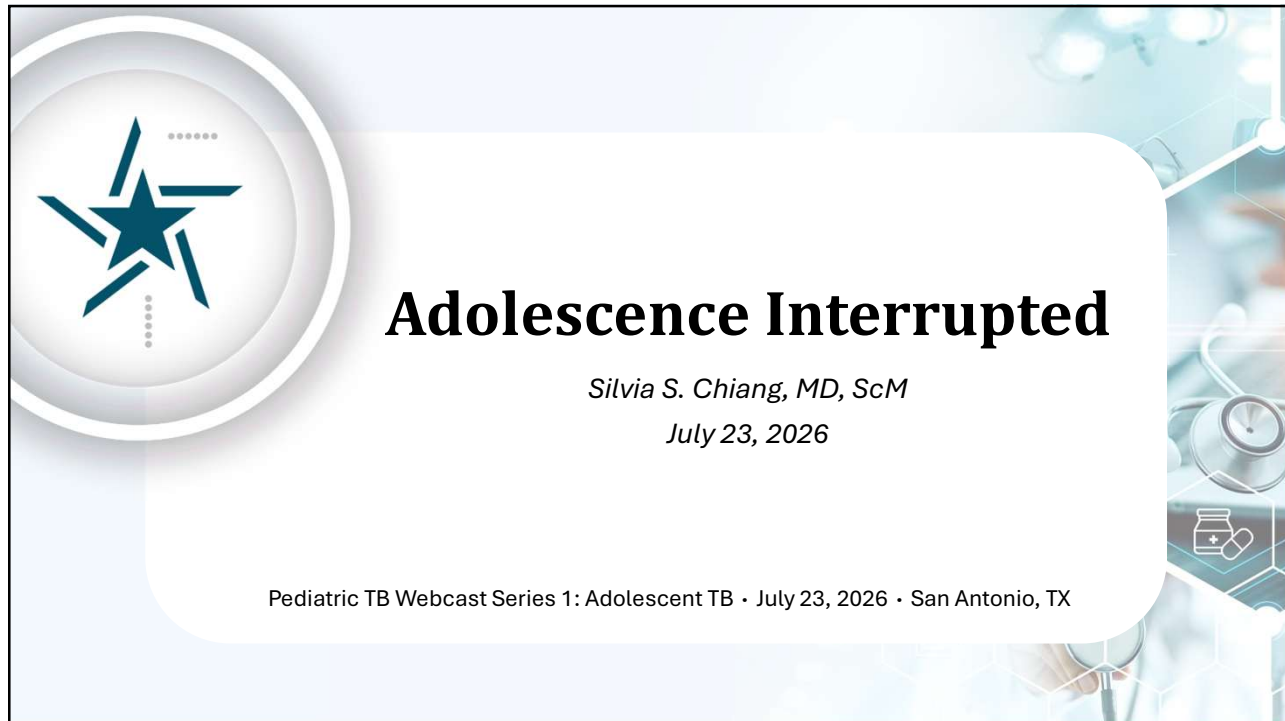
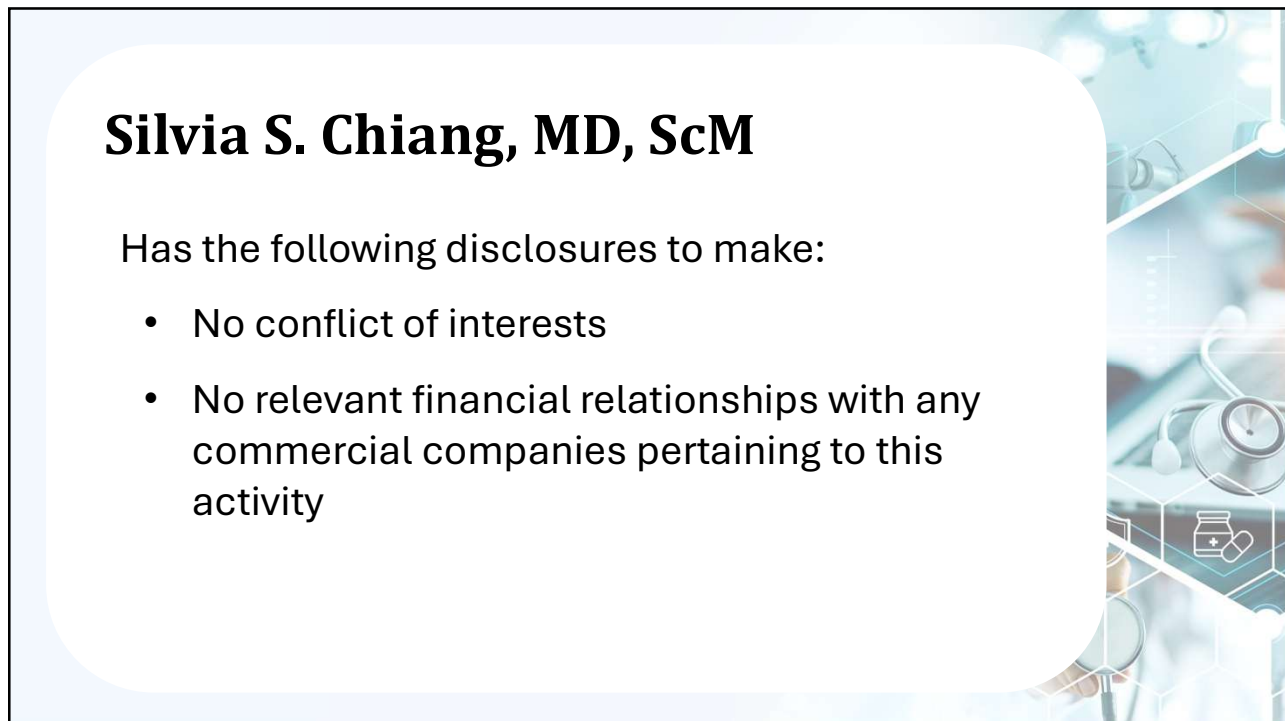




1



2

ADOLESCENCE INTERRUPTED

The Impact of Tuberculosis on Teens

Silvia S. Chiang, MD, ScM

Associate Professor of Pediatrics

July 2026

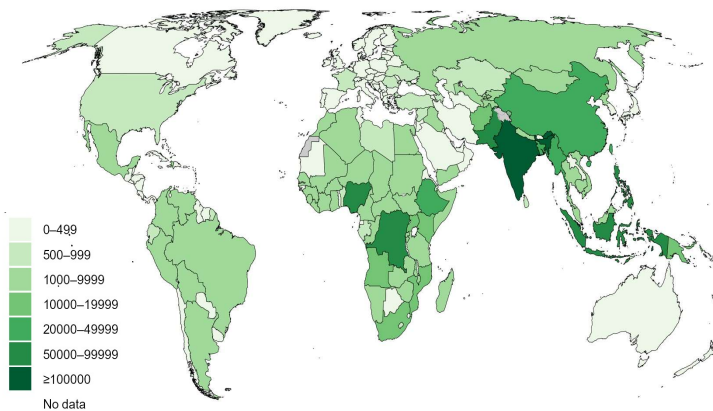


THE WARREN ALPERT
Medical School
BROWN UNIVERSITY

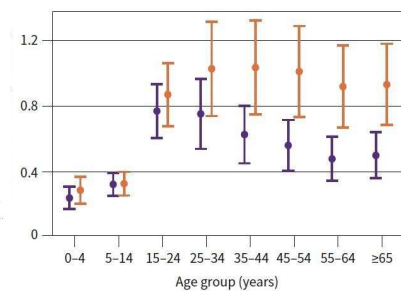
3

EPIDEMIOLOGY OF ADOLESCENT TB

ESTIMATED 1.065 MILLION INCIDENT CASES IN 10- TO 19-YEAR-OLDS IN 2024



GLOBAL TB INCIDENCE BY AGE AND SEX (FEMALE AND MALE), 2024



Sekadde M, et al. Lancet Child Adol Health, 2026.
WHO. Global TB Report, 2025.

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4

OBJECTIVES

1. Describe how TB illness and treatment impact each aspect of adolescent development
2. Propose approaches to optimize care for adolescents undergoing evaluation or treatment for TB

PHYSICAL



EDUCATIONAL



SOCIAL



PSYCHOLOGICAL



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IMPACT OF TB ON ADOLESCENT DEVELOPMENT

PHYSICAL



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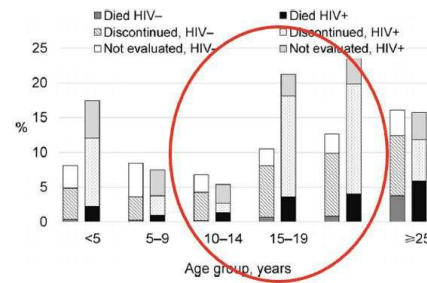
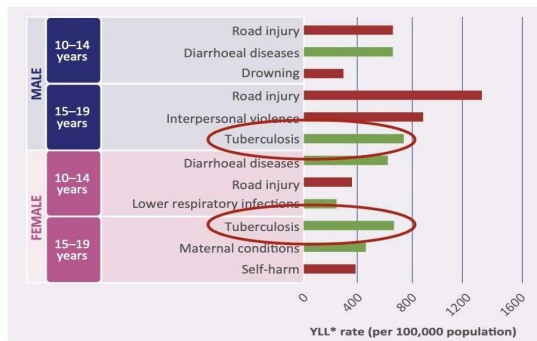


6

MORTALITY

PRIMARY REASON: DISENGAGEMENT

LEADING GLOBAL CAUSES OF ADOLESCENT DEATH, 2019



Western Cape,
South Africa,
2013



The Philippines,
2015

Snow KJ, et al. Int J Tuberc Lung Dis 2017; 21: 651-657. * Snow KJ, et al. Western Pac Surveillance Response J 2018;9:16-20. * Guthold R, et al. J Adolesc Health 2021;69:540.

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COMMON BARRIERS TO ADHERENCE (ANALYSES OF NTP DATA)

Setting	Sample size	Age ≥15 years	HIV	Prior TB	Male gender	Pregnancy
Peru	251				✓	
Botswana	330		✓			
South Africa	23,737	✓	✓	✓	✓	
Brazil	725		✓	✓		
Brazil	2507					✓
European Union	38,054	✓				

Enane LA, et al. Int J Tuberc Lung Dis 2016;20:1320-1325. * Mulongeni P, et al. PLoS One 2019;14:e0210937. * Kohlenberg A, et al. Int J Tuberc Lung Dis 2020;24:347-352. * de Oliveira MCB, et al. Am J Trop Med Hyg 2020;103:2492-2500. * Chiang SS, et al. Int J Tuberc Lung Dis 2020;24:723-725. * Chiang SS, et al. Clin Infect Dis 2026;82:513-521.

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COMMON BARRIERS TO ADHERENCE (QUALITATIVE RESEARCH)

BMJ Open Adolescent, caregiver and provider perspectives on tuberculosis treatment adherence: a qualitative study from Lima, Peru
2023;13(5):e069938.

Silvia S Chiang^{1,2}, Liz Senador,³ Elmer Altamirano,³ Milagros Wong,³
Catherine B Beckhorn,³ Stephanie Roche,⁴ Julia Coit,³
Victoria Elena Oliva Rapoport,⁵ Leonid Lecca,^{3,6} Jerome T Galea⁷

BMJ Open Understanding the relationship between adolescents with tuberculosis and health services: an indepth qualitative study from Cape Town
2025;15(5):e094295.

Dillon Timothy Wademan¹, Graeme Hoddinott^{1,2}, Zara Kavalieratos,¹
Mfundo Mlomezale,¹ Arlene J Marthinus,¹ Lucia N Jola,¹ Stephanie Jacobs,¹
Khanyisa Msimeli,¹ James Seddon^{1,3}

- Facility-based DOT w/ limited hours: inconvenience, cost
- Symptom resolution
- Treatment fatigue
- Pill burden, esp. for TB-HIV or MDR-TB
- Adverse drug events , esp. for TB-HIV or MDR-TB

IN LIMA, ADOLESCENTS WHO OVERCAME BARRIERS HAD GREATER SUPPORT FROM PARENTS OR OTHER ADULT CAREGIVERS

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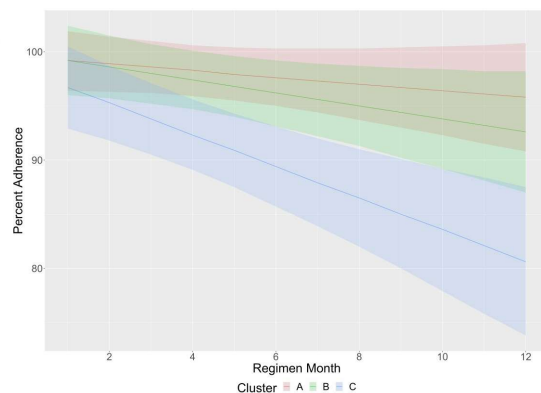
9

PLOS GLOBAL PUBLIC HEALTH 2024;4(2):e0002918.

RESEARCH ARTICLE

Identifying adolescents at risk for suboptimal adherence to tuberculosis treatment: A prospective cohort study

Silvia S. Chiang^{1,2*}, Joshua Ray Tanzer¹, Jeffrey R. Starke^{3,4}, Jennifer F. Friedman^{1,2},
Betsabe Roman Sinche⁵, Katya León Ostos⁶, Rosa Espinoza Meza⁶, Elmer Altamirano⁶,
Catherine B. Beckhorn⁵, Victoria E. Oliva Rapoport¹, Marco A. Tovar^{5,6}, Leonid Lecca⁵



Cluster C had aOR >5 of suboptimal adherence:

- Lower caregiver support score
- Lower support from friends
- Lower support from family members
- Lower frequency of being accompanied to clinic
- Higher ACE score

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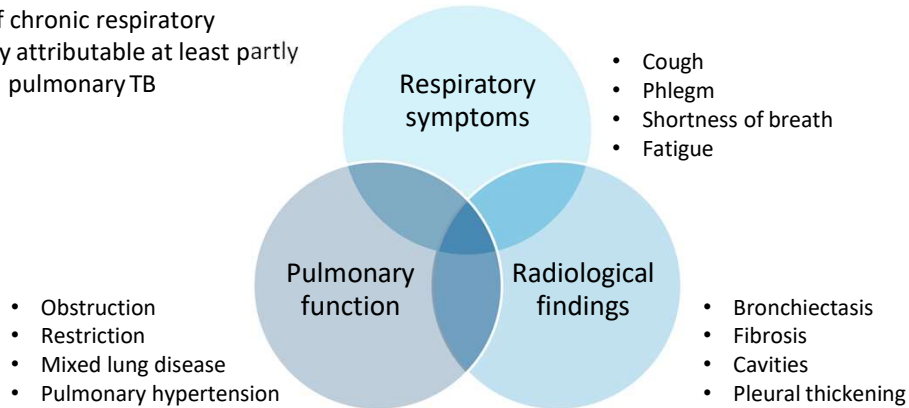
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10

POST-TB LUNG DISEASE

Evidence of chronic respiratory abnormality attributable at least partly to previous pulmonary TB



Bisson GP, et al. Lancet Infect Dis 2026;26:e315-e325.

9

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MORBIDITY: RESPIRATORY SEQUELAE / POST TB LUNG DISEASE

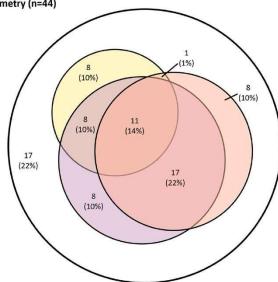
TWO CROSS-SECTIONAL STUDIES: 62-78% PREVALENCE OF PTLD, BUT NO CONTROL GROUPS

Post-tuberculosis respiratory impairment in Gambian children and adolescents: A cross-sectional analysis

Nkereuwem E, et al. Pediatr Pulmonol 2024;1-10.

- Any respiratory symptom present (n=28)
- Abnormal chest X-ray (n=37)
- Abnormal spirometry (n=44)

- 79 children and adolescents (median age 16, IQR: 12, 18)



UTLD OPEN 2(1):19-25
© 2025 The Authors <http://dx.doi.org/10.5588/ijtldopen.24.0039>

ORIGINAL ARTICLE

Post-TB sequelae in adolescent pulmonary TB survivors

C. Cesilia,^{1,2} F.R. Rinawan,³ P. Santos,⁴ H.M. Nataprawira¹

- 52 adolescents treated for DS- or DR-TB
- 35/52 (62%) had sequelae (persistent clinical symptoms, abnormal spirometry, abnormal CXR, or abnormal echo)

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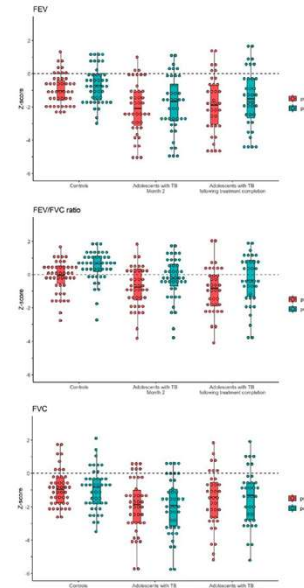
12

Impaired lung function in adolescents with pulmonary tuberculosis during treatment and following treatment completion

eClinMed 2024;67:102406.

Marieke M. van der Zaag^{a,c}, Vita W. Jongen^{a,b}, Ruon Swanepoel^c, Klassina Zimh^a, Brian Allwood^d, Megan Palmer^e, Rory Dunbar^e, Pierre Goussard^f, H Simon Schaaf^a, Anneke C. Hesselink^a and James A. Seddon^{a,f}

	Controls (n = 45)	Adolescents with tuberculosis	
		Month 2 (n = 42)	Following treatment completion (n = 37)
	n (%)	n (%)	n (%)
Abnormal lung function ^a	26 (58%)	32 (76%)	24 (65%)
Abnormal FEV ₁ ^b	11 (24%)	25 (60%)	21 (58%)
Abnormal FVC ^b	13 (29%)	23 (55%)	17 (46%)
Abnormal FEV ₁ /FVC ^b	3 (7%)	10 (24%)	12 (32%)
Obstructive ^c	3 (7%)	3 (7%)	5 (14%)
Restrictive pattern (spirometry only) ^d	13 (29%)	16 (38%)	10 (27%)
Restrictive disease ^e	8 (18%)	13 (31%)	7 (19%)
Mixed ^f	0 (0%)	7 (17%)	7 (19%)
Airtrapping ^g	0 (0%)	5 (12%)	3 (8%)
Abnormal diffusion capacity ^h	2/14 (14%)	8/22 (36%)	6/22 (27%)



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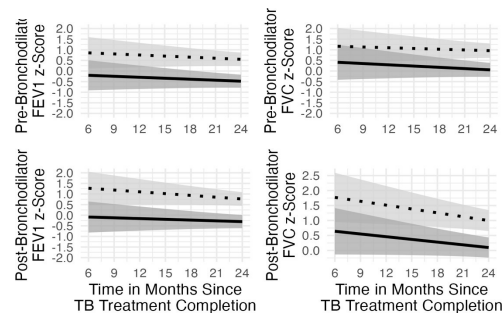
Posttuberculosis Lung Disease in Adolescents in Lima, Peru

Pediatrics 2026;158(1):e2025074970.

Silvia S. Chiang, MD, ScM,^{1,2} Savvas Andronikou, MBBCh, PhD,^{3,4} Betsabe Roman Sinche, RN,⁵ Michael Furman, MD,⁶ H. Simon Schaaf, MD, PhD,⁷ Clemens C. Sant'Anna, MD, PhD,⁸ Hansel J. Otero, MD,^{1,9} Joshua Ray Tanzer, PhD,¹ Leonid Lecca, MD, MSc,^{2,9} Anthony L. Byrne, PhD, MBBS, MPH^{8,10,a}

Group

- Comparison group (matched by age, sex, neighborhood)
- TB survivors



NO IMPROVEMENTS OVER TIME

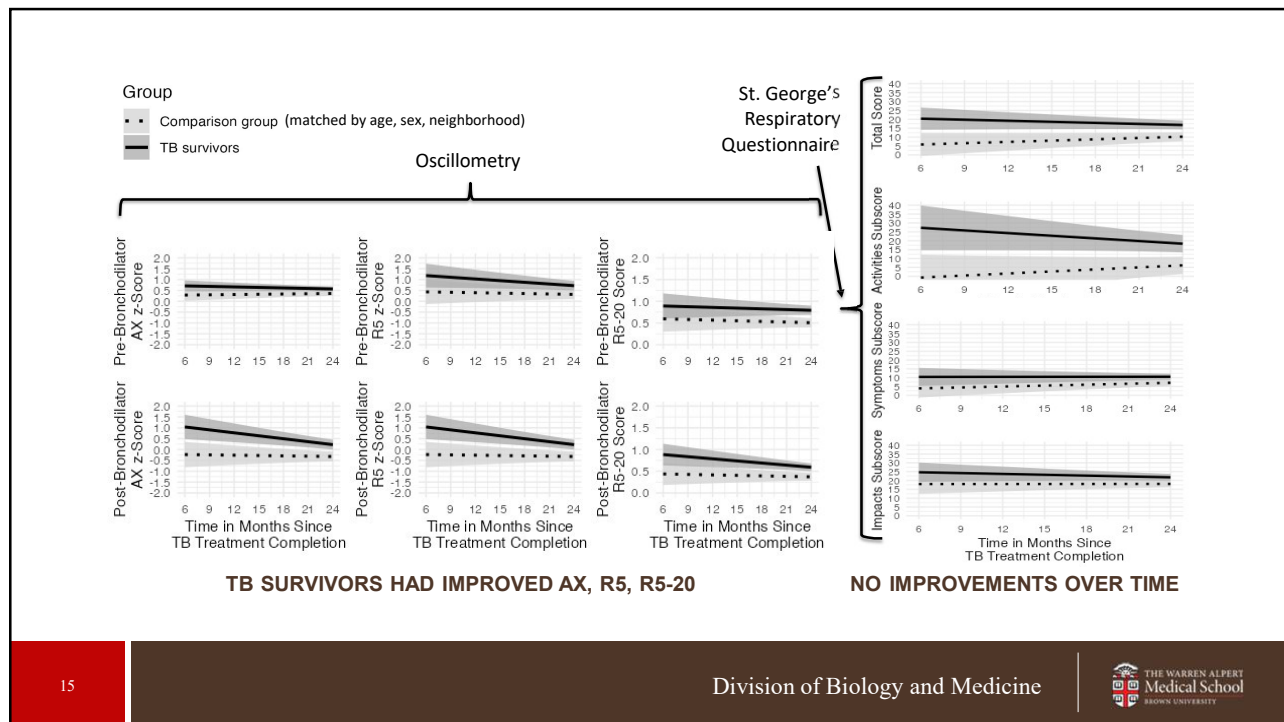
Evaluations, n (%)			p-Value
Disease pattern	TB survivors (n = 194)	Controls (n = 191)	
Pre-bronchodilator			
• Obstructive	39 (21.2)	20 (11.4)	0.01
• Restrictive	12 (6.5)	9 (5.1)	0.57
• Mixed	6 (3.3)	0 (0.0)	0.02
Bronchodilator response present	21 (12.3)	13 (8.2)	0.23
• Flow (FEV1)	16 (9.4)	0 (6.3)	0.31
• Volume (FVC)	12 (7.0)	6 (3.8)	0.20
Obstructive = FEV1/FVC < -1.64 z-score and FVC ≥ 1.64 z-score			
Restrictive = FEV1/FVC ≥ -1.64 z-score and FVC < -1.64 z-score			
Mixed = FEV1/FVC < -1.64 z-score and FVC < -1.64 z-score			
Bronchodilator response = ≥10% increase in flow (FEV1) or volume (FVC) relative to predicted value for age, sex, and height.			

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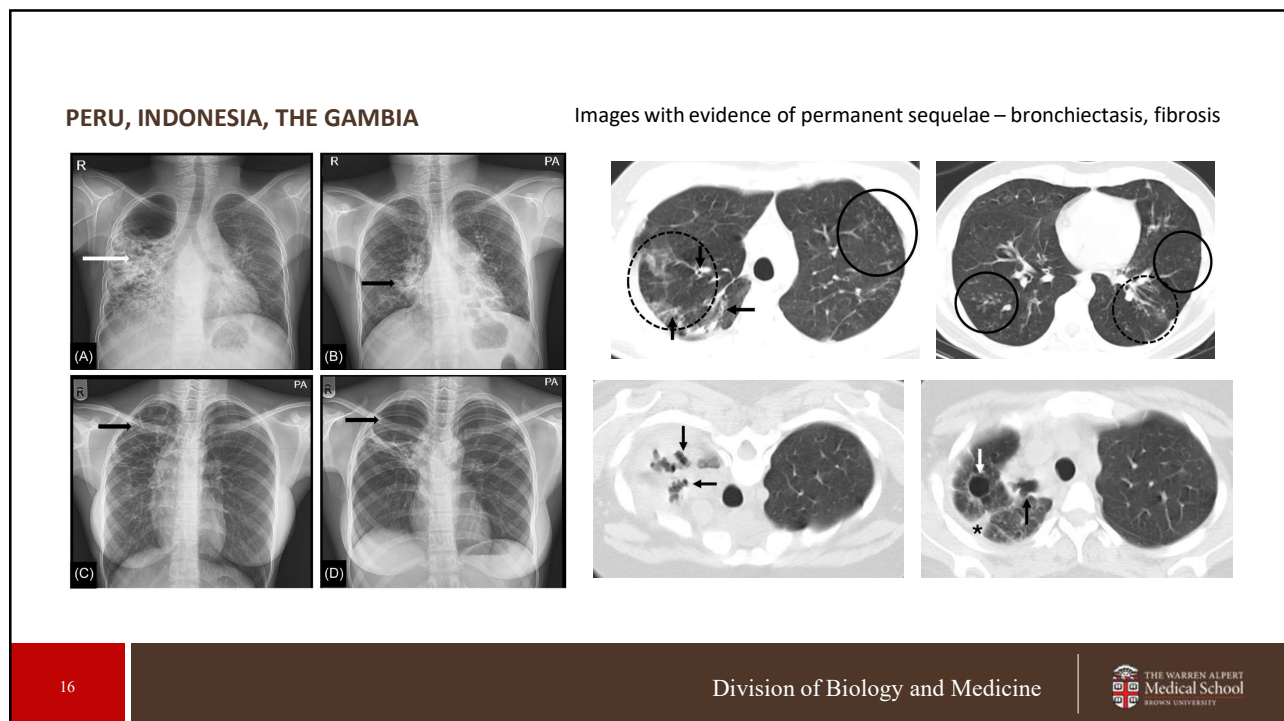
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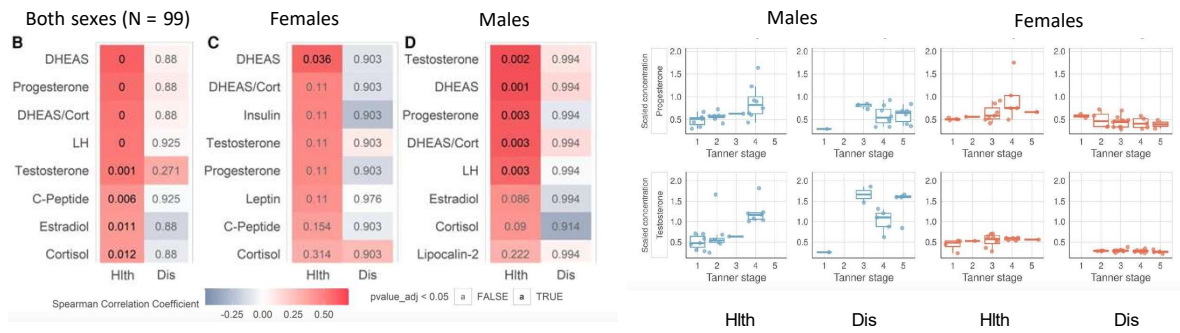
15



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Impact of Puberty on Immune Responses to *Mycobacterium tuberculosis* in South African Adolescents

Léanie Kleynhans,^{1,2,3,4} Elzina Maasdorp,^{1,3,4,5,6} Candice I. Snyders,³ and James A. Seddon^{1,2}



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IMPACT OF TB ON ADOLESCENT DEVELOPMENT

SOCIAL



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STRAIN ON SOCIAL RELATIONSHIPS

DATA FROM PERU, INDIA, RUSSIA, SOUTH AFRICA, ZIMBABWE



Das M, et al. PLoS One 2021;16:e0248408. * Zvonareva O, et al. PLoS One 2021;16(10):e0257379. * Oliva Rapoport VE, et al. BMJ Open 2022;12:e063287. * Wademan DT, et al. PLOS Glob Public Health 2024;4:e0003539. * Waterous P, et al. PLOS Glob Public Health 2024;4:e00003659.

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Anticipated stigma

"I used to sleepover at my grandmother's place and she would tell me about tuberculosis, how scary this disease is. I therefore saw tuberculosis as something you cannot tell anyone about, because our people spread gossip all the time and quite fast. Half of my friends really like to gossip and if I tell them, everybody will know. I am afraid of being discussed by the people around me. I am afraid they will point their finger at me." - Adolescent girl, Russia

Experienced stigma

"Especially the people at my school, I really felt neglected, like when you would go and sit on a bench, no one wanted to talk to you, no one wanted to be where you are, no one." - Adolescent girl, Zimbabwe

Internalized stigma

"I didn't tell [my girlfriend] about my TB because she'll never want to see me again. [. . .] She'll leave, I know her. [. . .] I don't want my friends to know, all of them because they are silly. [. . .] I only told my best friend that I have chest problems and did not tell him about TB because he was going to tell them." - Adolescent boy, South Africa

Zvonareva O, et al. PLoS One 2021;16(10):e0257379. *Wademan DT, et al. PLOS Glob Public Health 2024;4:e0003539. * Waterous P, et al. PLOS Glob Public Health 2024;4:e00003659.

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IMPACT OF TB ON ADOLESCENT DEVELOPMENT



EDUCATIONAL



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QUALITATIVE DATA FROM PERU, SOUTH AFRICA, TANZANIA, ZIMBABWE, INDIA, CHINA

- Exclusion from classes
- Schedule conflicts
- Adverse drug effects

- Missed classes
- Learning difficulties

- Decline of skills, knowledge
- Need to repeat semester or year
- Lost scholarships

- Academic desertion
- Changed career trajectory

Zhang S, et al. BMC Infect Dis 2016;16:758. * Das M, et al. PLoS One 2021;16:e0248408. * Oliva Rapoport VE, et al. BMJ Open 2022;12:e063287. * Ilaiwy G, et al. Am J Trop Med Hyg 2023;108:1235-1239. * Wademan DT, et al. PLOS Glob Public Health 2024;4:e0003539. * Waterous P, et al. PLOS Glob Public Health 2024;4:e00003659.

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IMPACT OF TB ON ADOLESCENT DEVELOPMENT



PSYCHOLOGICAL

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UTJLD Open 21(11):639-645
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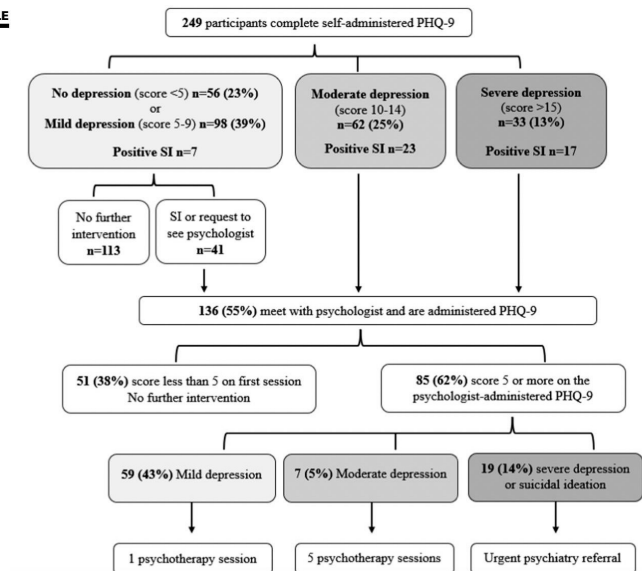
ORIGINAL ARTICLE

Depression in adolescents on treatment for rifampicin-susceptible TB in Lima, Peru

V. Sanchez-Guzman,¹ J.R. Tanzer,² B. Roman-Sinche,³ J. Santacruz,³ C. Contreras,³ A. Desrosiers,⁴ L. Lecca,³ S.S. Chiang^{1,5}

DEPRESSION ASSOCIATED WITH:

- Lower family support
- More food insecurity
- More drug and alcohol use
- Higher ACE score



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Severity of depression as measured by PHQ-9 ¹		
	Severe depression, PHQ-9 ≥ 15 (n = 19)	Moderate depression, PHQ-9 score 10-14 (n = 7)
Start of depression		
• At the same time or after start of TB treatment	6 (31.56)	6 (85.71)
• Before the start of TB treatment	12 (63.18)	1 (14.29)
• Unknown or prefers not to answer	1 (5.26)	0 (0)
Cause of depression		
• TB only	1 (5.26)	4 (57.14)
• Other factors only ²	9 (47.37)	2 (28.57)
• Both	6 (31.58)	1 (14.29)
• Unknown or prefers not to answer	3 (15.79)	0 (0)
¹ Results were not consistently reported for those with mild depression.		
² Most frequently reported other factors were interpersonal conflicts and socioeconomic challenges.		

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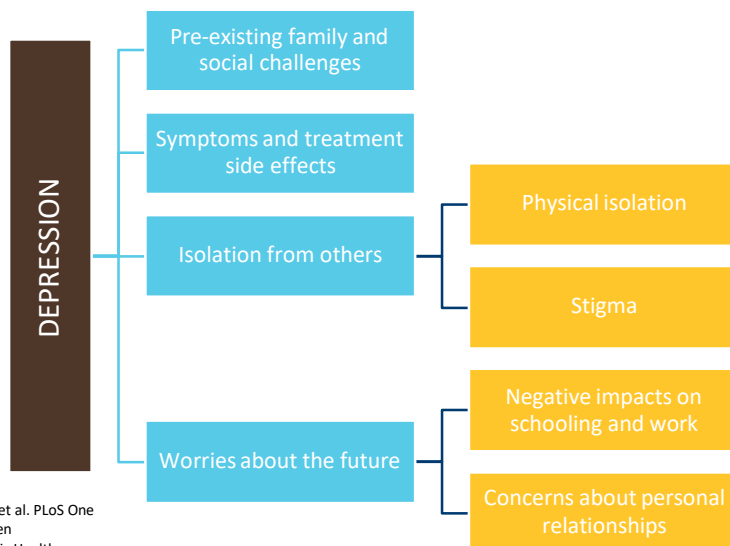
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DEPRESSION

QUALITATIVE DATA FROM PERU,
SOUTH AFRICA, INDIA, RUSSIA



Das M, et al. PLoS One 2021;16:e0248408. * Zvonareva O, et al. PLoS One 2021;16(10):e0257379. * Oliva Rapoport VE, et al. BMJ Open 2022;12(9):e063287. * Wademan DT, et al. PLOS Glob Public Health 2024;4:e0003539.

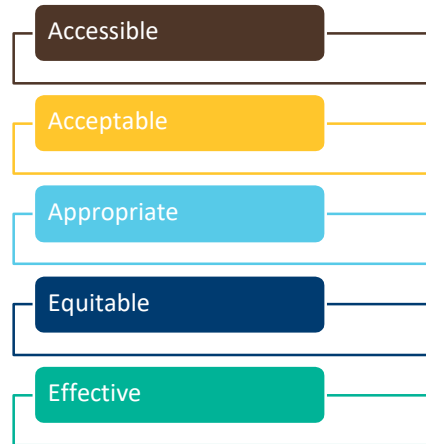
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ADOLESCENT-FRIENDLY CARE



COMMON PREFERENCES SHARED BY ADOLESCENTS, CAREGIVERS, AND PROVIDERS IN BOTSWANA, PERU, AND ZIMBABWE

- Greater flexibility with respect to hours, to avoid schedule conflicts with school
- Separate, private, and clean spaces for adolescents
- Respectful, friendly staff
- Mental health care, including treatment for substance use
- Nutritional support (food supplements, education)

Laycock K, et al. *Int J Tuberc Lung Dis* 2021;25(7):579-83. * Arango D, Cintron C, et al. *BMJ Open* 2025;15(3): e090707. * Waterous P, et al. *PLOS Glob Public Health* 2024;4:e00003659.

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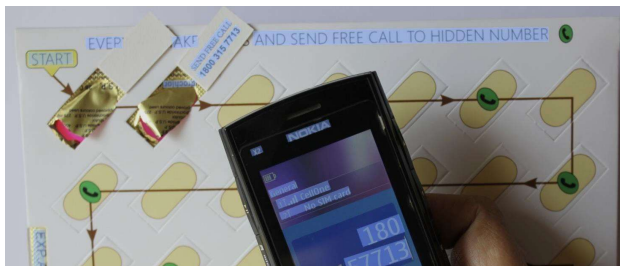
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Int J Tuberc Lung Dis 29(9):404-409
© 2025 The Union <http://dx.doi.org/10.5588/ijtld.24.0663>

ORIGINAL ARTICLE

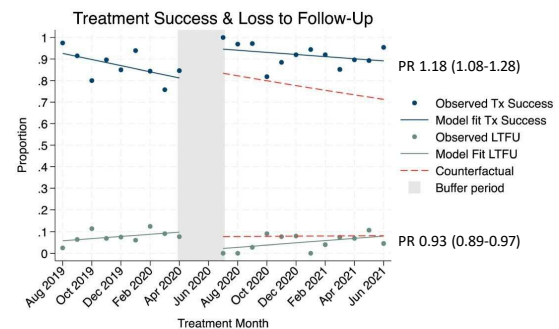
Use of a digital adherence technology to support TB treatment among adolescents

A.M. Schraufnagel,¹ R. Crowder,^{1,2} P. Wambi,³ S. Nakasendwa,⁴ A. Kityamuvesi,⁴ D. Jaganath,^{1,2,5} M. Musoke,⁴ J. Nannozi,⁴ J. Waswa,⁴ A.N. Sanyu,⁴ M. Lamunu,⁴ A. Twinamasiko,⁴ L.K. Tinka,⁴ D. Oyuku,⁴ D. Babirye,⁴ C. Berger,^{1,2} R. Thompson,⁶ S. Turyahabwe,⁷ D. Dowdy,^{4,6} A. Katamba,^{4,8} A. Cattamanchi,^{1,2,4,9} N. Kiwanuka^{4,10}



Interrupted time series study to evaluate 99DOTS

- All adolescents at 30 health facilities in Uganda
- Pre-intervention, n = 302 (19.8% on 99DOTS); post-intervention, n = 328 (78.4% on 99DOTS)



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Public Health Action

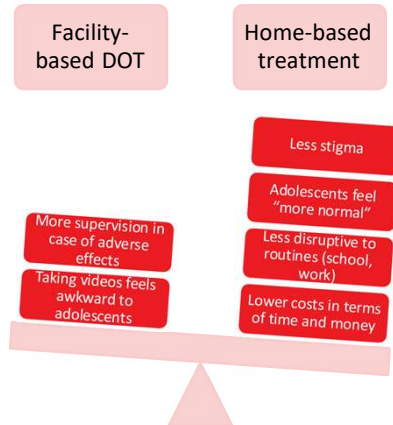
VOL 15 NO 4 PUBLISHED DECEMBER 2025

ORIGINAL ARTICLE

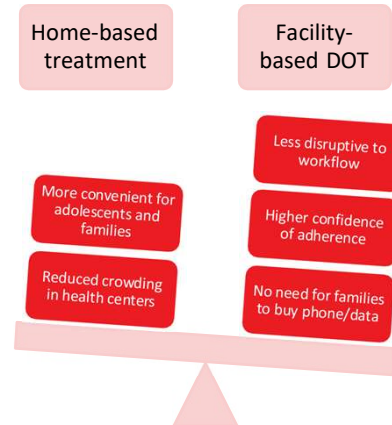
A qualitative study of home- versus facility-based TB treatment for adolescents in Lima, Peru

B. Roman-Sinche,¹ F.M. Doradea,² K. Tintaya,¹ L. Lecca,^{1,3,4} S.S. Chiang^{5,6}

ADOLESCENTS AND CAREGIVERS



HEALTH PROVIDERS



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RESEARCH ARTICLE

Strategies to resolve the gap in adolescent tuberculosis care at four health facilities in Uganda: The teenager's TB pilot project

Samson Omongot,^{1,2*} Winters Muttamba^{1,3}, Irene Najjingo¹, Joseph Baruch Baluku^{1,4}, Sabrina Kitaka¹, Stavia Turyahabwe⁵, Bruce Kirenga^{1,2}

PLoS One 2024;19(4):e0286894.

- Aim to improve low care seeking for cough ≥ 2 weeks by adolescents (44% per Ugandan National TB Survey)
- TB awareness package designed by adolescents
 - Posters displayed in communities
 - Song broadcast on local radio
 - Screening cards given to TB presumptive adults and adolescents for other adolescents in their household

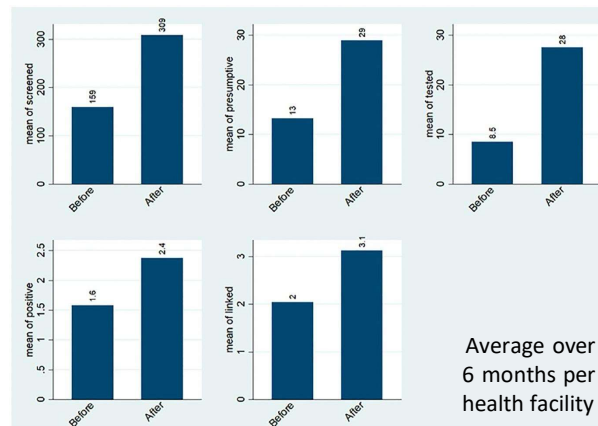


Fig 2. Overall average number of adolescents across TB care cascade before & after the intervention.

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FUTURE DIRECTIONS

WHAT DO WE KNOW?

- TB is a leading cause of adolescent death worldwide due to suboptimal engagement in care
- Although local contexts vary, adolescents from diverse settings face common treatment challenges (e.g., facility-based DOT, stigma, educational setbacks, mental health challenges)
- Although local contexts vary, adolescents from diverse settings around the world have common preferences for care

WHAT DO WE NEED TO WORK ON NEXT?

- Continue building an evidence base for effective interventions to deliver patient-centered care
 - Mostly home- or community-based
 - Accommodates education/work
 - Addresses mental health
 - Strengthens family support or provides other social support

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FUTURE DIRECTIONS

WHAT DO WE KNOW?

TB causes long-term respiratory disability and potentially disrupts pubertal development

WHAT DO WE NEED TO WORK ON NEXT?

Further research on adolescent PTLD

- Longer follow-up
- Different clinical phenotypes of adolescent PTLD
- Identify risk factors
- Elucidate pathophysiology to discover drug targets

Further research on interplay between TB and puberty

- Longer follow-up
- Larger sample size

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THANK YOU!

E-mail: silvia_chiang@brown.edu

