Factors Associated with Loss to Follow Up among Tuberculosis Patients in Embu County, 2016-2021

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Abstract

INTRODUCTION

Loss of follow-up among Tuberculosis patients is a significant challenge for Tuberculosis control. It may lead to prolonged infectiousness of Tuberculosis cases, increased rate of treatment failure, relapse, progression to drug-resistant TB, and deaths. The study aimed at identifying factors associated with loss to follow-up among TB patients in Embu County.

METHODOLOGY

A retrospective cohort study was carried out among all patients (n = 8983) notified between the years 2016-2021 in Embu County, Kenya. The data was obtained from the routinely collected TB data stored in the National Tuberculosis Program database. Descriptive statistics and multivariate logistic regression were performed to identify factors associated with treatment loss to follow-up. Data analysis was conducted using R statistical software.

RESULTS

Out of 8,983 patients notified, 657(7.3%) of them had a treatment outcome of loss to follow-up. The majority were; males (78%), age groups 15-44 (68%), Embu West Sub County (67%), public sector (91%), clinically diagnosed (51%), obesity (30%), and the HIV positive (19%). Being a male (aOR=1.6(95% _CI: 1.3 – 1.9), being in age-group 15-44 years, being clinically diagnosed (aOR=1.58(95% _CI: 1.31– 1.92), being previously treated (aOR=1.38(95%_CI: 1.03-1.83), and having HIV as a comorbidity (aOR=1.48 (95%_CI: 1.19-1.83) increased the risk of being loss to follow up during TB treatment.

CONCLUSION

Loss to follow-up among TB patients is still a challenge in Embu County. Sex, age, and HIV status were shown to increase the risk of loss to follow-up among TB patients; thus highlighting the need for strategic interventions to improve treatment adherence.

Keywords: *TB, Loss to follow up, Embu County*

Introduction

Worldwide, Tuberculosis (TB) cases are estimated to have reached 10.6 million in 2022 with more than 80% of cases coming from South-East Asia (46%), Sub-Saharan Africa (23%), and the West Pacific (18%). In addition, the report indicated that the treatment success rate among drug-susceptible TB patients was 88% which was higher compared to both 2019 and 2020 (1).

Kenya is one of the 30 high-burden countries for TB and TB/HIV in the world, and it is estimated that 133,000 people fell ill with TB in 2022. In that same year, the country notified a total of 90,560 TB cases and registered a

treatment success rate of 86% with an LTFU rate of 5% (2). During the same period, Embu County notified 1817 TB patients with a treatment success rate of 86%.

Several studies conducted in various regions, including South Africa, Papua New Guinea, India, and Kenya, shed light on the factors contributing to loss to follow-up (LTFU) among tuberculosis (TB) patients. In South Africa (5, 8), both gender and hospital accessibility emerged as significant influences on LTFU, with reduced access to TB diagnosis and treatment leading to an increase in TB-related deaths. In India (ref), social and behavioural factors such as drug side effects, alcoholism, social stigma, lack of disease awareness, and inadequate counselling were identified as contributors to LTFU among pulmonary TB patients.

Furthermore, the 2021 Global report highlighted inadequate evaluation and poor linkage of treatment facilities as reasons for poor treatment outcomes (7). In Western Kenya, pre-treatment LTFU was found to increase the risk of overall LTFU, with male gender, HIV-positive status, and previous TB treatment also being associated with higher LTFU rates (8). In Kibra, Kenya, factors like relocation, lack of family support, unemployment, and work commitments contributed to LTFU (9). Similar findings were observed in Embu, Kenya, where lack of knowledge and relocation were major reasons for treatment interruptions among TB patients (10). Additionally, a study in Kilifi County, Kenya, revealed that being male, elderly, previously treated for TB, HIV-positive, or having other comorbidities was associated with poor treatment outcomes (11).

These studies underscore the multifaceted nature of LTFU among TB patients and highlight the importance of addressing social, behavioural, and healthcare system-related factors to improve treatment adherence and outcomes. We aimed to identify the factors associated with loss to follow-up outcomes among patients initiated on TB treatment in Embu County.

Methodology
Study design
A retrospective cohort study among the TB patients diagnosed from 2016-2021 in Embu County. This included reviewing data from the national TB surveillance and reporting system (TIBU), a case-based surveillance system that stores national TB data.

Definitions of key terms
New patient. A patient who has never been treated for TB or has taken anti-TB drugs for less than 1 month.

Previously treated. A patient who has received 1 month or more of anti-TB drugs in the past.

Bacteriologically confirmed. One from whom a biological specimen is positive by smear microscopy, culture, or WRD (such as Xpert MTB/RIF).

Clinically confirmed. One who does not fulfil the criteria for bacteriological confirmation but has been diagnosed with active TB by a clinician including cases diagnosed based on X-ray abnormalities or suggestive histology and extrapulmonary cases without laboratory confirmation.

Pulmonary tuberculosis (PTB). Any bacteriologically confirmed or clinically diagnosed case of TB involving the lung parenchyma or the tracheobronchial tree.

Extrapulmonary tuberculosis (EPTB). Any bacteriologically confirmed or clinically diagnosed case of TB involving organs other than the lungs.

Loss to follow-up. As TB patients who interrupted treatment for ≥2 months or longer before the end of the treatment period.

Successful outcome. The sum of patients who were initiated on TB treatment, and went through the entire course with an outcome of cured or treatment completed.

Cured. Pulmonary TB patient with bacteriologically confirmed TB at the beginning of treatment who was smear- or culture-negative in the last month of treatment and on at least one previous occasion.

Treatment complete. A TB patient who completed treatment without evidence of failure

but with no record to show that sputum smear or culture results in the last month of treatment and at least one previous occasion were negative, either because tests were not done or because results are unavailable.

Study setting

Embu County is in the Eastern region of Kenya with a division of five sub-counties. The county is largely a rural setup occupying an area of 2821 km2 with a population of 608,599. Its economy is largely sustained by peasant farmers including cash crops such as tea, coffee, cotton, macadamia nuts, miraa (_khat_), and livestock rearing. Commercial food production and for subsistence was also observed.

Study population

The study included TB patients who were enrolled for drug-susceptible TB treatment in Embu County between the years 2016 to 2021

Data management and analysis

The study utilized data on TB cases notified between 2016 and 2021 from Embu County, Kenya, sourced from TIBU, the national TB surveillance system managed by the National TB Program. This system provides case-based

TB data routinely reported by health facilities across the country. Data variables included age, sex, sub county, BMI, type of patient, type of TB, HIV status, and treatment outcome.

The data were exported from the TIBU system into an analysable format in Excel and then imported into R software for further analysis. Descriptive analysis was performed to summarize the characteristics of the study population.

Multivariate logistic regression analysis was carried out to identify factors associated with loss to follow-up among TB patients using R statistical software (version 4.3.1). Crude odds ratios (uOR) and adjusted odds ratios (aOR) with 95% confidence intervals were calculated, with p-values less than 0.05 considered statistically significant.

Ethical considerations

The ethical approval was provided by the AMREF Ethics and Scientific Review Committee reference P1314-2022. A research permit from the National Commission of Science, Technology, and Innovation NACOSTI with reference NACOSTI/P/23/25226 was also issued.

Table 1:
Demographic Characteristics of the Notified TB Patients

Characteristic	A successful outcome, N = 8,326[1]	Lost to follow up, N = 657[1]	Overall, N = 8,983[1]	p-value[2]
Age group				0.001
0-14	1,353 (16%)	74 (11%)	1,427 (16%)	
15-24	1,120 (13%)	114 (17%)	1,234 (14%)	
25-34	2,050 (25%)	169 (26%)	2,219 (25%)	
35-44	1,845 (22%)	165 (25%)	2,010 (22%)	
45-54	962 (12%)	69 (11%)	1,031 (11%)	
55-64	493 (5.9%)	30 (4.6%)	523 (5.8%)	
65+	503 (6.0%)	36 (5.5%)	539 (6.0%)	
Sex				<0.001
Female	2,571 (31%)	145 (22%)	2,716 (30%)	
Male	5,755 (69%)	512 (78%)	6,267 (70%)	
Sub-county				<0.001
Embu East	2,064 (25%)	103 (16%)	2,167 (24%)	
Embu West	3,343 (40%)	439 (67%)	3,782 (42%)	
Mbeere North	1,510 (18%)	62 (9.4%)	1,572 (17%)	
Mbeere South	1,409 (17%)	53 (8.1%)	1,462 (16%)	
Sector				0.013
Other Faith Based	270 (3.2%)	15 (2.3%)	285 (3.2%)	
Prisons	143 (1.7%)	11 (1.7%)	154 (1.7%)	
Private	714 (8.6%)	35 (5.3%)	749 (8.3%)	
Public	7,199 (86%)	596 (91%)	7,795 (87%)	

[1]Median (IQR) or Frequency (%); [2]Pearson's Chi-squared test; Fisher's exact test

Further approval was obtained from the Embu County Health Department. Patient privacy and data confidentiality was ensured.

Results

Demographic characteristics

A total of 8,983 participants were included in the study. The majority were male 69% (5755), 60% (5015) were from the age group (15-44) years, and 16% (1353) were aged below 15 years. Out of all the patients, 7.3% (657) were lost to follow-up; amongst them 78% (512) were male, 68% (448) were 15-44 years, 67% (439) from Embu West sub-county and 91% (596) were treated from public health facilities as shown in Table 1.

Clinical characteristics

In terms of clinical characteristics, 93% (7738) were newly diagnosed TB patients with 87% (7223) having pulmonary TB (PTB). Among the LTFU, 91% (597) of the patients were newly diagnosed with TB; 70% (459) were HIV-negative, while TB-HIV co-infected were 19% (126). Of the clinically diagnosed LTFU 51% (334) and 30% (195) were obese.

Multivariate logistic regression

From the logistic regression model analyses (table 3) we observed that patients from Embu West were 2.8 ([CI: 2.2-3.5]) times more likely to be LTFU compared to patients receiving treatment in Embu East. Patients in Mbeere South were 0.4 ([CI: 0.3-0.6]) times less likely to be LTFU compared to patients in Embu East.

The male group were 1.6[CI: 1.3 – 1.9] times more likely to be LTFU as compared to the female group. Age groups 25-34 (0.5([CI: 0.4-0.7]), and 35-44 (0.6 ([CI: 0.4-0.8]), were more likely to be LTFU compared to children (0-14). By type of diagnosis, the PTB patients were 0.5 ([CI: 0.4-0.8]) less likely to be LTFU. Both patients with HIV positive 1.6 ([CI: 1.2-2.0]) or not done 4.0 ([CI: 3.0-6.0]) were more likely to be LTFU compared to HIV negative.

Discussion

Loss to follow-up remains a major concern to TB care and treatment. Studies done in African countries showed a high rate of loss to follow-up (12-15).

Table 2:

Clinical Characteristics of the Notified TB Patients

Characteristic	A successful outcome, N = 8,326[1]	Lost to follow up, N = 657[1]	Overall, N = 8,983[1]	p-value[2]
Type of TB P/EP				0.058
EP	1,103 (13%)	70 (11%)	1,173 (13%)	
P	7,223 (87%)	587 (89%)	7,810 (87%)	
TB history				0.048
New	7,738 (93%)	597 (91%)	8,335 (93%)	
Previously treated	588 (7.1%)	60 (9.1%)	648 (7.2%)	
HIV status				<0.001
Declined	18 (0.2%)	3 (0.5%)	21 (0.2%)	
Not done	240 (2.9%)	69 (11%)	309 (3.4%)	
Negative	6,794 (82%)	459 (70%)	7,253 (81%)	
Positive	1,274 (15%)	126 (19%)	1,400 (16%)	
Tuberculosis site				0.038
Bacteriologically confirmed	4,443 (53%)	323 (49%)	4,766 (53%)	
Clinically diagnosed	3,883 (47%)	334 (51%)	4,217 (47%)	
BMI category				<0.001
Severely malnourished	1,301 (16%)	96 (15%)	1,397 (16%)	
Moderately malnourished	2,285 (27%)	184 (28%)	2,469 (27%)	
Normal	2,706 (33%)	170 (26%)	2,876 (32%)	
Overweight	310 (3.7%)	12 (1.8%)	322 (3.6%)	
Obese	1,724 (21%)	195 (30%)	1,919 (21%)	

[1]Median (IQR) or Frequency (%); [2]Pearson's Chi-squared test; Fisher's exact test

Age distribution showed a noteworthy association with LTFU, particularly among the younger demographic aged 15-44 years, indicating a heightened risk compared to other age groups.

This finding resonates with earlier research (21-23) pinpointing the hurdles in retaining younger individuals within TB care frameworks. The explanation lies in socioeconomic dynamics (e.g. farming, being the main economic activity in the area of study) and mobility; individuals in this age bracket often juggle multiple obligations such as education, employment, and family duties, which may disrupt their ability to stay consistent with TB treatment. Furthermore, their increased mobility can pose challenges in accessing healthcare services regularly, compounding the risk of LTFU.

Additionally, this study found a 1.6 times higher likelihood of LTFU among males compared to females, a trend consistent with findings from studies conducted in China (16)

and Indonesia (17). Further insights into this disparity come from a study in Zimbabwe, which attributed the high percentage of male LTFU to socioeconomic factors, where men often prioritize work over seeking medical care to avoid job layoffs (18). Similarly, research in Vihiga County, Kenya, linked factors such as low income, smoking, and substance abuse to a higher rate of LTFU among male patients (19). However, it's worth noting that a study in Ethiopia reported more instances of female LTFU than males (20). Exploring healthcare-seeking behaviours, perceived improved health status post-treatment initiation, societal norms and traditional gender roles among males can provide valuable context to understand why they are more prone to LTFU compared to females.

Furthermore, sub county location was found as a significant predictor of LTFU. Variations in healthcare infrastructure, accessibility, and socioeconomic factors across different sub counties may contribute to disparities in TB care outcomes.

Table 3:
Multivariate Logistic Regression of the Factors Associated with Loss to Follow-Up among TB Patients in Embu County

	Characteristic	uOR	95% CI	p-value[1]	aOR	95% CI	p-value[1]
Age group	0-14	Ref					
	15-24	1.86	1.38, 2.53	**<0.001**	2.23	1.61, 3.11	**<0.001**
	25-34	1.51	1.14, 2.01	**0.004**	1.66	1.21, 2.29	**0.002**
	35-44	1.64	1.24, 2.18	**<0.001**	1.72	1.25, 2.37	**<0.001**
	45-54	1.31	0.93, 1.84	0.12	1.34	0.93, 1.93	0.12
	55-64	1.11	0.71, 1.70	0.6	1.20	0.75, 1.88	0.4
	65+	1.31	0.86, 1.96	0.2	1.38	0.89, 2.09	0.14
Sex	Female	Ref					
	Male	1.58	1.31, 1.91	**<0.001**	1.56	1.28, 1.91	**<0.001**
Sub-county	Embu East	Ref					
	Embu West	2.63	2.12, 3.30	**<0.001**	2.45	1.97, 3.09	**<0.001**
	Mbeere North	0.82	0.59, 1.13	0.2	0.92	0.67, 1.28	0.6
	Mbeere South	0.75	0.53, 1.05	0.10	0.81	0.57, 1.13	0.2
Type of TB	Extra Pulmonary	Ref					
	Pulmonary	1.28	1.00, 1.67	0.058	1.76	1.33, 2.35	**<0.001**
TB history	New	Ref					
	Previously treated	1.32	0.99, 1.73	**0.049**	1.38	1.03, 1.83	**0.028**
HIV status	Negative	Ref					
	Positive	1.46	1.19, 1.79	**<0.001**	1.48	1.19, 1.83	**<0.001**
	Declined	2.47	0.58, 7.32	0.15	1.78	0.41, 5.44	0.4
	Not done	4.26	3.18, 5.62	**<0.001**	2.83	2.10, 3.79	**<0.001**
TB site	Bacteriologically confirmed	Ref					
	Clinically diagnosed	1.18	1.01, 1.39	**0.038**	1.58	1.31, 1.92	**<0.001**

[1] OR = Odds Ratio, CI = Confidence Interval

Understanding the contextual factors specific to each sub county is essential for designing targeted interventions aimed at reducing LTFU and improving treatment adherence.

Compared to patients with other forms of TB, patients with PTB exhibited notably higher odds of being LTFU. This finding suggests that there may be specific factors inherent to PTB cases such as the severity of symptoms or socioeconomic challenges unique to PTB patients, which could provide valuable insights into mitigating LTFU in this subgroup. These findings were consistent with other studies conducted in Morocco (14, 15,24). HIV-positive status was associated with being lost to follow-up. This suggests the need for further exploration into potential contributing factors. One plausible explanation is the increased pill burden and adverse effects associated with HIV treatment regimens. HIV-positive individuals often face the challenge of adhering to multiple medication schedules, including antiretroviral therapy (ART) for HIV management and anti-TB drugs for co-infection cases. The combined pill burden and potential side effects may lead to treatment fatigue or non-adherence among patients, resulting in an elevated risk of LTFU. The findings are similar to other studies that showed the rate of LTFU was high among TB/HIV co-infected persons (20,25). Similarly, this would increase the co-infection rate as a study found in Cape town (26).

The type of patient (new vs. previously treated) was identified as a significant variable associated with LTFU. Being previously treated had a higher likelihood of being LTFU than newly initiated patients, this could be due to a lack of knowledge on the importance of completion of TB treatment. This correlates to other studies that showed previously treated patients were twice at risk of being LTFU (27,28). This study found that patients who were clinically diagnosed were more likely to be LTFU than bacteriologically confirmed. This could be attributed to seeking a second opinion from other health personnel/facilities. This finding was similar to a study done in Ethiopia,

South Africa that found that clinically diagnosed patients were more likely to be LTFU than bacteriologically confirmed (29,30). These findings underscore the importance of considering individual patient characteristics and clinical indicators when addressing barriers to TB treatment adherence.

Limitations of the study

The study relied on routinely collected TB data hence variations in data recording practices across health facilities or sub-counties may introduce errors or inconsistencies, potentially affecting the reliability of the findings.

Conclusion

In this study, the LTFU rate in TB patients remains high. Being a male, age group (15-44) years, being a TB/HIV coinfected, clinically diagnosed patient, previously treated with TB and Embu west sub-county was significantly associated with loss to follow up.

Recommendations

Interventions targeting men, ages 15-44 and Embu West sub-county need to be implemented to improve treatment adherence. Highlighting the need for strategic interventions to improve treatment adherence.

Conflict of interest. The authors declare that there is no conflict of interest

References

1. **WHO**. Global Tuberculosis Report 2023 [Internet]. Vol. t/malaria/, January. 2023. 2 p. Available from: https://www.who.int/teams/global-tuberculosis-programme/tb-reports
2. Tuberculosis N, Program LD. Annual Report 2022. 2022;
3. **Berry KM, Rodriguez CA, Berhanu RH, Ismail N, Mvusi L, Long L, *et al*.** Treatment outcomes among children, adolescents, and adults on treatment for tuberculosis in two metropolitan municipalities in Gauteng Province, South Africa. 2019;1–17.
4. I. Umo, 1 M. Kulai, 2 R. J. Commons3 **4**. Factors Associated with Loss to Follow-Up among TB patients in rural Papua New Guinea. *World Heal Organ Reg Publ - Eur* Ser. 2021; I (56):31–49.
5. Metabolomics H, Bag P**.** Factors Contributing

to Pulmonary TB Treatment Lost to Follow-Up in Developing Countries: An Overview Opperman, Monique and Du Preez, Ilse * Potchefstroom, South Africa, 2531. * Corresponding Author's E-Mail: ilse.dupreez@nwu.ac.za Article Hist. 2023; 17:60–73.

6. **Mishra P, Sharma RK, Yadav R, Rao VG, Nigam S, Lingala MA,** *et al*. Reasons for loss to follow-up (LTFU) of pulmonary TB (PTB) patients: A qualitative study among Saharia, a particularly vulnerable tribal group of Madhya Pradesh, India. *PLoS One* [Internet]. 2021 Dec 1 [cited 2023 Oct 9];16(12). Available from: https://pubmed.ncbi.nlm.nih.gov/34941885/

7. **Sillehu S, Rumaolat W, Cahyawati S, Utami TN, Kartika D, Rina W,** *et al.* Global Tuberculosis Report [Internet]. Vol. 14, WorldHealthOrganization. 2021. 2571–2575 p. Available from: http://apps.who.int/bookorders.

8. **Mulaku MN, Ochodo E, Young T, Steingart KR.** Public Health Action Pre-treatment loss to follow-up in adults with pulmonary TB in Kenya. [cited 2024 Jun 3]; Available from: http://dx.doi.org/10.5588/pha.23.0059

9. **Kizito KW, Dunkley S, Kingori M, Reid T**. Loss to follow up from tuberculosis treatment in an urban informal settlement (Kibera), Nairobi, Kenya: what are the rates and determinants? Trans R Soc Trop Med Hyg [Internet]. 2011 Jan [cited 2024 Jun 3];105(1):52–7. Available from: https://pubmed.ncbi.nlm.nih.gov/20889176/

10. **Kimani E, 1 ID, Muhula S, Kiptai T, Orwa J, Odero T,** *et al*. Factors influencing TB treatment interruption and treatment outcomes among patients in Kiambu County, 2016-2019. AMREF Heal Africa Kenya. 2016;(3).

11. **Katana GG, Ngari M, Maina T, Sanga D, Abdullahi OA.** Tuberculosis poor treatment outcomes and its determinants in Kilifi County, Kenya: a retrospective cohort study from 2012 to 2019. Arch Public Heal [Internet]. 2022;1–13. Available from: https://doi.org/10.1186/s13690-022-00807-4

12. **Wanyonyi AW, Wanjala PM, Githuku J, Oyugi E, Kutima H, Kenyatta J,** *et al*. Factors Associated with Interruption of Tuberculosis Treatment among Patients in Nandi County, Kenya 2015 Alfred. 2017; 28:11. Available from: http://www.panafrican-med-journal.com/content/series/28/1/11/full

13**. Nissen TN, Rose M V, Kimaro G, Bygbjerg IC, Mfinanga SG.** Challenges of Loss to Follow-up in Tuberculosis Research. 2012;7(7):1–8.

14. **Sbayi A, Arfaoui A, Janah H, Koraichi SEL, Quyou A**. Epidemiological characteristics and some risk factors of extrapulmonary tuberculosis in Larache, Morocco. 2020;36(381):1–9.

15. **Millett ERC, Noel D, Mangtani P, Abubakar I, Kruijshaar DME**. Factors associated with being lost to follow-up before completing tuberculosis treatment: analysis of surveillance data. 2001; Available from: https://doi.org/10.1017/S095026881200163X

16. **Dey A, Lahiri A, Jha SS, Sharma V, Shanmugam P, Chakrabartty AK.** Treatment adherence status of the TB patients notified from the private sector and its associated factors: Findings of a secondary data analysis from West Bengal, India. *Indian J Tuberc* [Internet]. 2022 Jul 1 [cited 2024 May 15];69(3):334–40. Available from: https://pubmed.ncbi.nlm.nih.gov/35760483/

17. **MoH**. Ministry of Health, Republic of Uganda [Internet]. 2012. Available from: http://health.go.ug/mohweb/

18. **Chikwaiwa, Belamino K.; Dzingirai, Vupenyu; Nyikahadzoi K**; &. Institutional and Personal Factors Influencing Aherence to Tuberculosis Treatment among patients in Harare, Zimbambwe. 2018;8(2):93–101.

19. **Waliaula Wekunda PI, Omondi Aduda DS, Guyah B**. Determinants of tuberculosis treatment interruption among patients in Vihiga County, Kenya. 2021; Available from: https://doi.org/10.1371/journal.pone.0260669

20. **Gezae KE, Abebe HT, Gebretsadik LG.** Incidence and predictors of LTFU among adults with TB/HIV co-infection in two governmental hospitals, Mekelle, Ethiopia, 2009-2016: survival model approach. BMC Infect Dis [Internet]. 2019 Feb 4 [cited 2023 Oct 9];19(1). Available from: https://pubmed.ncbi.nlm.nih.gov/30717705/

21. **Nabil Tachfouti1, &, Katia Slama2**, Mohammed Berraho1 CN 1Laboratory. The impact of knowledge and attitudes on adherence to tuberculosis treatment: a case-control study in a Moroccan region. 2012; 8688:1–8.

22. **Heemanshu A, Satwanti K**. Determinants of loss to follow up during treatment among tuberculosis patients in Delhi. *Int J Med Res Heal Sci* [Internet]. 2016; 5:145–52. Available from: www.ijmrhs.com

23. **Mishra P, Sharma RK, Yadav R, Rao VG, Nigam S, Lingala MA,** *et al.* Reasons for loss to follow-up (LTFU) of pulmonary TB (PTB) patients: A qualitative study among Saharia, a particularly vulnerable tribal group of Madhya

Pradesh, India. 2021; Available from: https://doi.org/10.1371/journal.pone.0261152

24. **Wekunda PW, Kosgei RJ, Gathara D, Maore N, Masini E.** Evaluation of Treatment Outcomes and Associated Factors among Patients Managed for Tuberculosis in Vihiga County, 2012 - 2015. 2017;2017(October).

25. **Shaweno T, Getnet M, Fikru C**. Does time to loss to follow-up differ among adult tuberculosis patients initiated on tuberculosis treatment and care between general hospitals and health centers? A retrospective cohort study. *Trop Med Health.* 2020;48(1):1–11.

26. **Id PM, Hermans S, Caldwell J, Bekker L-G, Wood R, Kaplan R**. HIV prevalence and determinants of loss-to-follow-up in adolescents and young adults with tuberculosis in Cape Town. 2019 [cited 2024 May 16]; Available from: https://doi.org/10.1371/journal.pone.0210937

27. **Wohlleben J, Makhmudova M, Sandoval F, Azamova S, Mergenthaler C, Verver S**. Risk factors associated with loss to follow-up from tuberculosis treatment in Tajikistan: a case-control study. *BMC Infect Dis* [Internet]. 2017 Aug 4 [cited 2023 Oct 9];17(1). Available from: https://pubmed.ncbi.nlm.nih.gov/28778187/

28. **Zahidah Sharani Z, Ismail N, Munira Yasin S, Zakaria Y, Razali A, Atiqah Rochin Demong N,** *et al*. Characteristics and determinants of loss to follow-up among tuberculosis (TB) patients who smoke in an industrial state of Malaysia: a registry-based study of the years 2013-2017. *BMC Public Health* [Internet]. 2021 [cited 2022 Dec 11]; Available from: https://doi.org/10.1186/s12889-022-13020-3

29. **Kigozi G, Heunis C, Chikobvu P, Botha S, van Rensburg D**. Factors influencing treatment default among tuberculosis patients in a high burden province of South Africa. *Int J Infect Dis* [Internet]. 2017; 54:95–102. Available from: http://dx.doi.org/10.1016/j.ijid.2016.11.407

30. **Mwai M, Matiangi M, Keraka M, Njuhigu E**. Determinants of Treatment Interruption among Pulmonary Tuberculosis Patients in Select Health Facilities in Embu County, Kenya. *Int J Curr Asp.* 2022;6(2):41–56.