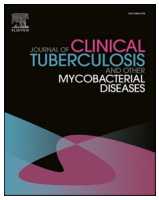
Journal of Clinical Tuberculosis and Other Mycobacterial Diseases 35 (2024) 100418

Contents lists available at ScienceDirect

Journal of Clinical Tuberculosis and Other Mycobacterial Diseases

journal homepage: www.elsevier.com/locate/jctube



TB-free Ebeye: Results from integrated TB and noncommunicable disease case finding in Ebeye, Marshall Islands

Richard J. Brostrom [a,b,*], Angela Largen [b], Joaquin N. Nasa [c], Glorine Jeadrik [c], Seiji Yamada [d], Subhash Yadav [e], Eunyoung Ko [e], Jon V. Warkentin [f], Terence L. Chorba [a]

[a] Centers for Disease Control and Prevention, Division of TB Elimination, Atlanta, GA, United States of America
[b] Hawaii Department of Health, TB Control Program, Honolulu, HI, United States of America
[c] Ministry of Health, Marshall Islands
[d] University of Hawaii Department of Family Medicine and Community Health, Honolulu, HI, United States of America
[e] World Health Organization, Western Pacific Region, Suva, Fiji
[f] Formerly of Tennessee Department of Health, TB Control Program, Nashville, TN, United States of America

ARTICLE INFO

Keywords:
Tuberculosis
Active case-finding
Diabetes mellitus
Marshall Islands

ABSTRACT

Background: Tuberculosis (TB) incidence rates in the Republic of the Marshall Islands are among the highest in the world, 480/100,000 in 2017. In response, the Health Ministry completed islandwide screening in Ebeye Island in 2017.

Methods: Participants were interviewed to obtain TB history, exposures, and symptoms. TB assessment included chest radiography with sputum collection for GeneXpert® MTB-RIF if indicated. TB diagnosis was made by consensus of visiting TB experts. Participants were also screened for Hansen's disease (HD) and diabetes mellitus (DM). For persons aged ≥21 years, blood pressure, cholesterol, and blood glucose were assessed.

Results: A total of 5,166 persons (90.0 % of target population) completed screening leading to the identification of 39 new cases of TB (755/100,000) and 14 persons with HD (270/100,000). DM was detected in 1,096 persons (27 %), including in 351 persons not previously diagnosed. The rate of hypertension was 61 % and of hypercholesterolemia was 15 %. New or prevalent TB diagnosis was associated with newly diagnosed or history of DM (aOR 4.68, 2.15–10.20).

Conclusions: In Ebeye, an integrated TB screening campaign found TB, HD, DM, and hypertension. TB and DM were strongly associated.

1. Background

The tuberculosis (TB) incidence rates in the Republic of the Marshall Islands (RMI) have been among the highest in the world, estimated as 480/100,000 persons in 2017 [1]. Working with national and international partners, the RMI Ministry of Health (MOH) initiated islandwide screening in Ebeye Island in February 2017. Ebeye Island, with its population of 9,614 per 2011 census, was chosen because of its high TB rate, averaging 326/100,000 between 2012 and 2016 (MOH data), and its exceptionally dense population [2,3]. The short-term goals for TB-Free Ebeye were to screen at least 80 % of the population aged ≥15 years, find and treat persons with active TB disease, expand TB contact investigations to include all household contacts, and implement rifampin-based TB prevention in contacts with latent TB infection (LTBI).

To maximize the public health benefits of an intensive TB screening effort, the MOH incorporated other RMI health priorities, including screening for diabetes mellitus (DM), Hansen's disease (HD), hypertension, obesity, and hypercholesterolemia [4].

The aim of this paper is to describe the results of the initial TB, HD, and noncommunicable disease (NCD) screening, describe the programmatic changes that occurred during the campaign, and evaluate the previously described association between DM and active TB in Ebeye [5].

* Corresponding author at: Hawaii State TB Control Program, 1700 Lanakila Ave, Honolulu, HI, 96817, United States of America.
E-mail address: hld4@cdc.gov (R.J. Brostrom).

https://doi.org/10.1016/j.jctube.2024.100418

Available online 3 February 2024

2. Methods

2.1. Screening methodology

The RMI MOH and multiagency teams completed integrated TB, HD, and NCD screening for persons aged ≥15 years on Ebeye between February and April 2017. Persons aged <15 years were excluded from TB active case finding (ACF) in accordance with 2013 World Health Organization (WHO) guidance which did not support radiography-based TB ACF in pediatric populations [6]. Children were included in TB screening only as part of household contact investigations when an adult household member tested positive for TB DNA via nucleic-acid amplification testing (GeneXpert® MTB-RIF). Persons were invited by public service messages to the screening clinics, and they were grouped by their neighborhood or weto.[1] Upon entering the screening center, patients were registered into a data collection system created by WHO for the screening campaign. After registration, participants were interviewed to obtain TB history, recent TB exposure (within 2 years), current TB symptoms, NCD history, and tobacco use. Participants aged ≥21 years then entered the NCD area to assess blood pressure, cholesterol, and blood glucose. To assess for diabetes, a stepwise pragmatic approach was employed [7]. Persons were first tested with a random whole blood glucose. If the initial random blood glucose was ≥140 mg/dl (7.77 mmol/L), an additional point-of-care hemoglobin A1c (HbA1c, Bayer® A1CNow+, Leverkusen, Germany) was assayed to confirm DM and assess longer-term glucose control. For those with a new diagnosis of DM (HbA1c ≥ 6.5 % or for those with a prior diagnosis but poor glucose control, individual DM counseling and referral was provided on site by a physician. To diagnose hypertension, three blood pressures were taken within 15 min, and a diagnosis of hypertension was based on systolic blood pressure average ≥130 mm Hg or diastolic blood pressure average ≥80 mm Hg. Elevated total cholesterol was defined as a non-fasting total cholesterol ≥200 mg/dL. Counseling and referral were provided for persons with a new diagnosis of hypertension or a new diagnosis of elevated non-fasting total cholesterol. The integrated ACF methodology also included a brief skin and nerve screening exam for HD.

For all participants, chest radiography was done and interpreted by on-site TB clinicians within minutes. Persons with findings indicating possible pulmonary TB or persons with signs and symptoms of TB were directed to an outdoor area for sputum collection. Sputum samples were transported daily to the Ebeye Hospital laboratory for next-day GeneXpert® processing.

After compiling new radiographs and prior radiographs from the Ebeye TB clinic (if available), known prior TB exposures, TB signs and symptoms, HbA1c results, and new GeneXpert® results, a final diagnosis of a "TB Case" was made by consensus of local and international experts. The new TB cases were referred to the local program for completion of workup and initiation of standard TB treatment. For persons with a positive GeneXpert® result, household contacts were elicited; these persons received a tuberculin skin test (TST). Household contacts with a positive TST result (≥5 mm induration) were evaluated for active TB, including a chest radiograph if one had not already been done as part of the community screening. Household contacts with a positive TST result who did not have active TB were given rifampin-based treatment for LTBI. For this ACF campaign, communitywide LTBI testing was not performed.

Prior to the TB Free Ebeye campaign, examination of household contacts and treatment for LTBI was limited to children ≤5 years and persons with HIV infection. Prior to the TB Free Ebeye campaign, rifampin-based LTBI treatment regimens had never been used in Ebeye. During the campaign, contact investigations were expanded to include all adult and pediatric household contacts of GeneXpert® positive persons. All contacts received TST and a chest radiograph if not already performed by the TB Free Ebeye screening campaign.

2.2. Ethical approval

All participants provided verbal consent in all aspects of the evaluation at the time of voluntary screening. The RMI MOH reviewed and approved the screening protocol.

2.3. Data collection and analysis

Data were collected and stored in a Microsoft Access-based database with local MOH storage and control. For this analysis, deidentified screening data were accessed by the Ebeye TB Program and the project epidemiologist.

Descriptive statistics were used to describe the demographic and clinical characteristics of the population, the results of the NCD screening, and laboratory results for newly diagnosed TB cases. Rates of newly diagnosed TB and HD were calculated among the screened cohort. The number needed to screen to find one new case of TB was calculated using the total screened population divided by the number of persons with newly diagnosed TB; the cross-sectional prevalence was calculated from persons with newly diagnosed cases of TB and persons who were already taking TB medications at the time they attended the integrated screening.

Logistic regression was used to assess the association between cross-sectional TB and DM among all participants; DM in this analysis was defined as HbA1c ≥6.5 % or a prior history of DM regardless of HbA1c level. The association of cross-sectional TB with level of glucose/HbA1c control in participants aged ≥21 years was assessed using Firth penalised logistic regression [9] to account for small cell sizes. Multivariable models for both analyses were constructed to adjust for demographic variables as well as established risk factors for TB [1,10,11];p-values of ≤0.05 were considered significant and complete case analysis was used to address missing data [12]. To assess potential interaction between DM and body mass index (BMI), a likelihood ratio test [13] was used to compare the overall multivariable model to a model also containing interaction terms for DM and BMI categories, with a p-value of ≤0.05 considered significant. This test did not produce evidence of a significant interaction ($p = 0.27$) so the findings from the model without the interaction are presented in the results. The Cochran-Armitage test [14] was used to assess the trend in TB diagnosis among levels of glucose/HbA1c control using standard A1c cutoffs [15]. Data management and analyses were carried out using SAS version 9.4 (SAS Institute, Inc).

3. Results

3.1. Population characteristics

The total population of Ebey island, based on the 2011 census, is 9,614 persons. Of the 5,734 persons ≥15 years in Ebeye village, a total of 5,166 persons completed screening, representing 90.0 % of the target population based on the 2011 census. [3] Persons screened had an average age of 36.1 years, compared to a census average of 34.9 years (≥15 years). The screening cohort was 51.7 % female, compared to the 2010 census which recorded 49.7 % female. Further demographic and clinical characteristics of the screened cohort are presented in Table 1.

3.2. TB Case-finding results

After initial radiography with abnormal findings, 391 (7.5 %) persons were referred for further evaluation by a panel of local and volunteer physicians during daily diagnostic case review. Among these 391, TB disease was diagnosed in 39 (10.0 %) (Table 2), with a rate of 755 per 100,000 persons screened. The number needed to screen to find

[1] Weto is a parcel of land based on Marshallese custom, averaging two to five acres. Ebeye residents are organised into 12 wetos, based on local land ownership.

Table 1
Demographic and clinical characteristics of persons screened (n = 5,166).

	n	%*
Sex		
Female	2,671	51.7
Male	2,495	48.3
Age, years		
15–24	1490	28.8
25–44	2193	42.5
45–64	1291	25.0
≥65	192	3.7
BMI, kg/m^2		
Median [IQR]	28 (23–33)	
Current tobacco use	1,896	36.8
Prior TB	222	4.3
Known TB exposure	341	6.7
At least one TB symptom†	530	10.3
Abnormal chest radiograph‡	430	8.4

*Percentages exclude persons with missing data. The number missing by variable include BMI = 820, tobacco use = 7, prior TB = 57, TB exposure = 99, TB symptoms = 21, chest x-ray = 25.
†Symptoms include cough ≥ 2 weeks, fever, night sweats, hemoptysis, fatigue, shortness of breath, and weight loss.
‡Includes persons screened and found to have an abnormal chest radiograph possibly consistent with TB.
BMI = body mass index; IQR = interquartile range.

Table 2
Findings related to TB diagnosis during the TB Free Ebeye campaign (n = 39)*.

	n	%
Overall laboratory confirmation (culture or GeneXpert® positive)	14	35.9 %
Culture positive	11	28.2 %
GeneXpert® positive	12	30.8 %
Smear positive	7	17.9 %
Cavitary chest radiograph	2	5.1 %
At least 1 TB symptom**	29	74.4 %

*Categories are not mutually exclusive.
**Includes any TB symptoms reported at time of screening or during further evaluation by the TB program. Symptoms include cough ≥ 2 weeks, fever, night sweats, hemoptysis, fatigue, shortness of breath, and weight loss.

one new TB case was 132. Although 74.4 % of TB cases reported at least 1TB symptom, bacteriologic confirmation among the TB cases was low at 35.9 %.

3.3. HD screening results

The HD screening resulted in 153 referrals for further assessment of skin or nerve findings. After local HD Clinic consultation and skin biopsy results, 14 persons were diagnosed with HD, a rate of 275 per 100,000 screened.

3.4. NCD screening results

Results of the NCD screening are presented in Table 3. DM was diagnosed in 1,096 (27 %) of persons aged ≥ 21 years, and 351 (32 %) of these diagnoses were new. Of those with DM, 44 % (441/1,009) had highly uncontrolled diabetes indicated by HbA1c ≥ 10.0 %. Hypertension was diagnosed in 2,482 (61 %), and 1,582 (64 %) of these were new diagnoses. Elevated cholesterol was found in 631 persons (15 %), and 128 (20 %) of these were new diagnoses.

3.5. Association between diabetes and tuberculosis

Overall, the presence of newly diagnosed or prevalent DM increased the odds for new or prevalent TB diagnosis by an unadjusted factor of 4.04 (2.32, 7.03), and a factor of 4.68 (95 %CI = 2.15,10.20) after adjusting for age, sex, BMI, history of TB, recent TB exposure, and current tobacco use.

Table 3
Results of noncommunicable disease screening, ages ≥ 21 years (n = 4,099).

	n	%*
Diabetes mellitus (HbA1c† ≥ 6.5 % after initial Glu ≥ 140, or prior DM diagnosis)	1,096	26.9
No prior diabetes history	351	32.1
Hypertension (systolic ≥ 130 or diastolic ≥ 80 mmHg, or prior diagnosis)	2,482	60.6
No prior hypertension history	1,582	63.7
Elevated/high total cholesterol (≥200 mg/dL or prior diagnosis)	631	15.4
No prior high cholesterol history	128	20.3

*Percentages exclude persons with missing data; the number missing by variable: diabetes = 26, new diabetes diagnosis = 2, hypertension = 5, new hypertension diagnosis = 7, cholesterol = 9, new cholesterol diagnosis = 3.
†HbA1c = hemoglobin A1c; Glu = glucose.

As assessed by glucose and HbA1c, inadequate glucose control was strongly associated with a new or prevalent diagnosis of TB among adults aged ≥ 21 years (Table 4). TB diagnosis was least common among those with a normal HbA1c (HbA1c < 5.7 %) [8] or random glucose (<140 mg/dL), while the frequency of diagnosis of active TB increased by 239 % for those who had poor glucose control (HbA1c ≥ 8.0 %) at the time of TB screening. Results of the Cochran-Armitage test indicated that the odds of TB increased significantly as HbA1c category increased ($p < 0.01$).

3.6. Program capacity building

Among 142 household contacts to infectious TB patients (aged 0–72 years), 13 (9 %) were diagnosed with active TB. Of the 129 remaining, 39 (30 %) had a positive TST result (≥5mm) and normal findings on chest radiography, indicating LTBI. A total of 29 of these persons (74 %) completed LTBI treatment: 20 took a rifampin-based regimen (i.e., 4 months of daily rifampin or 3 months of daily rifampin and isoniazid) and 9 took isoniazid for 6 months.

Table 4
The association between HbA1c and TB, ages ≥ 21 years*.

Glucose/HbA1c level†¶	TB cases/ total screened (46/ 4,066)	TB prevalence per 100,000	Unadjusted OR (95 % CI)	Adjusted OR§ (95 % CI)
Normal level (Glu < 140, or HbA1c < 5.7 %)	20/2,756	726	Reference	Reference
Pre-DM (HbA1c 5.7 %–6.4 %)	4/340	1,176	1.62 (0.56, 4.72)	2.26 (0.79, 6.48)
DM, controlled (HbA1c 6.5 %–7.9 %)	5/279	1,792	2.47 (0.93, 6.53)	3.54 (1.21, 10.36) ‡
DM, uncontrolled (HbA1c ≥ 8.0 %)	17/691	2,460	3.39 (1.79, 6.44) ‡	4.03 (1.74, 9.35) ‡

*Includes cross-sectional prevalent TB cases in persons ≥ 21 years of age.
†Persons with prior diabetes were included in the Normal level or Pre-DM level in this table if their glucose/HbA1c levels fell within these ranges at the time of testing.
¶n = 33 missing glucose/HbA1c results.
‡DM controlled, p = 0.02; DM uncontrolled, p < 0.01.
§Adjusted for age, sex, BMI, current tobacco use, self-reported history of TB, TB exposure and diabetes medication use.
DM = Diabetes mellitus; Glu = glucose; HbA1c = hemoglobin A1c; CI = confidence interval; OR = odds ratio.

4. Discussion

Active TB case-finding in Ebeye achieved short-term goals for diagnosing TB cases in the community. Of 5,734 persons aged ≥15 years, 5,166 (90.0 %) completed screening during the 10-week campaign. In addition to 11 prevalent TB cases among persons who completed the screening, 39 new TB cases were found in the screening group, and another 13 new TB cases were found through contact investigations in those who would otherwise not have been eligible to participate in the larger screening effort. Together, these new TB cases amounted to more than twice the annual reported incidence for Ebeye for 2017, a figure consistent with ACF efforts in other high-incidence countries [15].

The majority of persons diagnosed and treated for TB did not have bacteriological evidence for TB disease. Relying on chest radiograph as a defining component of ACF raises concerns about overdiagnosis, but this possible drawback was partially mitigated by the group of on-site clinical TB experts using a consensus-based diagnostic approach. Without the diagnostic certainty of bacteriologic confirmation (and with limited opportunity for 8 weeks of clinical observation pending TB culture results), the team of TB clinicians classified several persons as having active TB based upon abnormal chest radiograph. A test for infection, such as TST, was not part of routine diagnosis except among contacts. Studies have demonstrated a high rate of progression to active disease among persons with radiographic findings that suggest healed TB. [16–18] In the very high-risk setting of Ebeye, providing TB treatment to those with clinical evidence of TB but negative bacteriology results provided an opportunity to interrupt the cycle of TB transmission by treating TB disease in its earlier stages, before it could become infectious.

Prior to the ACF campaign, treatment for LTBI in Ebeye was limited to household contacts aged <5 years. Adults did not receive LTBI treatment unless they also had known risk factors for active TB disease, including DM. As part of the TB Free Ebeye campaign, contact investigations were expanded to include all household contacts to TB cases that were confirmed by GeneXpert® or TB culture. The Ebeye TB program also implemented treatment for LTBI with rifampin-based regimens (3 months of daily isoniazid and rifampin, or 4 months of daily rifampin), which could lead to improved treatment completion rates [19]. Expanded eligibility for LTBI treatment and the use of rifampin-based LTBI regimens were a precedent for RMI.

This is the first TB ACF campaign to include HbA1c as a marker for DM diagnosis and DM control in the Pacific. HbA1c is a useful tool for stratifying the risk of DM sequelae, including elevated TB risk [20–23]. Prior studies have linked DM with TB disease in the Pacific Islands, but none reported TB diagnosis stratified by HbA1c to assess overall level of glucose control [24–26]. In Ebeye, the relationship between TB disease and DM is significant, with a graded association between these two diseases [27].

Strengths of the TB-Free Ebeye screening campaign included the essential integration of noncommunicable diseases, including DM. Other strengths included a high participation rate, with credit to the local MOH for prioritizing the TB Free Ebeye campaign. The on-island presence of TB experts from the United States for more than 10 weeks provided opportunities to share expertise in chest radiography with local clinicians and to promote treatment of LTBI with rifampin-based therapy.

Limitations of this campaign and this analysis included the requirement for sustained engagement to support long-term improvements in TB control [28]. Continued partnership with the Ebeye TB Program is required to sustain the progress that was made during this campaign, particularly for expanded LTBI initiatives. The overall contribution of the campaign to short-term TB control in Ebeye is unknown, since the newly identified TB cases may have subsequently been identified by routine symptomatic presentation to the healthcare system. The presence of DM (whether new or longstanding) was not withheld from the medical team at the time of TB diagnosis. It is possible that when cases were presented to the clinical teams, the presence of DM influenced the clinical threshold for diagnosing active TB.

To achieve TB elimination, three strategies targeting TB prevention and control are necessary, in descending order of priority: (1) finding persons with active TB disease and following them through the completion of treatment, (2) screening, testing, and treating persons who have been infected with *M. tuberculosis* as the result of close contact with persons with TB, and (3) screening, testing, and treatment of other selected persons at high risk for LTBI [29]. In the efforts described here, attention was directed at each of these elements. Efforts to achieve long-term reduction in TB incidence and eventual TB elimination in these island groups will require concerted attention to all three of these elements.

5. Conclusions

In Ebeye, an integrated mass TB screening campaign in a very high-incidence country found 39 new cases of active TB and 14 new cases of HD, and identified 1,096 people with DM, 351 of whom were newly diagnosed. TB and DM were strongly associated. Active TB case-finding provided an opportunity to implement expanded program activities, including extending LTBI treatment to all household contacts. Treatment options for LTBI were expanded to include rifampin-based TB prevention regimens. Capacity-building efforts for TB diagnosis, chest radiograph interpretation, and initiation of TB treatment for high-risk persons were critical components of the campaign. Continued engagement and collaboration are required for sustainable program growth, and for tracking progress towards improved TB rates within and outside of the screened cohort.

Funding: Funding primarily from the Republic of the Marshall Islands with approval from the US Dept of Interior Insular Affairs Office. In-kind support provided by US CDC and WHO for on-site leadership. This operational research did not receive any funding in the commercial, or not-for-profit sectors.

Disclaimer: The findings and conclusions are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention (CDC). References in this manuscript to any specific commercial products, process, service, manufacturer, or company does not constitute its endorsement or recommendation by the U.S. Government or the CDC.

CRediT authorship contribution statement

Richard J. Brostrom: Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Supervision, Visualization, Writing – original draft, Writing – review & editing. **Angela Largen:** Conceptualization, Data curation, Formal analysis, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing. **Joaquin N. Nasa:** Investigation, Project administration, Writing – review & editing. **Glorine Jeadrik:** Project administration, Writing – review & editing. **Seiji Yamada:** Investigation, Supervision, Writing – review & editing. **Subhash Yadav:** Conceptualization, Investigation, Project administration, Writing – review & editing. **Eunyoung Ko:** Data curation, Investigation, Writing – review & editing. **Jon V. Warkentin:** Investigation, Writing – review & editing. **Terence L. Chorba:** Formal analysis, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This work could not have been completed without the immense support from the RMI Ministry of Health, especially Glorine Jeadrik, the Assistant Secretary of Health for Kwajalein Atoll. This work builds upon the determination and longstanding work of the RMI TB program, including Mareta Hauma, Dr. Tom Jack and the late Dr. Kennar Briand. Funding for this work was primarily provided by RMI National Government with approval from the US Department of the Interior, Insular Affairs Office, to whom we are most grateful. Additional support was received from the World Health Organization (Fiji and Manila offices), the Secretariat of the Pacific Community, the Australian Respiratory Council, the University of Hawaii John A. Burns School of Medicine, and the US Centers for Disease Control and Prevention. Finally, we are grateful to the expertise and energy of 37 members of the US National Tuberculosis Controllers Association who traveled to Ebeye to work shoulder-to-shoulder with their colleagues in the RMI TB Program.

References

[1] World Health Organization. Global tuberculosis report 2018. Geneva: World Health Organization; 2018.
[2] Ichiho HM, et al. An assessment of non-communicable diseases, diabetes, and related risk factors in the Republic of the Marshall Islands, Kwajelein Atoll, Ebeye Island: A systems perspective. Hawaii J Med Public Health 2013;72(5 Suppl 1):77–86.
[3] Anon. The RMI 2011 Census of Population and Housing Summary and Highlights Only. Republic of the Marshall Islands: Economic Policy, Planning, and Statistics Office; 2012.
[4] RMI Ministry of Health 3-Year Rolling Plan 2017-2019. Available from: https://www.ilo.org/dyn/natlex/docs/ELECTRONIC/112754/140999/F-141421640/MHL112754.pdf.
[5] Trinidad RM, Brostrom RJ, et al. Tuberculosis screening at a diabetes clinic in the Republic of the Marshall Islands. J Clin Tuberc Other Mycobact Dis 2016;5:4–7.
[6] World Health Organization. Systematic Screening for active tuberculosis: principles and recommendations. Geneva: World Health Organization; 2013. Available from: https://www.ncbi.nlm.nih.gov/books/NBK294083/.
[7] Manley SE, et al. The use of HbA1c for new diagnosis of diabetes in those with hyperglycaemia on admission to or attendance at hospital urgently requires research. Br J Diabet 2022;22(2):95–104.
[8] American Diabetes Association. Standards of medical care in diabetes-2019 abridged for primary care providers. Clin Diabetes 2019;37(1):11–34.
[9] Firth D. Bias reduction of maximum likelihood estimates. Biometrika 1993;80(1):27–38.
[10] Uys P, et al. The risk of tuberculosis reinfection soon after cure of a first disease episode is extremely high in a hyperendemic community. PLoS One 2015;10(12):e0144487.
[11] Soh AZ, et al. Diabetes and body mass index in relation to risk of active tuberculosis: a prospective population-based cohort. Int J Tuberc Lung Dis 2019;23(12):1277–82.
[12] Allison PD. Missing data. In: Millsap RE, Maydeu-Olivares A, editors. The SAGE Handbook of Quantitative Methods in Psychology. California: Sage Publications Inc; 2009. p. 72–89.
[13] Kleinbaum DG, Klein M. Logistic regression, a self-learning text. 3rd ed. New York: Springer; 2010.
[14] Cochran WG. Some methods for strengthening the common chi-squared tests. Biometr Int Biometr Soc 1954;10(4):417–51.
[15] American Diabetes Association. Standards of medical care in diabetes—2023. Diabetes Care 2023;46(suppl 1-4).
[16] Anon A. study of the characteristics and course of sputum smear-negative pulmonary tuberculosis. Tubercle 1981;62(3):155–67.
[17] Horsburgh Jr CR, et al. Revisiting rates of reactivation tuberculosis: a population-based approach. Am J Respir Crit Care Med 2010;182(3):420–5.
[18] Barry 3rd CE, et al. The spectrum of latent tuberculosis: rethinking the biology and intervention strategies. Nat Rev Microbiol 2009;7(12):845–55.
[19] Menzies D, et al. Four months of rifampin or nine months of isoniazid for latent tuberculosis in adults. N Engl J Med 2018;379(5):440–53.
[20] Qaseem A, et al. For the Clinical Guidelines Committee of the American College of Physicians. Hemoglobin A1c targets for glycemic control with pharmacologic therapy for nonpregnant adults with type 2 diabetes mellitus: A guidance statement update from the American College of Physicians. Ann Intern Med 2018;168:569–76.
[21] Selvin E, et al. Glycated hemoglobin, diabetes, and cardiovascular risk in nondiabetic adults. N Engl J Med 2010;362(9):800–11.
[22] Leung CC, et al. Diabetic control and risk of tuberculosis: a cohort study. Am J Epidemiol 2008;167(12):1486–94.
[23] Viney K, Mills T, Harley D. Tuberculosis and diabetes mellitus: a dose-response relationship between the odds of tuberculosis and HbA1c. Int J Tuberc Lung Dis 2019;23(10):1055–9.
[24] Viney K, et al. Tuberculosis and diabetes mellitus in the Republic of Kiribati: a case-control study. Trop Med Int Health 2015;20(5):650–7.
[25] Nasa JN, Brostrom RJ, et al. Screening adult tuberculosis patients for diabetes mellitus in Ebeye, Republic of the Marshall Islands. Public Health Action 2014;4(Suppl 1):S50–2.
[26] Viney K, Brostrom R, et al. Diabetes and tuberculosis in the Pacific Islands region. Lancet Diabetes Endocrinol 2014;2(12):932.
[27] World Health Organization. Collaborative framework for care and control of tuberculosis and diabetes. Geneva: World Health Organization; 2011.
[28] Burke RM, et al. Community-based active case-finding interventions for tuberculosis: A systematic review. Lancet Public Health 2021;6(5):e283–99.
[29] Cole B, et al. Essential components of a public health tuberculosis prevention, control, and elimination program: Recommendations of the advisory council for the elimination of tuberculosis and the National Tuberculosis Controllers Association. MMWR Recomm Rep 2020;69(7):1–27.