Total	31	82.8%	0.232	0.0968	2.99

ARTI: annual risk of tuberculosis infection

it was identified that in the following two years, at least nine (3%) participants of the 267 who had positive PPD results were reported to the Palmira tuberculosis control program with a diagnosis of pulmonary tuberculosis.

The median age of the nine participants who were identified as having pulmonary tuberculosis was 31 years, and the only risk factor in the participants with a positive PPD result for developing active pulmonary tuberculosis was having a BMI less than 18.5 at the time of evaluation. of the PPD, with an OR of 5.385 CI 95% 1.016-28.53 (p= 0.027) (Table 3).

Discussion

This research provides important information on the prevalence of latent tuberculosis and the dynamics of transmission in a prison institution in Palmira, Colombia. This is the first investigation carried out in a population deprived of liberty including identified close contacts with tuberculosis in Palmira, Colombia, through which we were able to determine the prevalence of latent tuberculosis through the PPD test.

We evaluated the most frequently reported risk factors in the scientific literature for latent tuberculosis and the annual risk of tuberculosis infection was also determined in the patios that reported close contacts of pulmonary tuberculosis. We also used the incidence of Pulmonary tuberculosis reported to the Palmira tuberculosis control program during two years of follow-up.

We report a prevalence of general PPD positivity of 91.0%. These findings are higher than estimates by the WHO, which suggest that one-third of the population is infected by Koch's bacillus (19). The evidence in Colombia shows that, measured through PPD, the prevalence of latent tuberculosis in the general population is 42.7%, while in contacts of patients with active tuberculosis it is 65.9% (20). In populations with pre-existing conditions such as diabetes, the prevalence is at least 35%.

Table. 3. Clinical and Demographic Characteristics of the Study Population with Active Tuberculosis by Comparison Group

Caracteristic	Description	TB latent n= 258	%	TB Active n= 9	%	OR	IC	p value
Age	Years (median IQ)	29	24-35	31	26.5-35.5	-		0.493*
Assurance	Contributive	6	2.3	0	0.0	-		0.4957
	Subsidized	36	13.9	3	33.3	3.083	0.738-12.88	0.2559
	UP	216	83.7	6	66.6	0.3889	0.093-1.616	0.3732
Time of Reclusion (months)	< 12	103	40.0	2	22.2	0.4312	0.088-2.111	0.4706
	>12	155	60.0	7	88.8			
Patio	1	106	41.0	1	11.0	0.1792	0.022-1.454	0.1450
	2	118	45.7	4	44.4	1.037	0.272-4.188	0.7727
	3	60	23.2	4	44.4	2.64	0.6871-10.14	0.2876
BMI	<18.5	13	5.0	2	22.2	5.385	1.016-28.53	0.0277
	>18.5	245	94.9	7	88.8			
Alcohol	YES	92	35.6	4	44.4	1.443	0.378-5.508	0.8520
	NO	166	64.3	5	66.6			
Smoking	YES	102	39.5	5	66.6	1.012	0.515-7.288	0.5365
	NO	156	60.4	4	44.4			
HIV	YES	5		0				0.4070
	NO	253		9				
Diabetes Mellitus	YES	16		1		1.891	0.226-16.06	0.9192
	NO	242		8				
Cancer of any type	YES	12		1		2.563	0.291-22.71	0.9224
	NO	246		8				
Chronic Kidney Disease	YES	15		0		-		0.9934
	NO	243		9				

*Mann-Whitney
TB: tuberculosis
UP: uninsured population

Regarding the prevalence of latent infection in the population deprived of liberty, this has been reported at 50.4% in Spanish prisons (21) and in Colombian prisons, it is 20 times higher than that of the general population (22). Regarding the annual risk of tuberculosis infection (ARTI) in the Palmira prison, this was 3.99%, an intermediate value compared to that reported in other Colombian prisons, which ranges between 2.73% and 5.09% (23).

The risk factors for latent tuberculosis described in this study were mainly the index of overcrowding, which was reported in 212%, the length of confinement and the origin of areas with a high incidence of tuberculosis. This is in agreement with the risk factors reported in the literature which identifies overcrowding, the high incidence of pulmonary tuberculosis and the presence of previous comorbidities. Other reported determinants were poor health services, having a history of previous incarceration and lack of screening in the general population for respiratory symptoms (21,23).

Although we found a high prevalence of PPD (91%), this figure could be underestimated given that it was not possible to carry out the second evaluation of PPD, due to the non-availability of the tuberculin protein derivative from the municipal health secretary. This unavailability, which was unfortunate, was due to the fact that the only derivative available was from Itagüí and Bucaramanga, Colombia, where the second PPD evaluation after one or three weeks adjusted to the previous positivity of 77.6% to 11%(23).

Although PPD screening for latent tuberculosis is not recommended in settings with a high incidence of tuberculosis, it is important to screen PPL on admission to prison and annually, as well as all workers in these prison sites. According to the indications for tuberculosis care in prisons from the WHO, and because of the high incidence of PPD, the initiation of treatment is recommended for latent tuberculosis. Screening with PPD allows the identification of recent conversion (if the screening criteria are met at the beginning of imprisonment and annually during the length of stay) and therefore a high risk of active tuberculosis. This is critical to impact the prevention of early transmission within prisons and in the general population (24).

Regarding the follow-up of the 267 individuals from within this population deprived of liberty who had a positive PPD, epidemiological records showed that nine people developed tuberculosis in the following two years, which indicates a positivity of 3.4%. It should be emphasized that the follow-up strategy, using the epidemiological registry and only including local information, leads to underreporting.

The rapid progression to active disease and the presence of being asymptomatically respiratory at the time of evaluation indicates that latent tuberculosis may possibly have been present at the time of incarceration(25). It is estimated that the risk of developing Mycobacterium tuberculosis infection ranges between 10 and 15% in the general population, while the incidence rate of latent tuberculosis in the general population ranges between 61.76% in Brazil and between 5.03 and 83.74% in the United States.

The reported PPD conversion rate for US prisons has been reported as 3.8% in low tuberculosis incidence states, 4.9% in medium tuberculosis incidence states, and 8.3% in high tuberculosis incidence states (24-28). As factors related to the conversion of latent tuberculosis to active tuberculosis, we only report statistically significant evidence: having been hospitalized in a high transmission patio (Patio one) and having a BMI below 18.5. In a study from Maryland, USA, the most significant variable relating to PPD conversion was the population density in the prison at the time of the study (29,30).

These findings regarding the high prevalence of latent infection in the prison population of Colombian prisons compared to prisons in developed countries, and even more so compared to the general population, are an important indicator of the unsanitary conditions and overcrowding that favor the high transmission of tuberculosis in Colombian prisons. This can be confirmed by measuring the ARTI in this population.

Guidelines need to be established as a priority for this population, which could benefit from an adequate assessment upon admission by personnel trained in the management of tuberculosis to identify respiratory symptoms or signs of active tuberculosis disease and the application of PPD for screening and identification of latent tuberculosis.

A positive PPD result combined with exposure risk assessment, history of incarceration, contact with a tuberculosis cases, history of prior tuberculosis, and/or a body mass index less than 18.5 kg/cm2 should require to a follow-up including clinical control appointments within the penitentiary including microbiological evaluation for tuberculosis. Every inmate with a negative tuberculin test upon entering the prison should be followed up every year in order to identify who requires treatment for latent tuberculosis.

The main limitation of this study lies in the fact that the risk of developing pulmonary tuberculosis was not determined in the population evaluated with PPD in the following two years. This was due to the administrative policies of the prison, the transfer of inmates to other prisons in the country and the release of inmates who move to other regions, all of which prevented the researchers from carrying out a strict follow-up of the population at risk. The incidence reported herein is therefore only declared in people who were reported to the Palmira tuberculosis program.

It was also not possible to evaluate the booster effect of negative PPD tests in vaccinated and elderly patients. Given the high prevalence of latent tuberculosis and the low frequency of people belonging to this age group, however, the probability of false negatives is significantly reduced.

Conclusions

Overcrowding, barriers to health care services, conditions of biological and social vulnerability and the high burden of disease present in prison settings increase the risk of TB transmission and the generation of epidemics, making these scenarios a focal point for infection that enhances and perpetuates the risk of disease transmission.

In confined settings, with a high rate of overcrowding and a high burden of tuberculosis, exposure to the disease tends to equalize the risk of transmission across all population groups exposed to these conditions. Health interventions are thus required to prevent and control tuberculosis in prison settings, which must be carried out constantly throughout the PPL.

Study Limitations

The main limitation of this study was the subjective way of classifying close contacts of the index cases of active pulmonary tuberculosis. This could lead to misclassification and consequently to either an underdiagnosis or a selection bias in the study population. Additionally, the epidemiological follow-up of the records of PPL who developed tuberculosis after leaving prison was limited to those who lived in Palmira, which could have led to a possible surveillance bias due to a lack of access to information.

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Conflict of interest

The authors of this work declare that they have no conflict of interest

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